Chehalis Basin Strategy

Draft Flood Retention Expandable Facility Mitigation Plan:
Aquatic Species and Habitat, Riparian and Stream Buffer, Wildlife Species and Habitat, Large Woody Material, Surface Water Quality

June 2022

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ACRONYMS AND ABBREVIATIONS

7-DADMax	Mean of 7 consecutive measures of daily max temperature
Applicant	Chehalis River Basin Flood Control Zone District
AR	atmospheric river
ASRP	Aquatic Species Restoration Plan
BMP	best management practice
CBS	Chehalis Basin Strategy
cfs	cubic feet per second
CHTR	Collection, handling, transfer, and release
Corps	U.S. Army Corps of Engineers
CSM	conceptual site sediment model
CWA	Clean Water Act
DAHP	Department of Archaeology and Historic Preservation
dbh	diameter at breast height
DEIS	Draft Environmental Impact Statement
Ecology	Washington Department of Ecology
EDT	Ecosystem Diagnosis and Treatment
EFH	essential fish habitat
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FCZD	Chehalis River Basin Flood Control Zone District
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
Footprint Model	CE-QUAL-W2 Footprint Model
FPHCP	Forest Practices Habitat Conservation Plan

FR	forest road
FRE	Flood Retention Expandable Facility
FRE HMP	Flood Retention Expandable Facility Habitat Mitigation Plan
GMU	game management units
gpm	gallons per minute
I-5	Interstate 5
LWM	large woody material
M&AMP	Monitoring and Adaptive Management Plan
mg/L	milligrams per liter
MOAR	Mitigation Opportunities Assessment Report
MSL	mean sea level
MSA	Magnuson-Stevens Act
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity units
OHWM	ordinary high-water mark
PMF	probable maximum flood
RCC	roller-compacted concrete
RM	river mile
SEPA	State Environmental Policy Act
SEPA/NEPA-DEIS	Draft Environmental Impact Statements by Ecology and the Corps
SMP	Shoreline Management Plan
SWAP	State Wildlife Action Plan
SWIFD	Statewide Washington Integrated Fish Distribution
TTT	temporary trap and transport
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

VMP	Vegetation Management Plan
WAC	Washington Administrative Code
WA DNR	Washington Department of Natural Resources
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation
WSEL	water surface elevation

EXECUTIVE SUMMARY

The Chehalis River Basin Flood Control Zone District (Applicant) is proposing construction of the Flood Retention Expandable (FRE) facility (Proposed Action) on the upper Chehalis River (river mile [RM] 108.5), near the Town of Pe Ell, Washington. The purpose of the Proposed Action is to reduce the severity of disruption and damage to businesses, properties, and infrastructure associated with periodic major flooding of the Chehalis River. The FRE facility would operate to temporarily store floodwaters only during major and catastrophic floods when river flows are forecasted to reach 38,800 cubic feet per second (cfs) or greater as measured at the United States Geological Survey (USGS) Chehalis River Grand Mound gage. At all other times, the FRE facility would allow normal river flow and would not store water.

Draft Environmental Impact Statements (DEISs) prepared by the Washington Department of Ecology (Ecology) under the State Environmental Policy Act (SEPA) and the U.S. Army Corps of Engineers (Corps) under the National Environmental Policy Act (NEPA) identified and quantified potential impacts to aquatic resources in the Chehalis River Basin that may arise as a result of construction and operation of the proposed FRE facility. Principal among these impacts would be effects on aquatic habitat, fish spawning habitat, and water quality (temperature and turbidity). This draft Flood Retention Expandable Facility Habitat Mitigation Plan (FRE HMP) describes the measures the Applicant proposes to implement, and demonstrates how the Applicant intends to fulfill their commitment to avoiding, minimizing, and mitigating these impacts to achieve no net loss of habitat function due to project-related impacts. The Applicant has systematically reviewed avoidance, minimization, and mitigation actions, and identified appropriate actions in the context of the proposed project. The principal actions proposed to avoid and minimize impacts include implementation of both the Vegetation Management Plan (VMP) to maintain adequate vegetation for shade and erosion protection in the temporary reservoir and Large Woody Debris Plan to provide an ongoing supply of material to the reach of the river below the site of the FRE facility. Mitigation actions proposed to offset unavoidable impacts include opening up fish passage to currently unacceptable stream reaches; construction of habitat features in the river channel to promote habitat diversity and complexity including temperature refuge habitats; enhancement of streamside vegetation and reforestation to re-establish natural processes such as stream shading, soil retention, increase of nutrient inputs; protection of wildlife habitats and reestablishment of forest processes; placement of large wood structures and recruitment of large wood over time; and measuring effects of actions on water quality to ensure compliance with goals and regulations.

The applicant has systematically surveyed the appropriate portions of the Chehalis River Basin and identified numerous potential opportunities for implementation of specific avoidance, minimization, and mitigation measures, and has determined that more than a sufficient number of feasible opportunities exist within the upper Chehalis River Basin to address and mitigate potential impacts identified in the SEPA DEIS or the NEPA DEIS, collectively referred to as the SEPA/NEPA-DEIS. The

Applicant commits to following a mitigation sequencing approach, working first to avoid and minimize potential effects on stream and terrestrial habitat, then restoring or rehabilitating the affected environment, and finally, compensating for unavoidable impacts.

The Applicant has previously assessed, developed, and submitted to Ecology and the Corps avoidance, minimization, and mitigation measures including a VMP, Fish Passage Plan, Water Temperature Sensitivity Analysis, Sediment Dynamics Analysis, and Spawning Habitat Assessment. Measures committed to by the Applicant in these plans may significantly reduce impacts identified in the SEPA/NEPA-DEIS as well as the Applicant's compensatory mitigation obligations under Section 404 of the Federal Clean Water Act and Section 10 of the federal Endangered Species Act. The Applicant's work to address project impacts has led to the understanding that conservative assumptions used in the preparation of the SEPA/NEPA-DEIS has led, in some cases, to estimates of impacts that are higher than are likely to actually occur. Nonetheless, in aggregate, the avoidance, minimization, and mitigation measures described in this FRE HMP have been programmed to sufficiently offset the greater impact quantities as presented in the SEPA/NEPA-DEIS.

This FRE HMP addresses six categories of compensatory mitigation: 1) Aquatic Habitat Access, 2) Aquatic Habitat Enhancements, 3) Riparian/Stream Buffer Expansion Downstream of the FRE Facility, 4) Wildlife Habitat Conservation, 5) Large Woody Material, and 6) Surface Water Quality Monitoring. In each category of this FRE HMP, measures also are proposed to ensure the long-term viability of the avoidance, minimization, and mitigation measures through a commitment by the Applicant through ongoing adaptive management.

The number of actions proposed in this plan would not only address the estimated impacts put forth in the SEPA/NEPA-DEIS, but would also help to alleviate existing habitat limiting factors in the basin and thereby generate overall improvement in the ecological conditions and habitat functions in the upper Chehalis River. The Applicant's proposed mitigation measures focus on improving specific currently degraded habitat conditions, including riparian habitat, lack of habitat complexity, and lack of large wood that would be further degraded with potential project impacts. The riparian and forest measures focus on improving habitat quality of degraded riparian and stream buffers, thereby, restoring increasing thermal buffering and soil retention properties to these important streamside habitats. In-channel and off-channel measures will increase the amount of habitat available to native fishes and improve habitat quality by creating habitat diversity and complexity in current uniform stream reaches. In this way the Applicant's combination of minimization and mitigation measures would go beyond no net loss of habitat function to provide ecological benefit, or habitat functional lift, for aquatic and wildlife species in the upper Chehalis River.

Proposed Action

The Proposed Action would be implemented on the Chehalis River at RM 108.5. This location is well suited for the FRE facility as the channel is naturally constrained by a bedrock canyon, has suitable topography to form a temporary reservoir, and because the Willapa Hills upstream are the primary source of floodwater during major floods. Also, temporary inundation of the river channel upstream of RM 108.5 would not interfere with residential or commercial development.

Permanent features of the Proposed Action include the FRE facility; a fish collection, handling, transfer, and release facility; aggregate source quarries and access roads; and improvements to the Town of Pe Ell Water System. Temporary features include structures and storage areas needed for construction that would be removed after completion. Construction of all infrastructure would be completed in approximately 4.5 years and operation could begin as early as spring 2030, pending qualifying floods.

The FRE facility would operate infrequently (once every several years) and only for a short time period (up to 32 days per event). At all other times, the FRE facility's five conduits would remain open allowing unimpeded natural run-of-river flow including downstream transport of water, sediment, and large woody material (LWM, up to 3 feet in diameter and 15 feet in length), and opportunities for both upstream and downstream fish movement. The FRE facility operation would be triggered when flood forecasts predict flood flows greater than 38,800 cfs as measured at Grand Mound gage. During operation, gates on the five conduits would close, retaining floodwater above the FRE facility. Following flood peak, the flood pool would be drawn down at a specific rate to manage sediment, entrained debris, and instream flow. Fish passage would be provided at all stages of construction and operation in compliance with National Marine Fisheries Service criteria either downstream via conduits or upstream with a trap and haul program.

Existing Baseline Conditions

The Impact Area associated with the Proposed Action includes the temporary reservoir extending approximately 6 miles upstream of the FRE facility downstream to the South Fork Chehalis River confluence at RM 88.1 for a total distance of approximately 26 river miles. The Applicant expanded the area under consideration for implementation of mitigation actions (i.e., Mitigation Area) to include headwaters in the Willapa Hills as well as tributary drainages along the mainstem.

Data for the Applicant's technical review of Existing Baseline Conditions was compiled from numerous reports by Washington Department of Fish and Wildlife (WDFW), Ecology, Corps, National Oceanic and Atmospheric Administration, USGS, Anchor QEA, Kleinschmidt Associates, and HDR Engineering, as well as peer-reviewed literature and regional white papers. The Existing Baseline Conditions Assessment provides a comprehensive description of the physical environment, current status of aquatic and terrestrial species, and factors currently limiting ecosystem function.

Land use practices across the Chehalis River floodplain have resulted in the loss of floodplain complexity and storage capacity, and loss of native riparian vegetation communities. These practices include agriculture, livestock grazing, and urban development in low elevation areas and timber production in higher elevation areas. Land use practices and road building have also contributed to the presence of numerous road culverts and other barriers which disconnect stream habitats and limit access to suitable upstream habitats for aquatic species. The result in the Impact Area is a mainstem river with one predominant incised channel that is disconnected from its floodplain, disconnected from aquatic habitat in tributaries, and has more sediment and warmer water temperatures relative to historic conditions.

Portions of the Impact Area are designated as Clean Water Act Section 303(d) Impaired Waters or Water of Concern for parameters including turbidity, nutrients, fecal coliform, dissolved oxygen, and temperature. Increased water temperature, documented widely in the Chehalis River Basin, is a particular concern during low flow summer months. Increased water temperature has been identified as a key limiting factor for spring-run Chinook salmon (*Oncorhynchus tshawytscha*) spawning in the upper Chehalis River. Stream temperature has been related to the loss of riparian vegetation along stream channels causing solar heating of the water. This, combined with reduced summer flow, creates habitat unfavorable for native fishes.

Although there are no Endangered Species Act (ESA) listed salmon populations in the Chehalis River, Essential Fish Habitat (EFH) has been designated for Chinook salmon and coho salmon (*O. kisutch*). Salmon EFH in the Chehalis River covers all accessible water bodies including the mainstem river and tributaries. Other species that rear or spawn in the Impact Area include steelhead (*O. mykiss*), Pacific lamprey (*Entosphenus tridentatus*), mountain whitefish (*Prosopium williamsoni*), western brook lamprey (*Lampetra richardsoni*), resident trout species (*Oncorhynchus sp.*), and Olympic mudminnow (*Novumbra hubbsi*). Other species of interest that may be found in or near the Impact Area and were noted in the SEPA/NEPA-DEIS include the still-water breeding western toad (*Anaxyrus boreas*), a candidate for state listing, terrestrial breeding amphibians; the Dunn's salamander (*Plethodon dunni*) and Van Dyke's salamander (*P. vehiculum*) which are both candidates for state listing; and the federally and state-listed marbled murrelet (*Brachyramphus marmoratus*).

In reviewing mitigation opportunities, the Applicant developed a list of limiting factors that broadly affect the target aquatic and terrestrial species and the habitats they rely upon. Identified limiting factors were poor-quality stream habitat and loss of access to quality habitat, degraded conditions in the riparian zone and on the floodplain, degraded water quality related primarily to temperature, and encroachment by invasive species. Analysis of limiting factors also considered the anticipated effect of future climate change. These analyses were used in the development of mitigation that would provide the greatest ecological lift and benefit to the species and habitats.

Draft Impacts

Ecology published a DEIS under the Washington SEPA in February 2020 (Ecology 2020). The Corps published a DEIS under the NEPA in September 2020 (Corps 2020). Both documents (SEPA/NEPA-DEIS) reported findings that the Proposed Action would have probable, unavoidable, and adverse impacts on aquatic and terrestrial habitats and species.

Impacts of the Proposed Action on stream and terrestrial habitat as described in the SEPA/NEPA-DEIS were used to anticipate potential mitigation obligations. The impacts are conservative as they were developed without the avoidance or minimization measures that the Applicant has committed to implement to reduce Proposed Action effects. For purposes of the FRE HMP development, DEIS impacts were categorized by Proposed Action phase (construction, operation) and duration (episodic/temporary, permanent). A brief description of categorized impacts determined by Ecology is as follows:

- Temporary Construction – related Impacts include periodic dewatering, fish passage interruption, and increased sediment load during construction.
- Permanent Construction – related Impacts include vegetation clearing in the temporary reservoir and site clearing for physical infrastructure, and loss of river channel and floodplain associated with the FRE facility and associated facilities.
- Temporary Operations – related impacts include episodic inundation of the temporary reservoir area; water temperature increases from loss of shade and corresponding dissolved oxygen decreases; episodic increases in turbidity with storm events; increased sediment loading during flood pool drawdown; interruption in sediment transport and LWM delivery to habitats downstream of the FRE facility; reduced ground water recharge due to decreased flood plain engagement; and decreased wildlife habitat function and mortality of non-mobile terrestrial species during inundation.
- Permanent Operations – related Impacts include loss of stream channels and stream buffers due to degradation associated with inundation; loss of salmon and native fish habitat; degradation of riparian function; indirect mortality to wildlife species and decreased distribution due loss of upland, wetland, and riparian habitat; and increased habitat suited for invasive species colonization.

Mitigation Approach

Mitigation planning described in this FRE HMP considers federal and state regulatory requirements and mitigation guidance. Standard mitigation sequencing is a process for avoiding, minimizing, or compensating for the potential effects of an action on the environment. Avoidance and minimization measures proposed under this FRE HMP are discussed in Sections 6.1.1 and 6.1.2. Compensatory mitigation actions were identified that prioritize actions that are on-site and in-kind in favor of actions that are off-site or out-of-kind. All mitigation actions proposed are actions widely accepted and implemented in the Pacific Northwest, and were deemed to be feasible in the upper Chehalis River. The Applicant would follow a mitigation sequencing approach, and has assessed and developed avoidance and minimization measures that provide a significant reduction in impacts identified in the SEPA/NEPA-DEIS, as well as compensatory mitigation measures for unavoidable impacts.

Compensatory Mitigation

Regulatory agencies apply mitigation ratios, typically during permitting, for a variety of purposes aimed at ensuring no net loss of ecological functions and values. Mitigation ratios use a multiplier of unit measure for mitigation versus impact to result in a larger area, or amount, of mitigation compared to the area or amount of impact. There is no set of standardized mitigation ratios for aquatic or terrestrial impacts, Bradford suggested that a multiplier of 1.5:1 or 2.5:1 is sufficient for addressing uncertainty when offsetting impacts to freshwater fish productivity (Bradford 2017). Since no mitigation ratio requirement has been determined for the Proposed Action at this time, the Applicant has assessed that enough feasible mitigation opportunities exist in the Mitigation Area to mitigate impacts at a ratio greater than 2.5:1.

The Applicant's proposed compensatory mitigation addresses Aquatic Habitat Access, Aquatic Habitat Enhancements, Riparian and Stream Buffer Expansion Downstream of the FRE Facility, Wildlife Habitat Conservation, Large Woody Material Recruitment and Placement, and Surface Water Quality.

Aquatic Habitat Access

The objective of this mitigation is to reconnect stream habitat currently disconnected due to fish passage impediments. A total of over 252 barriers and other impediments to fish habitat access have been identified in the Chehalis Basin, with nearly 375 miles of potential linear habitat gain opportunity for anadromous salmonids. The Applicant would open access to 42.5 miles (17 miles at a mitigation ratio of 2.5:1) of habitat suitable for spawning and rearing of salmon, steelhead, and other native fishes to offset any potential reductions in salmon and steelhead abundance, productivity, or spatial structure in the Impact Area.

Aquatic Habitat Enhancements

The objectives of this suite of mitigation actions are to improve the functional value of aquatic habitat through increasing channel and habitat complexity, engaging the floodplain, and providing thermal refuge habitat for aquatic species. Based on geomorphic reach level screening, a total of 56 aquatic habitat enhancements at 49 sites have been advanced. These enhancement actions would benefit habitats suitable for spawning and rearing of salmon, steelhead, other native fishes, and amphibians to mitigate indirect loss in overall species abundance and aquatic habitat productivity.

Water Temperature Improvements

The objective of cold-water retention projects is to improve water temperature conditions for native species by providing near-term and sustained thermal refugia and suitable dissolved oxygen. Reach level screening advanced 19 water temperature improvement sites. Cold water refugia distributed

> **Proposed Mitigation**
>
> - ❖ Fish habitat access to open passage to 42.5 miles of suitable stream habitat.
> - ❖ Increased habitat complexity and diversity across 26 river miles with up to 56 feasible habitat enhancement actions to advance to site-selection.
> - ❖ Riparian/stream buffer expansion along 25.5 miles of stream channel downstream of the proposed FRE facility location.
> - ❖ Conservation of 500 acres of coniferous forest and riparian enhancement to support wildlife habitats, forest, and wetland functions.
> - ❖ Placement of large wood structures to create habitat for the near term and riparian enhancements for future wood recruitment over the long term.
> - ❖ Management plan to monitor and evaluate compliance with water quality goals and requirements.

throughout the Impact Area would improve adult spring-run Chinook salmon holding habitat quality, juvenile salmon and native fish rearing habitat, and would also alleviate stress to native cold-water fishes from temperatures that exceed thermal habitat suitability criteria.

Instream Modifications

The goal of this mitigation is to offset stream habitat loss and degradation by increasing habitat complexity and LWM. Seven sites with suitable geomorphic features for instream modifications were identified upstream of the FRE facility, and three sites were identified downstream. Instream modifications are intended to provide multiple benefits to aquatic species with a particular focus on salmon spawning and rearing habitat.

Off channel Modifications

The objective of this mitigation is to enhance the habitat through increased habitat complexity and improved water temperature, specifically to provide additional high-quality rearing habitat for fish, amphibians, and other floodplain wildlife species. The reach-level screening advanced 22 potential off-channel modification sites. Off-channel enhancements provide highly productive rearing and foraging habitat, velocity refugia during high flow events, and may be configured to incorporate thermal refugia.

Gravel Retention Jams

The objective of this mitigation is to enhance aquatic habitat by creating high-quality spawning habitat for salmonids while also providing riffle habitat for stream-spawning amphibians. Seven suitable sites were advanced after reach-level screening. All sites, located upstream of the maximum extent of the temporary reservoir, were suitable to implement gravel retention jam projects in sequence with instream modifications to maximize ecological benefits. Gravel retention jams would provide immediate and sustained ecological benefits for salmon and amphibian spawning, and the intended ecological function would be fully realized in 1 or 2 years after implementation at locations where gravel augmentation is part of the action.

Riparian/Stream Buffer Expansion

The goal of the riparian and stream buffer expansion is to mitigate unavoidable impacts on stream temperature by expanding forested buffers downstream of the FRE facility. Riparian buffer expansion would provide the primary long-term means of mitigating impacts on water temperature related to the predicted loss of riparian shade in the temporary reservoir. In addition to providing shade, expanded forested riparian areas provide a source for wood recruitment, reduce soil erosion, and mitigate water quality impacts related to runoff from upslope land-use activities. An analysis of existing riparian shade information identified a total of 145.7 miles of degraded riparian habitat that provides mitigation opportunities for riparian enhancement and improved thermal buffering. The Applicant would expand riparian/stream buffers along 25.5 miles of stream channels within the area downstream of the FRE facility to the confluence with the Newaukum River, including tributary subbasins.

Wildlife Habitat Conservation

The objective of this mitigation action is to conserve and enhance a 100-foot wide forested buffer (each side of the stream bank) along 20.6 stream miles (500 acres) in the upper Chehalis Basin upstream of the temporary reservoir maximum pool elevation. This action would mitigate impacts associated with vegetation removal in the temporary reservoir and loss of stream buffers associated with inundation during flood retention. Current forest practices do not allow timber harvest within 50 feet of a stream's ordinary high-water mark (OHWM), but limited selective harvest is permitted in the riparian area 50-100 feet from the OHWM and beyond. As the enhanced and conserved forest stands mature, more natural processes would return resulting in improved ecological functions including nutrient cycling; reduction of surface erosion; increased habitat complexity; and long-term use for riparian- and forest-dwelling wildlife species such as marbled murrelets, bald eagles and other raptors, and Dunn's and Van Dyke's salamanders.

Large Woody Material Recruitment and Placement

The objective of this mitigation action type is to provide future LWM recruitment through the conservation and expansion of riparian buffers and increase in-stream LWM through installations associated with aquatic habitat enhancements. The Applicant identified approximately 20.8 miles of large river habitat and 143.2 miles of small stream habitat with riparian canopies that are degraded and present opportunities for this mitigation action type. The Applicant proposes to conserve 20.6 stream miles of coniferous riparian forest upstream of the FRE facility, and to enhance and expand 25.5 stream miles of mixed riparian forest in the Mitigation Area downstream of the FRE facility. In addition, as part of Aquatic Habitat Enhancements, the placement and stabilization of LWM would provide an immediate increase in instream habitat structure and cover; facilitate the enhancement, restoration, inducement, or creation of habitat-forming processes; and promote hydraulic diversity, substrate diversity, high flow refugia, pool formation, and gravel retention in suitable reaches.

Surface Water Quality

The objective of this mitigation type is the development of a water quality monitoring plan to document the effectiveness of mitigation measures at offsetting temperature, dissolved oxygen, and turbidity effects resulting from FRE facility operation. Surface water quality is a metric that would be applied to all appropriate mitigation action types, and therefore, no site selection analysis was completed for this metric specifically.

Due to existing degraded conditions of the water quality in the upper Chehalis River, any potential reductions in low flow summer water temperatures and increases in dissolved oxygen, even localized effects, would be a benefit to native species. Localized cold water refuge habitat would particularly benefit spring-run Chinook salmon that are vulnerable to high stream temperatures due to their long residence time in freshwater prior to spawning.

Monitoring and Adaptive Management

The Applicant is proposing a three-tiered approach to addressing uncertainty in mitigation performance. First, mitigation would be designed conservatively to account for changing hydrology and channel adjustments that might be expected under varying future hydrology. This will ensure project resiliency in the face of changing climate conditions. Second, the Applicant would apply an agreed-upon mitigation ratio, whereby the quantity of mitigation is some factor greater than the quantity of impact – a mitigation ratio of 2.5:1 has been proposed as sufficient to address aquatic productivity (Bradford 2017). Third, the Applicant proposes to develop a Monitoring and Adaptive Management Plan (M&AMP) to address uncertainties that may arise after mitigation implementation that could affect ecology function.

The M&AMP would identify: 1) mitigation specific performance measures that would be monitored to evaluate how successful the mitigation is meeting goals and objectives, 2) monitoring sampling design and timeframes, and 3) the adaptive management framework within which monitoring results would be evaluated with respect to project success or triggering potential corrective actions or implementation of contingencies required.

The Applicant proposes to develop separate M&AMPs for six categories of mitigation proposed in Section 8 of this FRE HMP. These plans would be developed in consultation with the Adaptive Management Committee, WDFW, and appropriate agency representatives during the permitting phase of the project. The monitoring framework discusses key assumptions, specific monitoring objectives, and example metrics. The adaptive management framework presents examples of possible triggers for engaging in the adaptive management process and example actions that would be addressed by the Adaptive Management Committee. A timeframe for implementing the M&AMPs is provided that begins at Year 1 of FRE facility construction and continues through the life of the project.

1 INTRODUCTION

1.1 Background

The Chehalis River Basin Flood Control Zone District (Applicant) is proposing construction of the Flood Retention Expandable (FRE) facility (Proposed Action) on the upper Chehalis River (river mile [RM] 108.5), near the Town of Pe Ell, Washington, and levees located in the downstream developed areas between the cities of Centralia and Chehalis, Washington.

The Proposed Action is currently under environmental review. Washington State Department of Ecology (Ecology) published a Draft Environmental Impact Statement (DEIS) under the Washington State Environmental Policy Act (SEPA) in February 2020 (Ecology 2020). The U.S. Army Corps of Engineers (Corps) published a DEIS under the National Environmental Policy Act (NEPA) in September 2020 (Corps 2020). Both documents reported findings that the Proposed Action would have unavoidable, adverse impacts on aquatic and terrestrial resources.

The Flood Retention Expandable Facility Habitat Mitigation Plan (FRE HMP) describes the existing and potential future conditions of the aquatic and terrestrial species and habitats in the area potentially affected by construction and operation of the FRE facility (Impact Area) as well as the area considered for mitigation (Mitigation Area). Based on the SEPA DEIS or the NEPA DEIS, collectively referred to as the SEPA/NEPA-DEIS, the Impact Area is defined as the maximum temporary reservoir extent above the FRE facility, the FRE facility footprint, and the mainstem Chehalis River 20 miles downstream of the FRE facility. The Mitigation Area includes the upper Chehalis Basin from its headwaters upstream of the FRE facility downstream to the Newaukum River confluence (RM 75.2).

Existing conditions are described relative to the species and habitats that were identified in the SEPA/NEPA-DEIS as potentially impacted by the Proposed Action. This document summarizes the potential impacts of the Proposed Action on these resources, describes avoidance and minimization measures, and identifies conceptual actions to mitigate unavoidable impacts. The conceptual mitigation actions will be further refined following field evaluation of potential mitigation sites to determine project feasibility, and consultation with state and federal agencies. Once finalized, the Applicant will present these actions as a formal environmental commitment statement for consideration by Ecology and the Corps in the development of the respective Final Environmental Impact Statements (FEISs). Affirmative commitments are enforceable and may be given full consideration by the agencies when making SEPA and NEPA determinations regarding residual project effects.

The resources used to develop this mitigation plan include the Ecology SEPA DEIS and the Corps NEPA DEIS which include analyses of existing conditions and potential effects associated with the Proposed Action and the Chehalis Basin Strategy (CBS) Programmatic EIS (CBS 2017). Additional data on the presence, distribution, and status of aquatic and terrestrial habitat and species was gathered from numerous reports by Washington Department of Fish and Wildlife (WDFW), Ecology, Corps, National

Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS), Anchor QEA, Kleinschmidt Associates, and HDR Engineering, as well as peer reviewed literature and regional white papers. These data are summarized in Section 3 and presented in detail in Appendix A1.

1.2 Purpose and Scope

The purpose of this draft FRE HMP is to provide a mitigation proposal to the SEPA and NEPA lead agencies to inform their evaluation and determination of whether adequate mitigation to offset unavoidable Proposed Action effects on aquatic and terrestrial habitat is technically feasible and economically practicable. This FRE HMP provides a form of due diligence as the Proposed Action advances to the next phase of environmental review under SEPA and NEPA processes.

This mitigation plan is intended to support the SEPA and NEPA environmental review processes. It is a precursor to future mitigation plans that will include the detail necessary to inform environmental permitting for local (e.g., shorelines, critical areas, land use), Clean Water Act (CWA) Sections 401 and 404, Endangered Species Act (ESA) Section 7 consultation, Hydraulic Project Approval, and other related permits. This mitigation plan specifically addresses impacts from the Proposed Action as identified in the SEPA/NEPA-DEIS.

2 PROPOSED ACTION DESCRIPTION

2.1 Project Objective and Siting/Location

During periodic floods, the Chehalis River overtops its banks and enters the floodplain resulting in extensive bank erosion and turbidity, and water damage that has devastated homes, farms, businesses, churches, and schools. Many of these floods have caused the closure of Interstate 5 (I-5) and state highways 6 and 12, disrupting the flow of traffic and transport of commercial goods between Seattle, Washington and California. Flooding of this type has occurred as recently as 2022.

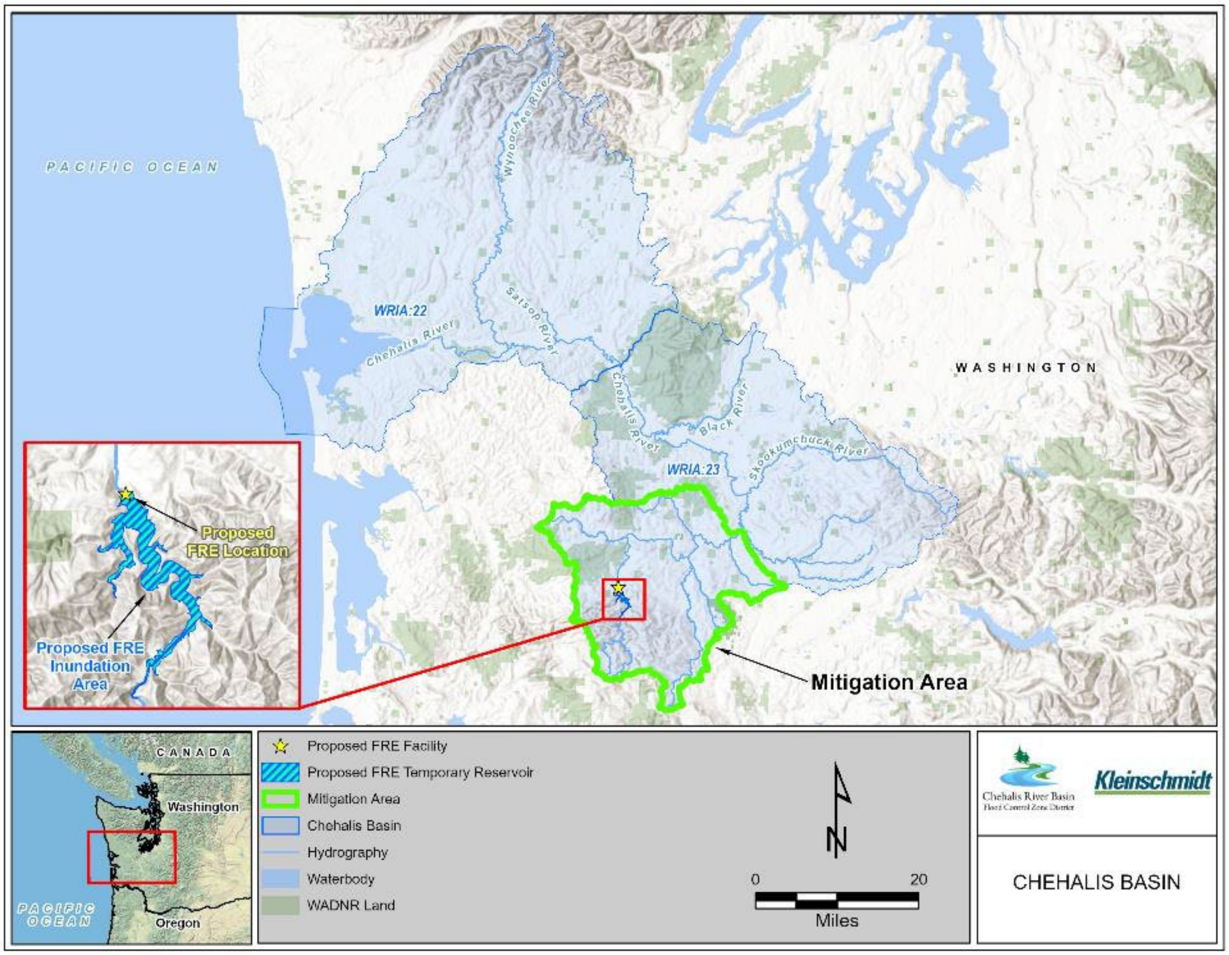
The Proposed Action would be located at RM 108.5, about two miles north of the Town of Pe Ell, and would operate to reduce flood damage and minimize transportation disruption during major floods as described below (Figure 2.1-1). The Proposed Action would not protect communities from all flooding, nor was it designed to prevent regular annual flooding from the Chehalis River. The Proposed Action would reduce flooding originating in the Willapa Hills during major flood events but would not be operated during smaller floods.

The FRE facility would only operate during major floods, when river flows are forecasted to reach 38,800 cubic feet per second (cfs) or greater as measured at the USGS Chehalis River Grand Mound gage (USGS Gage No. 12027500) located at RM 59.9 in Thurston County. Under the current hydrologic regime, floods of this magnitude are projected to have a 15% probability of occurrence in any one year, or a 7-year recurrence interval on average. The facility would be operated to temporarily retain floodwater and then slowly release it following the flood peak. Specific temporary reservoir drawdown operations would depend on inflows and the need to hold water to relieve downstream flooding.

When the FRE facility is not operating, the Chehalis River would flow freely through the structure's low-level outlets at its normal flow rate and volume, and no water would be retained in the temporary reservoir. Thus, when the FRE facility is not operating, sediment transport and fish passage would occur as they do under current conditions.

The preliminary design of the proposed FRE facility, construction, and operations were presented in the engineering design report and supplement (HDR 2017, 2018b) and are summarized below. Once permitted, the FRE facility construction is anticipated to begin in 2025 and would be ready for operation in 2030.

Figure 2.1-1
Study Area for the Chehalis Basin Including Location of the Proposed FRE Facility, and Planned Mitigation Area



2.2 FRE Facility Features

The FRE facility would be constructed along the mainstem Chehalis River at RM 108.5, just downstream from the Crim Creek confluence. The FRE facility would be located in uplands (landward of the OHWM), in-water (waterward of the OHWM), or both and would include a combination of permanent and temporary (i.e., removed after construction) features. The design, construction methods, and operations plans summarized below are subject to updates during future design phases.

2.2.1 Permanent Features

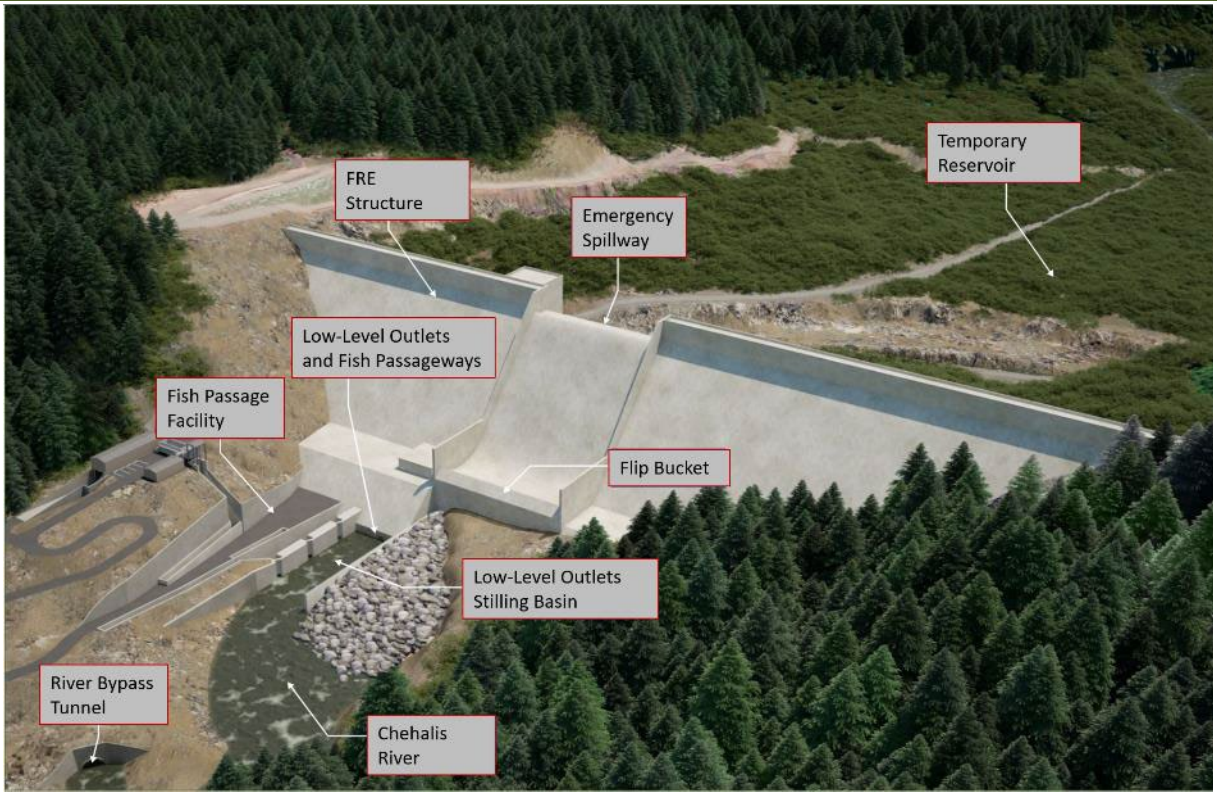
Permanent features of the Proposed Action include the FRE facility; fish collection, handling, transfer, and release (CHTR) facility; aggregate source quarries and access road improvements; and improvements to the Town of Pe Ell water system. These and other permanent features are described below.

2.2.1.1 FRE Facility

The FRE facility (Figure 2.2-1) would be designed to impound water temporarily during major floods. The primary components include the following:

- A roller compacted concrete (RCC) flood retention structure sized for 65,000 acre-feet of flood retention (equivalent flood volume of the December 2007 flood of record) with an estimated maximum structural height of 254 to 270 feet, crest elevation of 651 feet mean sea level (MSL), and a spillway crest elevation of 628 feet.
- An overflow spillway, designed to pass flood flow up to and including the Probable Maximum Flood (PMF), estimated to be 69,800 cfs at the Grand Mound gage (Mauger et al. 2016), without structure overtopping, as required under the Washington State Dam Safety Office guidelines. The spillway includes an uncontrolled crest structure, spillway chute, flip bucket, and plunge pool.
- Five 270-foot long, unlit conduits through the bottom of the structure to convey normal river flow and gates for flood regulation, provide for upstream and downstream fish passage, and allow downstream movement of sediments, and woody material (up to 3 feet in diameter and 15 feet in length).
- Fish passage facilities designed for volitional fish passage upstream and downstream when the FRE facility is not operating, and assisted fish passage during flood retention periods.
- A concrete apron for fuel tank unloading and fuel storage containment areas.

Figure 2.2-1
Proposed FRE Facility Roller-Compacted Concrete Gravity Structure, Measuring 1,550 Feet Long, 270 Feet High. Proposed In-situ Location at Chehalis RM 108.5



Source: Ecology 2021.

2.2.1.2 Fish Collection, Handling, Transfer, and Release Facility

The FRE facility would be designed to allow for upstream and downstream fish passage when the FRE facility is not operating. The FRE facility is anticipated to operate for retention of major flood waters approximately once every 7 years on average under current conditions and every 4-5 years on average under future modeled mid- and late-century conditions (Ecology 2021). During flood retention operation of the FRE facility and subsequent woody debris removal, all but one of the flow outlets would be closed. One outlet would remain partially open to convey minimum instream flows to downstream reaches. At these times, fish passage would be restricted. To prevent upstream passage delays, a CHTR facility would be constructed along the right-bank (looking downstream) adjacent to the conduit stilling basin (HDR 2018b). The facility would collect fish, and operations personnel would transport them to release sites upstream of the FRE facility.

Concepts for the CHTR facility were developed from 2013 through 2017 in collaboration with multi-agency resource specialists from the CBS Fish Passage Technical Subcommittee. The CHTR facility would be designed to pass all life stages of resident, anadromous, and lamprey species that currently occupy the Impact Area.

A half-Ice Harbor-type adult fish ladder was selected for the CHTR facility; in part, because of its ability to accommodate passage of aquatic species with a wide range of swimming and jumping capabilities. The current design features meet National Marine Fisheries Service (NMFS) passage criteria for adult salmonids (NMFS 2011). The juvenile fish ladder would be nearly identical to the adult fish ladder except for minor differences (e.g., no turning pools, only one resting pool entrance, additional pool in the ladder, overall fish ladder slope, and floor slope across each pool) that meet NMFS passage criteria for juvenile salmonids (NMFS 2011). A Bonneville-style steel flume lamprey ramp with resting boxes would be located adjacent to the west wall of the juvenile fish ladder. A gravel area would provide an access path adjacent to the lamprey ramp for its full length.

A fish lift would be located at the upstream end of the ladder and would consist of a trap, hopper, and lift. A vee-trap would be built into the hopper to allow fish to volitionally enter but not exit. The lift system would vertically transport fish approximately 80 feet to a sorting and handling area. The fish lift would carry fish to respective holding tanks with separate water supplies and drainage systems. Each gallery would be equipped with sprinkler systems and a false weir at the upstream side of the structure. Netting would be provided over galleries holding juvenile fish. Both adult and juvenile holding galleries would meet NMFS criteria for holding (NMFS 2011). Fish would be hand-sorted by operators and sent through automatic diverter gates to the appropriate holding tanks, and eventually on to haul trucks for upstream release.

The CHTR facility would require water for operations. Water for some CHTR facility elements would be supplied via gravity flow while others would be pumped. The CHTR facility intake would draw water from the conduit stilling basin through a set of fish screens designed to meet NMFS juvenile screening criteria (NMFS 2011). A prefabricated or concrete masonry unit building would be constructed adjacent to the sorting building to house mechanical and electrical equipment, and provide storage for equipment and materials associated with the CHTR facility.

2.2.1.3 Aggregate Source Quarries and Access Road Improvements

Construction of the FRE facility would require the development of a quarry site to source aggregate materials for concrete production and road base. While only one quarry would be developed to support FRE facility construction, two potential quarry sites (north and south) have been identified. Although the size of the quarry has not yet been defined, for the purposes of this assessment, it was assumed that the selected site would be cleared of vegetation to support up to a 10-acre quarry. In addition, each quarry would require upgrades and widening of existing access roads Forest Road (FR) 1000 and FR 1020 (Pacific Forest Resources, Inc. 2019), resulting in additional vegetation clearing of 6 acres.

2.2.1.4 Improved Construction Access Roads – FRE Facility Site

To the extent possible, the Applicant would minimize disturbance and new impervious surfaces by using existing roads to provide access to and around the construction site. Permanent road improvements would be necessary to provide sufficient load bearing for construction equipment. Access road improvements would likely use quarry spalls and may require ongoing maintenance activities during construction. Designed improvements would require the implementation of applicable measures to minimize erosion and sediment inputs to the river.

2.2.1.5 Long-Term Vehicle Access Around Inundation Area

To the extent possible, the Applicant proposes to use existing roads to provide permanent access around the temporary reservoir; however, a bypass may be required for FR 1000, which is a main access road for Weyerhaeuser forestry operations in the upper basin. Up to 6 miles of FR 1000 would be inundated during peak flood retention, at which time a detour could be used consisting of FR A-line, FR F-line, and FR 2000 to rejoin FR 1000 upstream of the temporary reservoir. Future designs will inform the nature of proposed upgrades and long-term vehicular access.

2.2.1.6 Power/Data Lines

The FRE and CHTR facilities would require an electrical supply during construction and operation for pumps, conduit gates, fish holding tanks, and other equipment. The permanent electrical service would be provided by installation of an overhead or buried distribution power line to the electrical grid. The location of the interconnection and route of the interconnecting distribution line would be determined in coordination with the local power utility. At this time, the Applicant anticipates that overhead or buried lines would be installed along existing roads within 6 months of year 1 of the construction schedule.

2.2.1.7 Debris Management Staging and Storage Areas

Following flood retention events, the temporary reservoir would be drawn down, and accumulated woody debris would be removed. A debris management sorting yard would be constructed with an appropriate surface (e.g., rock or gravel) to allow vehicular access and use following drawdown. Debris management storage and staging areas would support the deployment of boats and barges from existing access roads. Debris would be stockpiled in a log sorting yard located between RMs 109.6 and 109.9.

2.2.1.8 Improvements to the Town of Pe Ell Water System

The primary water source for the Town of Pe Ell is Lester Creek, which flows into Crim Creek just upstream of its confluence with the Chehalis River, and upstream of the proposed FRE facility at approximately RM 108.5 (Ecology 2020). This primary water supply system includes the water intake and reservoir system on Lester Creek, more than 10,000 linear feet of 8-inch water line, a pump station, a treatment facility, and a distribution system. The water line spans the Chehalis River on an existing bridge. During low-flow periods, the town uses the Chehalis River as a secondary (backup) water intake, but its use is limited. The Chehalis River intake is approximately 2,500 feet south of and approximately 180 feet lower in elevation than the water treatment facility.

Based on their location in relation to anticipated construction areas, Pe Ell's water treatment facility and the Lester Creek intake would not be affected by FRE facility construction; however, the water supply pipeline may be affected as approximately 8,000 feet of the pipeline is located within the modeled temporary reservoir area. Therefore, portions of the pipeline may require improvement or relocation. In addition, improved access to the Lester Creek intake is potentially necessary to allow for long-term inspections and maintenance during FRE facility operations, which may inundate the lower portion of Lester Creek and associated access areas. At approximately 640 feet in elevation MSL, the Lester Creek withdrawal point is located upstream of and outside of the maximum flood pool elevation, which would be 620 feet in elevation MSL (based on the 2007 flood). The water treatment facility and pump station would be outside of the area of modeled inundation and are therefore not anticipated to be affected by the Proposed Action.

Although the Applicant acknowledges that improvements to Pe Ell's surface water system (e.g., intake on Lester Creek and the water transmission line) may be necessary to construct and operate the FRE facility, specific improvements have not yet been defined. The Applicant will coordinate with the Town of Pe Ell in future design phases to determine what is required. For the purposes of this assessment, however, the Applicant assumes that improvements to or relocation of the existing water line are part of the Proposed Action.

In addition, for the purposes of this assessment, the Proposed Action includes improvements to or replacement of the Lester Creek intake, improved access to the Lester Creek intake, and possible upgrades at the Chehalis River intake. Designs for any renovation or replacement of existing intake structures would meet current NMFS and WDFW screening criteria for the protection of fish (WDFW 2009).

2.2.2 Temporary Features

Temporary features include structures and storage areas needed for construction. These features will be removed, and habitats will be restored post-construction.

2.2.2.1 Concrete Batch Plant

To produce concrete for construction, a concrete batch plant would be constructed along the right-bank (looking downstream) of the Chehalis River. It would produce both roller compacted concrete and conventional concrete and include the following:

- Roller compacted concrete batch plant,
- Conventional concrete batch plant,
- Aggregate crushing and screening,
- Aggregate storage,
- Fly ash storage,
- Cement storage.

2.2.2.2 Dewatering and Water Management Facilities and Materials

A series of temporary cofferdams would be installed in the river to divert flow around construction areas and to facilitate construction of in-water elements "in the dry." Other dewatering elements include:

- Super Sack®, Ecology block, Aqua bag, or other with Visqueen;
- Temporary dewatering pumps, screens, settling basins or structures (e.g., Baker tanks).

2.2.2.3 Temporary Trap and Transport for Upstream Adult Salmonid Passage

During FRE facility construction, a tunnel would be built to bypass the river around the FRE facility and CHTR facility in-water work areas. This tunnel would provide downstream fish passage during the 32-month FRE facility/CHTR facility in-water construction period; however, due to high estimated velocities in the tunnel, it would not meet standards for upstream fish passage. Therefore, a temporary trap and transport (TTT) facility (HDR 2022, Appendix B) is proposed to provide upstream passage for migratory fishes during construction when the river bypass is operating.

The TTT facility would be installed and begin operation prior to any other in-water work. The TTT facility would consist of a channel-spanning velocity barrier (Ogee crest or similar) with a fish ladder on the right bank that leads to holding ponds/tanks that would be accessed by transport trucks. The TTT would include right- and left-bank abutments; a channel-spanning barrier; and a right-bank ladder with attraction water intake, holding tank, and haul truck approach. Depending on the type of barrier selected, power may be required to operate the facility. The upstream fish passage barrier would be located downstream of the bypass tunnel outlet to direct all the fish passing upstream into a trap. Once in the trap, fish would be transferred to transport tanks. Personnel would drive the tanks upstream to predetermined release sites selected in coordination with U.S. Fish and Wildlife Service (USFWS), NMFS, and WDFW. Individual fish would be released into the river to continue their migration upstream. Once construction is complete and the FRE facility begins normal run-of-river operation, the TTT, or portions thereof, would be removed.

The intake for the TTT facility would conform to the most current NMFS and WDFW fish passage (NMFS 2011) and screening design (WDFW 2009) guidelines and criteria. At this time, the Applicant proposes targeted upstream passage for anadromous and resident species known to occur in the Impact Area and areas upstream of the temporary reservoir. This includes adult and juvenile spring-run and fall-run Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), winter steelhead (*O. mykiss*), cutthroat trout (*O. clarkii*), adult Pacific lamprey (*Entosphenus tridentatus*), and Western brook lamprey (*Lampetra richardsoni*), and 14 resident fish species (Ecology 2021). Juvenile salmonids, resident fish, and lamprey that are captured and collected would be transported upstream of the construction area and released into the Chehalis River. The TTT operational period would be the same as that of the bypass tunnel.

2.2.2.4 River Diversion Bypass Tunnel

A bypass tunnel would be excavated via blasting in uplands along the right-bank of the Chehalis River to provide a river bypass during construction of the FRE facility. Based on the estimated peak flow rates that would be likely to occur during the 32-month in-water construction period and the height of proposed upstream cofferdams to direct water into the tunnel, the bypass tunnel would be designed to accommodate approximately 7,000 cfs, which corresponds to an approximately 2.8-year recurrence flow event. The tunnel would provide downstream fish passage for all fish for the duration of FRE facility construction. The tunnel would be constructed to meet NMFS passage guidelines (NMFS 2011), including velocity and slope criteria, and would be removed when flows are returned to the river channel post-construction.

2.2.2.5 Temporary Construction Access Roads

To the extent possible, the Applicant proposes to use existing roads to provide temporary access to and around the construction site. Approximately 9,100 linear feet of gravel temporary roads would be developed within the active construction site for construction access. Temporary construction roads would provide access for various planned work activities, equipment and material storage, and construction administration. Temporary roads would also provide access to and from the selected quarry site to material processing and production areas. Currently, the Applicant proposes to decommission all temporary roads in the active construction site following construction, and to restore habitats to preconstruction condition.

2.2.2.6 Staging Areas

Six primary staging areas would be established near the construction site and would include construction offices, areas for material processing and storage, parking for construction vehicles, and fuel storage and containment. Material excavated from the FRE facility structure footprint and abutments would be permanently relocated, stabilized, and revegetated at site mobilization and staging activity areas. Staging and construction laydown areas would be prepared with appropriate site grading, surfacing, and drainage provisions that allow for construction equipment and materials to be stored, secured, and utilized.

2.3 FRE Facility Construction

Construction of all FRE facility infrastructure would be completed in approximately 4.5 years and would begin as early as spring 2025. The FRE facility engineering design report and supplement (HDR 2018a, 2018b) contain conceptual design drawings including details of all proposed facilities.

2.3.1 Access, Mobilization, and Staging

Trips to and from the FRE facility site from regional locations where materials are sourced have not been directly evaluated. No new access roads would be required, as all construction related vehicular trips would use existing roadways where construction related vehicular use would become indistinguishable from background levels of traffic.

Access to the FRE facility construction site would be provided from Muller Road and FR 1000. The Applicant anticipates that construction workers would park off-site in existing lots and be shuttled to the construction area to limit construction-related traffic and vehicles. A rough range of two-axle truck off-site round trips would be between 100,000 and 180,000 loads, and three-axle or larger off-site truck round trips would be between 16,000 and 26,000 loads over the 4.5-year duration of construction activities. Based on this information, between 10 and 40 truck trips are expected for a typical workday. During FRE facility construction, vehicles would access the left bank atop both the upstream and downstream RCC cofferdam structures. The existing right-bank upstream access roadway is at elevation 465 feet and would connect to the upstream RCC cofferdam at the same elevation.

2.3.2 Construction Equipment

Construction equipment would include the following, to be refined during final design of the FRE facility:

- Bulldozers, excavators, front-end-loaders, off-road fixed wheel and articulated haul-trucks, integrated tool carriers, and rollers;
- Cranes ranging up to 250 tons or larger;
- Quarry and FRE facility project site material processing equipment including pneumatic drills, blasting product transfer and storage, concrete production equipment, generators, utility buildings, electrical control, and large vehicles;
- Support equipment (trucks, water trucks, vacuum trucks, boom trucks, vans), shipping containers, and temporary buildings.

2.3.3 Site Clearing

Site preparation for upland construction would require establishing erosion and sedimentation control measures and clearing and grubbing. Approximately 23 acres of mixed coniferous/deciduous upland forest vegetation of varying sizes and age classes would be cleared for construction and for staging. Approximately 6.5 acres of vegetation within this cleared area would be occupied by the FRE facility's footprint (structures, access roads, and other features required for operations), and the vegetation would be permanently lost. The Applicant would restore and revegetate all areas cleared for construction staging and access that are not part of the permanent facility footprint. Plants selected for revegetation would be flood tolerant.

2.3.4 Pre-operations Vegetation Management

The Applicant has prepared a draft Vegetation Management Plan (VMP) (HDR 2021a, Appendix C) to guide selective removal of flood intolerant vegetation and replanting of more flood tolerant trees and shrubs in the temporary reservoir including pre- and post-construction. A primary objective of the VMP is to minimize the extent of tree clearing and vegetation removal in the temporary reservoir, while balancing the need to reduce the amount of woody material that would be generated within the area during a major flood that triggers FRE facility operation.

The temporary reservoir was modeled to determine the water surface elevation (WSEL) of the temporary reservoir at various floods and the duration of time that the area would be inundated (HDR 2020). The inundation analysis described three discrete phases of temporary reservoir drawdown, or evacuation which are currently being assessed in the VMP to define selective tree harvest and vegetation removal strategies (Figure 2.3-1):

- Final Reservoir Evacuation Area,
- Debris Management Evacuation Area,
- Initial Reservoir Evacuation Area.

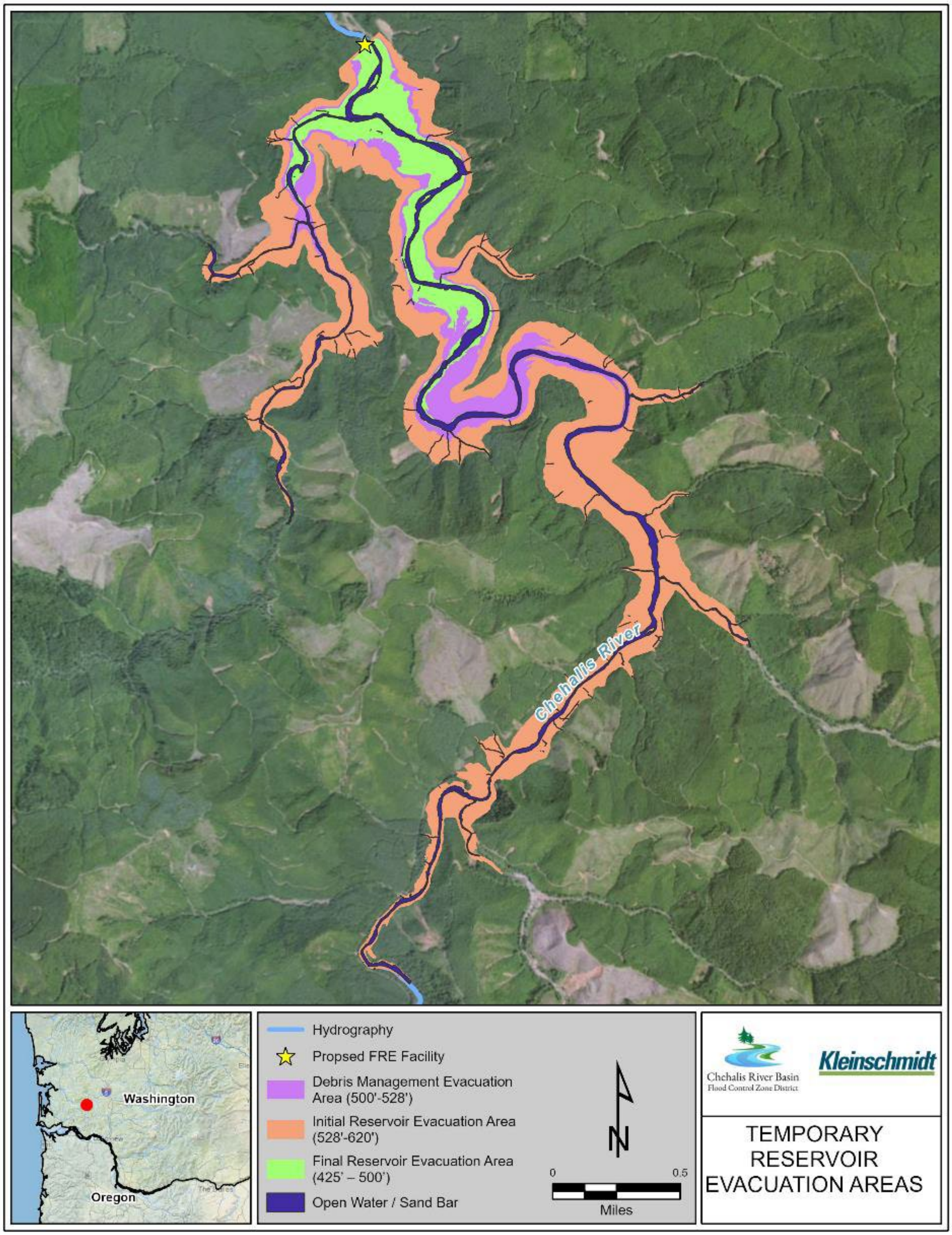
It is anticipated that tree and shrub species within the temporary reservoir will perish at varying rates depending on the projected inundation depths, duration of inundation, and flood tolerance of the species. The expected volume and duration of the flood pool within each evacuation zone are presented in Table 2.3-1. The following sections describe the selective removal and in-planting that would occur by reservoir evacuation area.

Table 2.3-1
Expected Volume and Duration of the Flood Pool at Each Reservoir Evacuation Area

EVACUATION AREA	WATER SURFACE ELEVATION (FEET MSL)	AREA OF FLOOD POOL (ACRES)	DURATION OF FLOOD POOL (DAYS)
Initial Reservoir Evacuation Area[1]	528-620[1]	238-527[1]	6-11[1]
Debris Management Evacuation Area	500-528	122	20-25
Final Reservoir Evacuation Area	425-500	159	26-32

Notes:
1. The area and duration of inundation in the Initial Reservoir Evacuation Area depend on the magnitude of a storm event. The 2007 flood event, a catastrophic flood with a <1% chance of occurrence on average, corresponds to a water surface elevation of 620 feet MSL, and a 527-acre flood pool that would be inundated up to 11 days.

Figure 2.3-1
FRE Reservoir Evacuation Areas



2.3.4.1 Initial Reservoir Evacuation Area

The Initial Reservoir Evacuation Area is not slated for pre-construction logging. This portion of the temporary reservoir would be inventoried and monitored following construction. Tree retention is proposed to help limit temporal effects on shading and river temperature associated with the tree removal in the Initial Reservoir Evacuation Area.

Twenty percent of the proposed selective tree harvest would occur each construction year over the 5-year construction period. Species harvestable for commercial timber may be removed for this purpose. Selective tree harvest would be sequenced such that trees within the Riparian Management Zones of the Chehalis River and its tributaries are harvested last. Appropriate flood tolerant trees would be replanted each year during construction to replace the trees selectively harvested. Monitoring would be conducted throughout the temporary reservoir to document pre-construction riparian function, wetland management zone conditions, and upland habitat conditions as they pertain to vegetation community composition.

2.3.4.2 Debris Management Evacuation Area

The Debris Management Evacuation Area also is expected to require logging of affected trees, but some of the existing vegetation is expected to survive and be retained. Tree species that are expected to be intolerant of flooding, such as Douglas fir, would be removed as they perish following flood retention operations and replaced with more flood-tolerant species. In-planting flood-tolerant trees and shrubs would occur in 105 acres of this evacuation area at the start of construction and prior to logging which would also assist in the establishment of flood-tolerant species and those that may require some shade during establishment, such as Western red cedar. This area would also include the establishment of a debris management sorting yard that would intercept and stockpile woody debris that may be transported into the temporary reservoir during a flood event. The woody debris that is stockpiled may be used for mitigation actions associated with the overall Proposed Action. Selective replacement of overstory near the river would help moderate the temporal effect on stream shading and river temperature associated with tree removal in the Debris Management Evacuation Area.

2.3.4.3 Final Reservoir Evacuation Area

The vegetation within the Final Reservoir Evacuation Area would be most affected by the operation of the proposed FRE facility. This area would be flooded most frequently and for a longer duration than the other evacuation areas. One goal of vegetation removal within the temporary reservoir is to reduce the potential for debris and vegetation to damage the new facility and to reduce the safety risk for operations personnel. Full removal of large trees near the facility or trees that have been determined to pose a threat to the safe operation of the facility would occur to achieve this goal. Once the large trees have been removed, appropriate flood-tolerant vegetation would be planted within 115 acres of the Final Reservoir Evacuation Area. The approach would be to aggressively plant the riparian portions of this area with highly flood-tolerant species of woody plants (mostly willow species).

The remaining acres within the Final Reservoir Evacuation Area would be initially in-planted and converted over time to species that are more tolerant of flooding than the existing vegetation. Shrub and organic material will be retained in this area to provide soil stabilization during the overstory conversion. Large woody material removed from this area would be harvested in a manner that is conducive for reuse of the material in habitat restoration or enhancement efforts associated with the overall Proposed Action.

2.3.5 Quarry Site Preparation and Blasting

Site preparation for quarry site development at either of the two sites under consideration would require site clearing, excavation, and blasting to mine aggregate rocks, and development of temporary access roads and staging areas. Quarry blasting is expected to continue for up to 3 years of the total construction period and would occur one to four times per week, up to several times per day, during active development of the quarries.

2.3.6 Slope Stabilization

In addition to implementing the VMP and best management practices (BMPs), additional stabilization of steep slopes in the temporary inundation area may include the introduction of horizontal drainage into vulnerable slopes or the placement of berms at the toes of steep slopes.

2.3.7 Source Water for Concrete Mixing and Other Construction

During construction, water would be required for a variety of objectives, including on-site concrete mixing, dust suppression, and truck wash-downs. The quantity of required water would vary depending upon the nature of construction-related activities but could average 100 to 750 gallons per minute (gpm) for non-concrete mixing uses. During aggregate and RCC production to construct the FRE facility, a constant supply of 200 to 400 gpm (approximately 0.44 to 0.89 cfs) would be required for up to 32 months of construction. Such water may be provided from multiple sources, including water delivery trucks or a temporary well for construction. Any water withdrawn from a temporary diversion structure would be screened with screens meeting NMFS and WDFW criteria for fish protection (WDFW 2009).

2.3.8 Site Dewatering

The FRE facility in-water construction area would occupy 5.82 acres of habitat within the OHWM, including adjacent areas isolated by cofferdams (Corps 2020). Construction of all facilities within the river channel would take place in dewatered conditions. Dewatering the river channel would be accomplished by installing a series of cofferdams and construction of a bypass tunnel.

Most in-water work directly related to construction of the FRE facility and CHTR facility would occur over a period of approximately 32 months. During this 32-month period, the river would be diverted into a bypass tunnel and around the work site. Prior to the 32-month river bypass period, two consecutive in-water work windows would be required to construct the bypass tunnel, the TTT, and the RCC cofferdams. Preparatory phases of in-water work in Years 1 and 2 have been proposed to occur from

July–September to minimize the footprint of dewatering facilities, minimize the impact to the river, and reduce the risk of flooding dewatered areas. Following this 32-month period, one additional July 1–September 30 in-water work period would be required to complete the project and remove the RCC cofferdams. In total, FRE facility construction below the OHWM would require approximately 4.5 years based on the proposed sequencing.

The construction contractor would be required to submit dewatering plans to the Applicant a minimum of 60 days prior to in-water work, and 30 days to agencies for regulatory review to ensure consistency with existing environmental authorizations.

2.3.9 Aquatic Species Salvage

Fish, and potentially other aquatic species of concern, such as amphibians and mussels, would be present in the Chehalis River during all phases of in-water construction. The Applicant would coordinate with WDFW during future permitting phases to develop fish and aquatic species salvage plans for each stage of in-water work. Salvage would be accomplished by experienced biologists using a combination of netting, electrofishing, and progressive pumping down of the water level. Fish salvage would be conducted in accordance with fish exclusion protocols developed by Washington State Department of Transportation (WSDOT 2016). Electroshocking would occur in accordance with NMFS electrofishing guidelines (NMFS 2000).

2.3.10 Pile Driving: FRE Facility Foundation and TTT Support

Impact pile drivers may be used to provide temporary excavation support within the FRE facility construction area, including the area isolated for the TTT. At the current stage of design, the number and size of piles that may be required is unknown, and the duration of pile driving is also unknown. All impact-driven piles, if required, would be installed “in the dry” behind isolation cofferdams.

2.3.11 In-Channel and Near-Channel Blasting

In-channel or near-channel blasting would be required for preparation of the FRE facility structure foundation (waterward of OHWM) and diversion bypass tunnel excavation (adjacent to natural OHWM, in uplands). Blasting for tunnel construction would occur once or twice per day over a period of approximately 9 months with almost all blasting occurring in the interior of the tunnel. Blasting for preparation of the FRE facility structure foundation would occur as often as four times per week over approximately 12 months.

2.4 Operations and Maintenance Phase

During non-flood retention periods, the FRE facility would function as a run-of-river facility, where all five conduits would be continuously held open allowing unregulated flows through the facility. During these periods, most of the natural hydrologic, geomorphic, and hydraulic stream processes would be maintained. Water and sediment are expected to freely pass through the FRE facility, upstream and downstream fish passage would be provided via the conduits, and woody material up to 3 feet in diameter and 15 feet in length would pass through the conduits to be transported downstream.

During typical seasonal flow (e.g., 2-year flood of 3,000–6,000 cfs) and flows up to 12,500 cfs (approximately a 10-year event) at the FRE facility, water would pass through the low-level conduits without surcharging (i.e., backwatering/ponding upstream). The FRE facility would operate when flood forecasts predict a major or greater flood. The FRE facility conduit gates would begin to close and start retaining water approximately 48 hours before flows at the Grand Mound gage were predicted to exceed 38,800 cfs. Once conduit gates begin to close, flows through the conduit gates would be reduced to a flow of 300 cfs. A 300-cfs flow is a naturally occurring winter low flow on the Chehalis River. The outflow rate would be adjusted based on observed flows and revised predictions. The FRE facility would be operated to keep river outflow at a reduced rate until the peak flood passes the Grand Mound gage.

FRE facility operation would cause the temporary reservoir to fill. The extent of the flood pool depends on the peak of the flood flow and its duration; the maximum extent would be 808 acres for a >100-year flood and would have a maximum depth of 212 feet (measured at conduit invert elevation of 408 feet MSL). Peak flood flows for major or greater floods are predicted to last about 2 to 3 days. Once the peak flood flow has passed, a three-stage reservoir evacuation operation would be implemented. The duration of temporary reservoir evacuation would depend on the magnitude of the flood and the volume of the flood pool. For catastrophic floods of 75,100 cfs or greater, it is estimated that inundation would last approximately 32 days total from the closing of conduit gates through final reservoir evacuation.

2.4.1 Fish Passage

Across the range of normal flows and smaller flood conditions, fish would pass both upstream and downstream through the five conduits in the FRE facility concrete. The conduits would be designed to mimic current passage conditions through the 450-foot-long bedrock canyon through which the Chehalis River flows at the proposed FRE facility location. Depending on river flows, conduit gates would be operated to maintain optimum fish passage conditions. Most of the time, when no retention is occurring, aquatic species passing upstream would be able to move from the river, into the stilling basin, through the conduits, and back into the river upstream of the FRE structure. Fish passing downstream would follow the same path in the opposite direction. The FRE facility conduits would be designed to provide year-round, volitional upstream and downstream passage for migrating adult salmon and steelhead, resident fish, and lamprey for the full range of flow conditions up through the high fish passage design flow as required by NMFS criteria (NMFS 2011). During low-flow periods, the conduits would be managed to concentrate flow through one or more conduits to meet minimum design passage requirements.

2.4.1.1 CHTR Facility Upstream Fish Passage During FRE Facility Operations

During major floods that trigger FRE facility operation, the conduits would be closed except for the largest conduit, which would remain partially open to convey minimum instream flows (300 cfs) downstream. During these periods, upstream fish passage would be provided by the CHTR facility. The CHTR facility would collect migrating adult salmon and steelhead, juvenile salmon and steelhead, resident fish, and lamprey moving upstream during an impoundment event and safely transport them upstream of the FRE facility structure. Attraction water would draw fish passing upstream from the river into the conduit stilling basin, and into the fish ladders. Water supplied to the fish ladders and lamprey ramp would attract fish and lamprey to the traps. The conceptual designs for the juvenile/resident fish ladder and lamprey ramp are based on the best available science, including studies published as recently as 2018 (HDR 2018a). Once trapped, fish would be sorted or passed into transport tanks and moved upstream of the FRE facility structure. The upstream release sites will be determined during future design or construction phases.

Although adult salmon and steelhead only pass upstream during certain periods of the year, the CHTR facility would be capable of operating at any time of year to accommodate resident fish, lamprey, juvenile salmon, and steelhead that currently traverse this reach of the Chehalis River and volitionally move upstream. Based on an evaluation of historic monthly flows at the Grand Ronde stream gage, floods that would have triggered FRE facility operation occurred primarily from November through February. The months of December through February have the highest probability of FRE facility operation, and subsequent CHTR facility operation.

The CHTR facility would begin operations as soon as the FRE facility conduit gates begin closing and would continue to operate until the temporary inundation pool is emptied and run-of-river operations resume. At the beginning of CHTR facility operations, river flow through the conduits would be well above the high fish passage design flow (2,200 cfs; see HDR 2018b). Although NMFS and WDFW guidelines do not require that fish passage be provided during these periods (i.e., conduit passage at flows above the high fish passage design flow), the CHTR facility would operate during this period to provide upstream passage. Operation of the CHTR facility would continue through impoundment of flood water behind the FRE facility structure, as the temporary inundation pool is evacuated, as release from the temporary inundation area is slowed for debris management, and as the last remaining water is released. This process may last several weeks.

Once the temporary inundation pool is evacuated and the FRE facility structure would return to normal run-of-river operation through the conduits, the CHTR facility would be shut down. As part of the shutdown of the CHTR facility, any remaining fish would be safely removed and returned to the river, the fish ladder entrance gates would be closed, and the water supply turned off. The CHTR facility would be cleaned, prepared for the coming extended dormant period, and secured.

2.4.2 Downstream Fish Passage During FRE Facility Operations

Downstream passage of out-migrating fish would be delayed during flood water storage events coincident with FRE facility operations. During FRE facility operation and impoundment, the conduit gates would be nearly closed (allowing only 300 cfs to pass at all times) and water would be retained upstream of the FRE facility structure. Subsequently, any out-migrating fish entering the impoundment at this time would be temporarily detained in the temporary reservoir unless, in an unlikely scenario, they were able to locate the semi-opened conduits gates at depth. Downstream fish passage would become available through the FRE facility conduits as flood retention operations cease and the temporary reservoir drawdown is initiated.

2.4.3 Temporary Reservoir Evacuation

During FRE facility operations and resultant creation of a temporary reservoir, release rates would be maintained at 300 cfs until unregulated flow at the Grand Mound gage is less than 38,800 cfs. After flood flows decrease, the FRE facility temporary reservoir would be evacuated over a period of up to 32 days, depending on the volume of water stored. To empty the pool, the conduit gates would be opened, and outflow increased from 300 cfs to approximately 6,000 cfs for a very large flood. Inundation pool drawdown rates during the release of stored water would be limited to 10 feet per day (5 inches per hour) from the maximum pool elevation down to WSEL 528 feet.

When the temporary reservoir is drawn down to WSEL 528 feet, the drawdown rate would decrease to 2 feet per day to accommodate debris handling activities in the temporary reservoir. Reduction in the drawdown rate during this period would cause a corresponding reduction in outflow. Debris management operations would occur for approximately 2 weeks. Following debris management, and when the temporary reservoir has reached WSEL 500 feet, drawdown rates would increase again to 10 feet per day (2 to 5 inches per hour) until the temporary reservoir is emptied. The temporary reservoir would be empty at an elevation of 425 feet, at which time the conduit gates would be completely opened, and the Chehalis River would return to a free-flowing state (Anchor QEA 2017).

2.4.4 Post-Flood Retention Sediment Transport

Following a flood-retention event, any sediment that had deposited within the conduits prior to gate closure would be swept through the conduits and deposited in the stilling basin or downstream in the natural channel.

2.4.5 Large Woody Material Management

Wood and vegetation debris from surrounding tributaries and hillslopes would be transported into the temporary reservoir during major floods. Following initial drawdown (10 feet per day), the drawdown rate would slow to 2 feet per day when the temporary reservoir level reaches WSEL 528 feet. Boats would be used to remove floating debris to a designated sorting yard on the west bank between RMs 109.6 and 109.9 that is accessible from existing roads for reuse in downstream habitat enhancement projects.

Debris would be cut up and disposed of, and wood suitable for instream mitigation actions would be sorted and trucked out of the temporary reservoir area. The removal of stockpiled material would occur after the temporary reservoir is drained and once the ground dries out enough to allow heavy equipment onto the sorting yard. Debris management would end when the water surface elevation of the temporary inundation area falls to WSEL 500 feet, which is the ground elevation at the sorting yard.

2.4.6 Post-Construction Vegetation Management

The Applicant has developed a draft VMP that includes monitoring vegetation within the temporary reservoir for significant stress and mortality following a major flood event (Appendix C). Flood stress in plants can cause yellowing or browning of leaves, curled leaves, leaf wilt and drop, reduced size of new leaves, early fall color, branch dieback, formation of sprouts along stems or trunk, and greater susceptibility to harmful organisms such as canker fungi and insects (Jull 2008). There is uncertainty in predicting an elevation at which trees may be severely stressed or killed once the FRE facility is activated during major floods. The uncertainty is due in part to both the unpredictable nature of floods and the difficulty in predicting how individual trees would respond to various levels and duration of inundation.

Trees in the FRE facility temporary reservoir would be monitored by a forester or other approved professional annually and after periods of prolonged inundation for signs of flood stress. Unhealthy and dead trees would be marked and removed on an as-needed basis to eliminate potential risks to dam operations personnel and facility infrastructure. Trees that would need to be removed would be either cut and removed from the site, topped and retained as a snag, cut and retained on-site as downed large woody material, or removed and utilized as material for other mitigation projects for the Proposed Action. These areas would be planted with an appropriate array of native flood-tolerant species to maintain the desired tree canopy cover. On-going monitoring efforts would be conducted to evaluate the establishment of tree and shrub species in planted areas (i.e., Debris Management Evacuation and Final Reservoir Evacuation areas) and would include surveys for noxious and invasive plant species. If noxious or invasive plant species are found, they would be monitored, removed, or flagged for further action as appropriate based on the species and class-specific measures for removal or containment. Areas would continue to be replanted with appropriate native flood-tolerant species until the desired canopy cover is achieved.

3 EXISTING BASELINE CONDITIONS

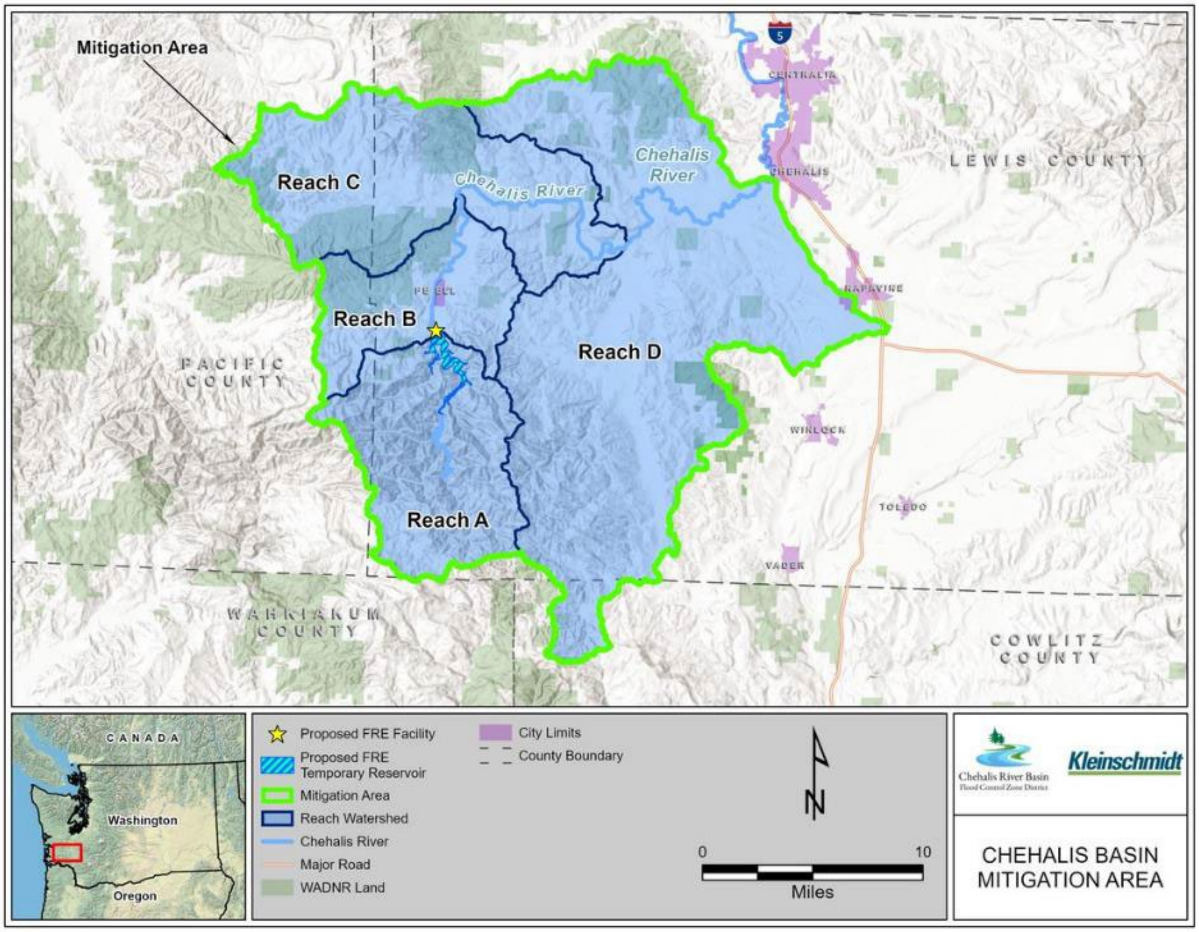
3.1 Proposed Mitigation Area

The Chehalis River is the second largest river system in Washington State with 125 mainstem river miles and a drainage area of 2,700 square miles. It originates at the confluence of the West Fork Chehalis River and East Fork Chehalis River, in southwestern Lewis County, flows east, then north, then west, in a large curve, before emptying into Grays Harbor, an estuary of the Pacific Ocean. The Chehalis Basin includes more than 3,300 miles of rivers and streams that drain the Willapa Hills, and foothills of the Cascade and Olympic mountains. The Chehalis Basin is divided for management purposes into Watershed Resource Inventory Areas (WRIAs) 23 (upper Chehalis) and 22 (lower Chehalis) (Figure 3.1-1). The upper Chehalis (WRIA 23) drains 1,294 square miles and includes the upper reaches of the Chehalis River and four major tributaries: South Fork Chehalis (RM 88.1), Newaukum (RM 75.2), Skookumchuck (RM 67.0) and Black (RM 47.0) rivers.

Based on the SEPA/NEPA-DEIS, the Impact Area from the Proposed Action includes the temporary reservoir upstream of the FRE facility (RM 108.5) and the mainstem Chehalis River 20 miles downstream of the FRE facility to the South Fork Chehalis River confluence at RM 88.1. To mitigate for unavoidable impacts, the Applicant expanded the area under consideration for implementation of mitigation actions (i.e., Mitigation Area) to the upper reaches of WRIA 23 from the Willapa Hills headwaters downstream to the Newaukum River (RM 75.2) including tributary drainages. To evaluate these estimated effects and develop a feasible and specific plan to mitigate them, the Applicant completed a technical review of the Existing Baseline Conditions in the estimated Mitigation Area related to aquatic and terrestrial habitat and species (Appendix A1). Data was compiled from numerous reports by WDFW, Ecology, Corps, NOAA, USGS, Anchor QEA, Kleinschmidt Associates, and HDR Engineering, as well as peer reviewed literature and regional white papers.

The Existing Baseline Conditions Assessment in Appendix A1 provides a comprehensive description of the upper Chehalis River including physical environment and current status of aquatic and terrestrial species and their habitats, and identifies factors currently limiting aquatic and terrestrial species. Changes to the current status of aquatic and terrestrial habitats and species associated with climate change were also considered during this analysis. This assessment provided the basis for evaluation of site-specific mitigation opportunities that could feasibly be implemented to provide functional lift and species benefits that outweigh estimated effects of the Proposed Action. The following sections summarize results of the assessment including species presence, limiting factor analysis, and potential Future Conditions based on climate change modeling.

Figure 3.1-1
Chehalis River Basin Including Location of the Proposed Action and Mitigation Reaches Both Downstream and Upstream of the FRE Facility



3.1.1 Mitigation Area Reaches

To structure an approach to mitigation, four sub-watersheds or reaches were designated in the Mitigation Area based on the extent of potential effects of the Proposed Action both upstream and downstream of the FRE facility, river geomorphology, and the location and extent of mitigation opportunities. The mitigation reaches are described in Table 3.1-1 and displayed in Figure 3.1-1.

Table 3.1-1
Description of Chehalis Mitigation Area Reaches A Through D

REACH	REACH DESIGNATION	STREAM LENGTH (RM)	CATCHMENT SIZE (MI^2)
A	Mainstem Chehalis River and Tributaries upstream of the FRE Structure (RM 108.5)	11.5 mainstem 157.5 tributary	76.2
B	Tributaries and mainstem Chehalis River from the FRE facility (RM 108.5) to Elk Creek confluence (RM 100.2)	8.7 mainstem 98.6 tributary	57.1
C	Tributaries and mainstem Chehalis River from Elk Creek (RM 100.2) to South Fork Chehalis River (RM 88.1)	12.6 mainstem 223.2 tributary	100.5
D	Tributaries and mainstem Chehalis River from South Fork Chehalis River (RM 88.1) to the Newaukum River (RM 75.2)	13.5 mainstem 517.5 tributary	215.8

3.1.2 Land Use

The predominant land uses in the upper Chehalis River Basin are forestry and agriculture with some urbanization in the low-gradient valley reaches. The Chehalis River floodplain has been heavily influenced and degraded by these land uses. Historic and current land use practices have contributed to existing conditions of channel incision and loss of floodplain storage. Under current conditions, agriculture, including livestock grazing and farming, dominates land use and occurs within 41% of the total floodplain area. Timber production and recreational land uses follow closely behind agriculture, occurring within 39% of the floodplain, while 11.5% is in urban development. Land use in the floodplain has resulted in a paucity of wood and riparian vegetation, making the river's edge susceptible to erosion, and allowing the water to be warmed by direct sunlight, both of which reduce aquatic habitat quality.

Mitigation Reach A is managed for timber harvest. Various access roads exist along the streams, including FR 1000 that runs along the right bank of the mainstem and on the hillslopes, with bridges spanning inflowing tributaries. Existing conditions in Reach A have been impacted by historic timber practices resulting in even-aged stands that are dominated by Douglas fir in various stages of growth and density. Most of the habitat in the area around the FRE facility and temporary reservoir is privately-owned evergreen forest that has been managed for many decades. The forests are typically even-aged stands of trees, usually ranging from less than 10 years to more than 60 years old. In general, timber practices in the commercially managed portions of the Proposed Action area operate on a 50-year harvest cycle.

In developing the VMP, the Applicant mapped the land cover types within the proposed FRE temporary reservoir. Table 3.1-2 below summarizes land cover classifications, typical vegetation in each cover classification, and distinct characteristics that were used to map identified land cover types. Additional information regarding the land cover classifications can be found in Appendix A of the VMP (Appendix C of this FRE HMP).

Table 3.1-2

Land Cover Classifications, Typical Vegetation Cover by Classification, and Distinct Characteristics of Land Cover Types Within the FRE Temporary Reservoir

LAND COVER CLASSIFICATION	COVER IN FRE/TEMPORARY RESERVOIR (%)	TYPICAL VEGETATION	DISTINCT CHARACTERISTICS
Wetlands	1%	See Anchor QEA (Anchor QEA 2018)	Wetlands delineated by Anchor QEA (Anchor QEA 2018).
Open Water/Sand Bar	10%	Unvegetated	Mapped aquatic features
Terrestrial Bare Ground/Roads	4%	Unvegetated	Lack of vegetation over multiple growing seasons; often associated with wide logging roads and equipment staging areas.
Herbaceous/Grass	1%	Reed canarygrass (*Phalaris arundinacea*), colonial bentgrass (*Agrostis capillaris*), sword fern (*Polystichum munitum*), western lady fern (*Athyrium angustum*), piggyback plant (*Tolmiea menziesii*), creeping buttercup (*Ranunculus repens*)	Grasses and forbs present during growing season; often found adjacent to wetlands, riparian corridors, and recently disturbed areas.
Deciduous Riparian Shrubland	<1%	Various willows (*Salix* spp.), young red alder (*Alnus rubra*), red-osier dogwood (*Cornus alba*), vine maple (*Acer circinatum*), Indian plum (*Oemleria cerasiformis*), thimbleberry (*Rubus parviflorus*), salmonberry (*Rubus spectabilis*)	Dominated by deciduous shrub/saplings less than 6 meters (20 feet) tall (>75% cover).
Deciduous Riparian Forest with Some Conifers	17%	Red alder, Western red cedar (*Thuja plicata*), Western hemlock (*Tsuga heterophylla*), black cottonwood (*Populus balsamifera*), cascara (*Frangula purshiana*), willows, big leaf maple (*Acer macrophyllum*), red elderberry (*Sambucus racemosa*), snowberry (*Symphoricarpos albus*)	Dominated by deciduous tree species 6 meters (20 feet) tall or taller (>75% cover).
Mixed Coniferous/Deciduous Transitional Forest	29%	Douglas fir (*Pseudotsuga menziesii*), red alder, big leaf maple	Approximately equal distribution of deciduous and coniferous species (not clearly dominated by one or the other).
Coniferous Forest	28%	Douglas fir	Dominated by coniferous species (>75% cover).

Land use in the floodplain of Reaches B through D becomes more progressively composed of agriculture and rural development. Much of the riparian corridor consists of patches of forested riparian habitat or narrow strips of cottonwood/willow habitat. The lack of wood and riparian vegetation makes the river bank susceptible to erosion and allows the water to be warmed by more direct sunlight, both of which reduce aquatic habitat quality. NOAA developed a process-based analysis for quantifying historical, current, and future habitat conditions (Beechie et al. 2021) in the Chehalis River Basin to support the Aquatic Species Restoration Plan (ASRP). As described in Appendix A2, the Applicant reviewed the riparian shade analysis to identify opportunities for riparian enhancement mitigation in Mitigation Reaches B through D and prioritize stream reaches where the riparian canopy has undergone considerable change.

In addition to impaired aquatic habitat quality, there are numerous man-made (e.g., culverts, dams, and fishways) fish passage barriers that limit access to potential spawning and rearing habitat. A total of 252 non-WSDOT culverts and other barriers to salmonid fish habitat have been identified in the Mitigation Area (WDFW 2022b). Of these, 228 barriers have been assessed and prioritized by WDFW using the Fish Passage Inventory, Assessment, and Prioritization Manual (WDFW 2019d), which includes survey of physical habitat characteristics above and below the barrier, condition of riparian vegetation, potential quantity of fish habitat available for reconnection, water quality metrics, completeness of barrier, and landowner data. A complete index of barriers in the Mitigation Area including information on the above metrics and location of barriers is presented in Appendix A1, Attachment 1.

3.1.3 Hydrology

The Chehalis Basin has a maritime climate characterized by cool, wet winters and warm, dry summers (Gendaszek 2011). Average annual precipitation varies from 46 to 50 inches in the low-lying valleys near Centralia and Chehalis, to 140 inches in the Willapa Hills, and more than 200 inches in the Olympic Mountains (Gendaszek 2011; WSE 2014). Most of the Chehalis Basin, including the Mitigation Area, is rain-dominated (79%), while only limited portions are snow dominated (Perry et al. 2016).

Over the past decades the Chehalis Basin has experienced both extreme flooding as well as drought, both of which impact physical characteristics of aquatic habitat and water quality. Flooding is associated with winter (November-March) precipitation events known as atmospheric rivers (ARs) that produce high rates of rainfall in the upper Chehalis Basin (Neiman et al. 2011). In contrast, summer months experience low rainfall or drought.

3.1.4 Sediment Transport

Reach A is considered a transport reach, meaning that instream sediment is mobile and is transported downstream, while Reaches C and D are deposition reaches (CBS 2017). During significant floods, large substrate (cobble) input originating in the headwaters and upper tributaries has been transported as far downstream as approximately RM 80, while gravel from the same source has been transported as far downstream as RM 73. Sediment sources include landslides, bank erosion, and inflow from tributaries during high flow events. The frequency of landslides has increased since the beginning of timber harvest in the upper Chehalis Basin. A USGS desktop study of bedload and suspended load indicated that inputs from the upper watershed (i.e., Reach A) occurred mostly during catastrophic floods and that most transported sediment originating from Reaches B, C, and D came from bank erosion and channel migration occurring in the reaches (CBS 2017). The immense volume of rain that fell in the Chehalis Basin during the winter 2007 catastrophic flood event caused more than 1,000 landslides and other channel forming events which resulted in input of an estimated 5.7–8.7 million tons of sediment into the Chehalis River (Sarikhan et al. 2008).

3.1.5 Large Woody Material (LWM)

Above the FRE facility, LWM is primarily recruited during extreme precipitation events which cause root failure, landslides, and debris torrents in headwaters of the watershed. The 2007 flood resulted in significant input of LWM to the basin because of landslides, hillslopes failure, and bank erosion (CBS 2017). This material can be carried from Reach A above the FRE facility downstream into Reaches B, C, and D as far downstream as RM 80, downstream of the South Fork Chehalis River confluence. Consistent with tree harvest, and the increased frequency of landslides since the beginning of timber harvest in the upper Chehalis Basin, large wood recruitment into the channel has been reduced. Current Forest Practices Rules (Washington Administrative Code [WAC] 2021) are in place to protect riparian areas and promote the development of the riparian forest and processes for recruitment of LWM. While not all riparian tree stands are fully functioning, they are on a trajectory to mature and become a future source of LWM.

LWM recruitment from within Reaches B, C, and D comes from small-scale bank erosion more than major floods (Collins et al. 2002). Most of the riparian area in these reaches lacks mature vegetation, decreasing the potential for local LWM recruitment.

3.1.6 Aquatic Habitat

While the aquatic and riparian habitat conditions in the upper basin above the FRE facility, have been degraded by historic and to a lesser degree current timber harvest, this area supports relatively high-quality spawning and rearing habitat for salmonids and other native species. The riparian buffer is fairly intact, providing shade to maintain cooler water temperatures. The mainstem Chehalis River and tributaries in Reach A are primarily steep gradient, single-channel streams constrained by the steep valley walls of the Willapa Hills mountain range (Hayslip and Herger 2001). The mainstem channel has limited potential for lateral channel migration (CBS 2017). The area is characterized by low permeability basal bedrock including Tertiary basalt and sedimentary rock. Therefore, this reach has little to no groundwater storage capacity (CBS 2017). The habitat is composed of pools and riffles with gravel, cobble, and fine substrate and some areas of bedrock (Winkowski et al. 2018).

The upper Chehalis River below the FRE has been highly degraded by historic timber harvest, agriculture, and rural development. Channelization of the mainstem has degraded the habitat quality by the lack of braiding and channel complexity, few instream structures, log jams, and limited overhanging vegetation – all features that contribute to quality fish habitat for rearing, foraging, and finding refuge from thermal stress or predators. In addition to the single-channel, disconnected channel morphology and lack of mature riparian vegetation are also considered impairments in this reach of the Chehalis River (WDFW 2020a).

Between the FRE facility and Elk Creek (Reach B), the Chehalis River is a single thread channel confined by a narrow canyon. The habitat is comprised of pools and long riffle habitats, with an average gradient of 0.21%. The riverbed in this section consists largely of a thin layer of alluvial substrate over bedrock. Mixed gravel substrate can be found throughout this reach.

Below Rainbow Falls (RM 97), channel straightening and floodplain alteration have increased the river's susceptibility to erosion and direct thermal inputs. The result is a mainstem segment with one predominant incised channel that is disconnected from its floodplain, has more fine-grained sediment, and warmer water temperatures relative to historic conditions.

3.1.7 Water Quality

The upper Chehalis River above the FRE facility (Reach A) does not include any water quality impairments for temperature, dissolved oxygen, or other parameters. However, the headwaters of the Chehalis are relatively warmer than other western Washington headwater areas due to the relatively lower elevation. Reach A has an intact riparian buffer of large coniferous trees which contributes to the slightly lower summer high temperatures observed by WDFW relative to other unshaded reaches of the mainstem Chehalis River. The tributaries in Reach A also provide cooler water input to the mainstem (Winkowski et al. 2018).

Below the FRE facility, consistent with degraded aquatic and riparian habitat, water quality in the upper Chehalis Basin is impaired as indicated by Clean Water Act Section 303(d) and Water of Concern listings for several parameters including turbidity, nutrients, fecal coliform, dissolved oxygen (DO), and temperature. Total maximum daily load plans are in place in the upper Chehalis River for DO (Jennings and Pickett 2000), temperature (Ecology 2001), and bacteria (Ahmed and Rountry 2004).

A total maximum daily load plan has not been developed for turbidity. Although often lower than 2 nephelometric turbidity units (NTUs) in summer months, turbidity increases from winter storm-induced runoff and has been documented as high as 610 NTUs (Ecology 2020). The section of the mainstem Chehalis River between Stearns Creek and the Newaukum River is 303(d) listed for turbidity for the designated use of Aquatic Life – Salmonid Spawning, Rearing and Migration.

Water quality issues in the Chehalis River downstream of Rainbow Falls (RM 97) are compounded by water rights concerns. Low base flows below Washington State's requirements for minimum instream flow have resulted in curtailment of junior water rights, cessation of recreational fishing, and further concern related to instream temperature which is considered impaired throughout this reach. Summer temperatures frequently exceed the preferred temperature range criteria for salmon and steelhead (Ecology 2020) (WAC 173-201A).

Solar heating is the primary driver of water temperatures, and elevated stream temperatures in the Chehalis River are attributed to a lack of stream shading, with some heating attributed to the loss of shade that was historically provided by mature riparian vegetation (Ecology 2020). The water frequently exceeds maximum temperature thresholds in summer for salmon and steelhead including the 7-day consecutive mean daily max temperature (7-DADMax) criterion of 16°C in stream reaches designated as core summer salmonid habitat in WAC 173-201A-602 and the 13°C criteria applied September 15 to July 1 in stream reaches designated with supplemental spawning/incubation criteria (Anchor QEA 2014). Data has also shown acute impairment that exceeds Washington's lethality guidelines (Anchor QEA 2014).

Water temperature appears to be a driver of fish distributions in the Chehalis River. Fish species assemblage has been found to be consistently associated with stream temperatures in August rather than physical habitat characteristics (Winkowski et al. 2018). Warm summer stream temperatures limit the rearing potential, habitat use, and spatial distribution of aquatic species, especially Pacific salmon. More specifically, temperature has been implicated as a limiting factor for spring-run Chinook salmon (*O. tshawytscha*) (Winkowski and Zimmerman 2017).

3.2 Aquatic Species

The following section summarizes the aquatic species, including fish, shellfish, and amphibians that occur in the upper Chehalis Basin with an emphasis on those species identified in the SEPA/NEPA-DEIS as being potentially affected by the Proposed Action.

3.2.1 Fish

There are no ESA-listed, threatened, or endangered fish species in the upper Chehalis Basin (Corps 2020). Pacific lamprey, a federal Species of Concern, is identified as a Species of Greatest Conservation Need under the Washington State Wildlife Action Plan (SWAP), and as a Priority Species under the WDFW Priority Habitat and Species Program (WDFW 2019a, 2019b). Priority species require protective measures for their survival due to their population status, sensitivity to habitat alteration, and/or recreational, commercial, or tribal importance. In addition, Native American tribes regard Pacific lamprey as a highly valued resource, both for their ecological and cultural importance, and for food and spiritual sustenance. Chinook salmon and steelhead are Washington State Candidate Species and coho salmon are a State Priority Species. The Olympic mudminnow (*Novumbra hubbsi*), designated as a state-listed Sensitive Species, is the only resident fish with special status in the upper basin. It is also identified as a Species of Greatest Conservation Need and a WDFW Priority Species (WDFW 2019a).

Although there are no listed salmon populations in the Chehalis River, Essential Fish Habitat (EFH) has been designated for Chinook and coho salmon (*O. kisutch*). Salmon EFH in the Chehalis River covers all accessible waterbodies including the mainstem river and tributaries in the Proposed Action area.

The fish species identified in the SEPA/NEPA-DEIS as potentially affected by the Proposed Action include both anadromous and resident species listed in Table 3.2-1. The list also includes non-native warmwater species which may indirectly affect native species under future conditions of changing water quality.

Table 3.2-1
Fish Species of Interest in the Proposed Mitigation Area

COMMON NAME	SCIENTIFIC NAME	MITIGATION REACH A	B	C	D
Anadromous					
Spring-run Chinook Salmon	*Oncorhynchus tshawytscha*	S, R	S, R	S, R	S, R
Fall-run Chinook Salmon	*Oncorhynchus tshawytscha*	S, R	S, R	S, R	S, R
Coho Salmon	*Oncorhynchus kisutch*	S, R	S, R	S, R	S, R
Steelhead	*Oncorhynchus mykiss*	S, R	S, R	S, R	
Pacific Lamprey	*Entosphenus tridentatus*	S, R	S, R	S, R	S, R
Resident					
Mountain Whitefish	*Prosopium williamsoni*	S, R	S, R	A	A
Western Brook Lamprey	*Lampetra richardsoni*	S, R	S, R	S, R	S, R
Rainbow Trout	*Oncorhynchus mykiss*	S, R	S, R	S, R	S, R
Cutthroat Trout	*Oncorhynchus clarkii*	S, R	S, R	S, R	S, R
Olympic Mudminnow	*Novumbra hubbsi*				S, R
Non-native					
American Shad	*Alosa alosa*				S, R
Bass Species	*Micropterus* spp.				S, R

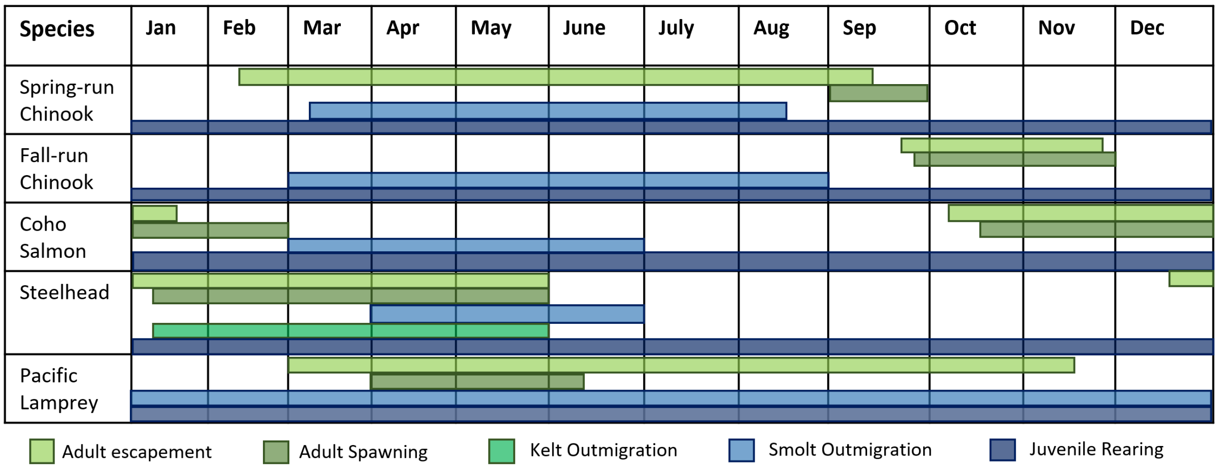
Notes:
S = spawning; R = rearing; P = present; A = assumed present.

3.2.1.1 Anadromous Fish

The life history of anadromous fishes is complex, and each life history stage has unique requirements for habitat, water quality, and movement opportunities (passage) depending on whether individual fish are spawning, rearing, migrating, or redistributing in-basin. All salmonid species need adequate flow and water quality, spawning riffles and pools, a functional riparian zone, and upland conditions that favor stability, but some of these specific needs vary by species, such as preferred spawning areas and gravel. In the Chehalis Basin, Chinook salmon, coho salmon, steelhead, and Pacific lamprey movement for spawning occurs throughout the year, with the most overlap across species occurring between fall and early spring. Figure 3.2-1 illustrates the timing of movement patterns of anadromous species in the Chehalis Basin.

All the anadromous species migrate upstream of the FRE facility to spawn; however, an evaluation of the salmon spawning habitat potential upstream as a proportion of the entire basin, was estimated as less than 1% for fall-run Chinook and coho salmon, 2.5% for steelhead, and 3% for spring-run Chinook salmon. Of the 3% spring-run Chinook salmon spawning habitat that occurs in the upper basin (upstream of RM 98), most (97%) occurs within 6 miles upstream of the proposed FRE facility site (Ecology 2020). While coho salmon and steelhead spawning occurs within the temporary reservoir, the majority of suitable habitat for these species is located upstream or in tributaries. The percentage of coho salmon and steelhead spawning habitat in the temporary reservoir is less than 35%, because suitable spawning habitat extends further upstream for these species.

Figure 3.2-1
Movement Patterns by Life History Stage for Anadromous Fish Species Present in the Chehalis Basin



Source: CBS 2017.

3.2.1.1.1 Spring-run Chinook Salmon

The distribution of spring Chinook salmon in the Mitigation Area is provided in Table 3.2-2 by mitigation reach and is displayed in Appendix A1. In October 2018, a peak-spawning supplemental survey for spring Chinook salmon redds was conducted on the mainstem Chehalis from above the proposed FRE facility downstream to the Newaukum River. A total of 39 redds was observed in this reach (Reaches B through C), while zero redds were observed above the proposed FRE facility (Ronne et al. 2020). The documented redds were evenly distributed from the proposed FRE facility downstream to RM 78.5, below the town of Adna. Zero redds were observed between RM 78.5 and the confluence with the Newaukum River (RM 75.2) (Ronne et al. 2020). In the Mitigation Area, spring-run Chinook salmon spawning also occurs in the South Fork Chehalis River.

Ronne et al. estimated the contribution of spring-run Chinook salmon above the FRE facility to be 1.25% of the entire Chehalis Basin spawner abundance (Ronne et al. 2020) (Table 3.2-3). Of the seven spring-run Chinook salmon redds observed above the proposed FRE facility from 2015 through 2019, five (71%) were found in the temporary reservoir in the mainstem (4 redds) and Crim Creek (1 redd), and 2 redds (29%) were found in the mainstem Chehalis River upstream of the upper extent of the maximum pool elevation of the temporary reservoir (Ronne et al. 2020).

Throughout the Chehalis Basin, the abundance of spring-run Chinook salmon has been declining in recent years (Lestelle et al. 2019) and there is much concern over the future of spring-run Chinook salmon in the upper Chehalis Basin. Limiting factors for spring-run Chinook salmon in the Chehalis Basin include temperature, lack of key habitats, and lack of habitat diversity. Temperature is the primary limiting factor for spring-run Chinook salmon during holding, spawning, and rearing, likely due to riparian loss, increased sedimentation resulting in channel changes, and decreased summer flows in the mainstem and tributaries (Smith and Wenger 2001). Lack of habitat complexity and low stream flows have decreased the availability of cold water holding and staging refugia, and further elevate spring-run Chinook salmon vulnerability to increased stream temperature.

Table 3.2-2
Distribution of Chinook and Coho Salmon and Steelhead by Mitigation Reach

MITIGATION REACH	WATERBODY	DISTRIBUTION (MILES)		
		CHINOOK SALMON	COHO SALMON	STEELHEAD
A	Mainstem Chehalis River	11.2	11.5	11.5
	Tributaries	8.0	34.8	36.9
B	Mainstem Chehalis River	8.7	8.1	8.1
	Tributaries	0	27.2	30.8
C	Mainstem Chehalis River	14.6	13.0	13.0
	Tributaries	11.7	12.5	12.5
D	Mainstem Chehalis River	24.2	165.0	218.2
	Tributaries	80.1	310.9	382.3
TOTAL		11.2	11.5	11.5

Source: Statewide Washington Integrated Fish Distribution (SWIFD) portal, updated April 2018.

Table 3.2-3
Estimated Historical and Current Adult Salmon and Steelhead Abundance of the Entire Chehalis Basin Upstream of RM 9 and Upstream of the Proposed FRE Facility

SPECIES	ABUNDANCE UPSTREAM OF RM 9[1]			ABUNDANCE UPSTREAM OF FRE (REACH A)[2]		
	AVERAGE (YEAR)	HIGH (YEAR)	LOW (YEAR)	AVERAGE (YEAR)	HIGH (YEAR)	LOW (YEAR)
Spring-run Chinook Salmon	2,095 (1991-2018)	5,034 (2,004)	496 (2018)	5 (2015-2018)	8 (2017)	3 (2015, 2018)
Fall-run Chinook Salmon	5,352 (1971-2018)	9,951 (2018)	2,862 (1994)	395 (2015-2018)	578 (2018)	239 (2017)
Coho Salmon	24,190 (1987-2017)	46,398 (2010)	8,966 (2007)	1,070 (2013-2018)	2,128 (2018)	174 (2013)
Winter-run steelhead	2,650 (1983-2018)	4,604 (2004)	1,164 (2011)	1,214 (2013-2018)	1,850 (2014)	870 (2017)

Notes:
1. Sources: Scharpf 2019, WDFW 2019c. Describes total estimated number of fish that were spawned naturally; excludes fish caught in downstream fisheries.
2. Source: Ronne et al. 2020. Data were collected from return years 2013 through 2018. Includes winter-run steelhead that spawn before and after the March 15 date used for discerning hatchery-origin "early" stock from the wild "late" stock.

3.2.1.1.2 Fall-run Chinook Salmon

Fall-run Chinook salmon spawn throughout the mainstem Chehalis River between the Satsop River near Elma (RM 28.0) and the Skookumchuck River (RM 67.0), and from the South Fork Chehalis River (RM 88.1) to upstream of the proposed FRE facility (Appendix A1). Within the Mitigation Area, fall-run Chinook salmon spawning also occurs in the South Fork Chehalis River and in lower Elk Creek.

During October 2018, a peak-spawning supplemental survey for fall-run Chinook salmon redds was conducted from above the proposed FRE facility downstream on the mainstem Chehalis River to the Newaukum River. A total of 480 redds were observed in the mainstem between the proposed FRE facility and the Newaukum River, while 139 redds were observed above the proposed FRE facility (Ronne et al. 2020). The documented redds below the proposed FRE facility had the highest density in the upper portion of the survey reach near the Town of Pe Ell and were observed downstream to RM 76.2. No redds were observed between RM 76.2 and Newaukum River (RM 75.2) (Ronne et al. 2020).

Ronne et al. estimated the contribution of fall-run Chinook salmon above the proposed FRE facility to be 3.37% of the entire Chehalis Basin production (Ronne at al. 2020) (Table 3.2-3). Of the fall-run Chinook salmon redds observed above the proposed FRE facility from 2015 through 2019, 92% were found within the temporary reservoir in the mainstem Chehalis River, Crim Creek, Lester Creek and Big Creek, and 8% were found upstream of the upper extent of the maximum pool elevation of the temporary reservoir in the mainstem Chehalis River, Crim Creek, Big Creek, Thrash Creek, and the West Fork Chehalis River (Ronne et al. 2020).

3.2.1.1.3 Coho Salmon

Coho salmon are widely distributed throughout the Chehalis Basin, including the major tributaries in the upper Chehalis River (Table 3.2-2; Appendix A1).

During December 2018, a peak supplemental survey for coho salmon redds was conducted in the mainstem Chehalis River and the tributaries above the proposed FRE facility down the mainstem Chehalis River to Rainbow Falls (RM 97). A total of five redds were observed in the mainstem between the proposed FRE facility and approximately RM 103 (about 2.7 miles above the Elk Creek confluence), while 533 redds were observed in the mainstem and tributaries both within and above the proposed temporary reservoir (Ronne et al. 2020). Of the five documented redds in the mainstem Chehalis River below the proposed FRE facility, four were located near the Town of Pe Ell downstream of Stowe Creek and one was located near the Shields Creek confluence.

Ronne et al. estimated the contribution of coho salmon above the FRE facility to be 2.72% of the entire Chehalis Basin coho salmon abundance (Ronne et al. 2020) (Table 3.2-3). Of the coho salmon redds observed above the FRE facility from 2013 through 2019, 32% were found within the mainstem and tributaries of the FRE temporary reservoir, and 68% were found upstream of the upper extent of the maximum pool elevation of the temporary reservoir in the mainstem Chehalis River; Crim, Lester, Browns, Big, Roger, Alder, Thrash, Mack, Cinnabar, and George creeks; and the East Fork and West Fork Chehalis rivers (Ronne et al. 2020).

3.2.1.1.4 Winter-run Steelhead

In the upper Chehalis River, most documented winter steelhead spawning occurs in the mainstem Chehalis above the South Fork Chehalis River confluence and in the Skookumchuck, Newaukum, and South Fork Chehalis rivers as well as other medium and small tributaries (Appendix A1).

During April 2019, a peak-spawning supplemental survey for winter steelhead redds was conducted in the mainstem Chehalis River and the tributaries above the proposed FRE facility and in the mainstem Chehalis River from the Pe Ell bridge downstream to the Newaukum River confluence (RM 75.2). A total of 53 redds were observed in the mainstem between the Pe Ell bridge and the Newaukum River while 399 redds were observed in the mainstem and tributaries both within and above the proposed FRE temporary reservoir (Ronne et al. 2020). Of the 53 documented redds in the area of the mainstem Chehalis River surveyed, all but two were located upstream of the Elk Creek confluence with a higher density occurring near Pe Ell. No winter-run steelhead redds were observed below RM 97.

Ronne et al. estimated the contribution of combined winter-run steelhead above the FRE facility to be 15.43% of the entire Chehalis Basin steelhead spawner abundance (Ronne et al. 2020). Of the steelhead redds observed above the proposed FRE facility from 2013 through 2018/2019, 31% were found in the mainstem and tributaries of the FRE facility temporary reservoir, while 69% were found upstream of the upper extent of the maximum pool elevation of the temporary reservoir in the mainstem Chehalis River; Crim, Lester, Browns, Big, Roger, Alder, Thrash, Mack, Cinnabar, George, and Sage creeks; and the East Fork and West Fork Chehalis rivers (Ronne et al. 2020).

3.2.1.1.5 Pacific Lamprey

Pacific lamprey appear to be broadly distributed in the mainstem Chehalis River and major tributaries. They have been documented in the mainstem upstream of and downstream of the proposed FRE facility site (USFWS 2011), and were observed in every sub-basin sampled (Jolley et al. 2016). Spawning population size and run timing of Pacific lamprey have not been documented in the Chehalis Basin, though spawning distribution was surveyed by WDFW from 2013 through 2018. Spawning was concentrated in the mainstem Chehalis River between the Stearns Creek and the South Fork Chehalis River, from Pe Ell upstream to the FRE facility, and within the area upstream of the FRE facility.

3.2.1.2 Resident Fish

Summer stream temperatures in headwaters and the upper mainstem Chehalis River are cooler than downstream areas and support a cold-water fish assemblage dominated by salmonids compared to reaches downstream from Rainbow Falls (RM 97) that are dominated by native cyprinids (minnows) (Winkowski et al. 2018).

Both rainbow (*O. mykiss*) and cutthroat trout are widely distributed throughout the upper mainstem Chehalis River and the larger tributaries. Like anadromous salmonids, resident trout also prefer clean, cold-water habitat with habitat features including riffles and pools, especially key for spawning. Mountain whitefish (*Prosopium williamsoni*) have been documented throughout the mainstem Chehalis River within several miles both downstream of and upstream of the FRE facility. Whitefish prefer clear, cold water and large deep pools, and spawn in the fall in areas of coarse gravel or gravel. Olympic mudminnow only occur in streams with little or no flow, wetlands, and ponds. They are known to occur in low densities in off-channel habitat adjacent to the Chehalis River between the confluences of the Black River and the South Fork Chehalis River (RM 47.0 to 88.1; Hayes et al. 2016, 2019).

3.2.1.3 Non-native Fish

Largemouth bass and smallmouth bass are warmwater non-native species that present the greatest threat to native fish. Bass are opportunistic predators, and large individuals can prey heavily on juvenile salmon where their distributions overlap (Wydoski and Whitney 2003). The presence of invasive predators, including bass, is a potential limiting factor for the sustainability of some salmon populations in the Chehalis Basin (Grays Harbor County Lead Entity Habitat Work Group [GHLE] 2011). Bass thrive in the warmer reaches and slow-moving off-channel habitats of the mainstem. The upstream extents of bass invasion into salmonid-dominated river habitats are associated with warm water temperatures above 50°F and is projected to increase under future climate scenarios (Wydoski and Whitney 2003; Rubenson and Olden 2019). Bass have not been observed upstream of the confluence of the mainstem Chehalis River with the South Fork Chehalis River at RM 88.1 (Winkowski et al. 2018).

3.2.2 Freshwater Mussels

Three species of native freshwater mussels have been documented in the Chehalis River: western floater (*Anodonta* spp.), western pearlshell (*Margaritifera falcata*), and western ridged mussel (*Gonidea angulata*; Waterstrat 2013). In addition to the native mussels, Asian clams, a non-native species, have been documented in Bunker Creek. The western ridged mussel is currently proposed for federal listing under the ESA (Blevins et al. 2020).

Native freshwater mussels have been observed throughout the upper Chehalis River; however, little is known about their distribution and habitat use. During WDFW surveys conducted in 2020 and 2021, freshwater mussels were found to be numerous in the mainstem Chehalis River from about RM 101 just upstream of the confluence with Elk Creek near the community of Doty, downstream to the Newaukum River confluence (RM 75.2). They appear to be more common between Rainbow Falls (RM 97.0) and the confluence with the Newaukum River than reaches upstream of Rainbow Falls. Mussel densities in some reaches were so high that they were the major substrate (Winkowski et al. 2018). No mussel beds were observed in the vicinity of the proposed FRE facility or temporary reservoir during freshwater mussel surveys conducted by WDFW in 2020 (Douville et al. 2021).

3.2.3 Amphibians

Amphibian species can be grouped into categories according to their breeding habitat: still-water breeding, stream breeding, and terrestrial breeding. Still-water breeding amphibians in the Mitigation Area are often associated with off-channel floodplain habitats including oxbows and ponds. Stream breeding amphibians utilize flowing water in rivers and streams, while terrestrial breeding amphibians are often associated with riparian habitats and moist cool forests. Terrestrial-breeding amphibians are discussed below in Section 3.3-1.

Priority aquatic amphibian species found in the Mitigation Area include the western toad (*Anaxyrus boreas*), a candidate for state listing. The western toad is a still-water breeding species that is known to breed in the mainstem Chehalis River and larger tributaries in the proposed temporary reservoir (Hayes et al. 2016). Western toad spawning and incubation occurs in standing water, including ponds, lakes, slow-moving reaches of streams, springs, reservoirs, canals, and roadside ditches. Adults have been observed as far as 1.6 miles from breeding sites. Hibernation occurs in terrestrial locations, but little else is known about their hibernation (Washington State Department of Natural Resources [WA DNR] 2013). In addition to being documented in the temporary reservoir area, western toad has also been documented in areas both upstream and downstream (Hayes et al. 2017).

3.3 Terrestrial Species

The upper Chehalis Basin provides habitat for a wide array of wildlife species and has the highest diversity of amphibians in Washington State. The following sections address priority terrestrial-breeding amphibians, birds, and mammals that may occur in the Mitigation Area or are indirectly affected by potential impacts associated with the Proposed Action. Attributes of native species that are described in the following sections include their federal and state special status and ecological role in the Chehalis Basin. Terrestrial species included in this discussion are listed in Appendix A1, Attachment 2.

3.3.1 Amphibians

Still-water breeding and stream breeding amphibians are discussed above in Section 3.2.3 under aquatic species (Section 3.2). Terrestrial breeding amphibians are often associated with forested riparian habitats and moist cool forests. Priority terrestrial-breeding amphibian species in the Mitigation Area include the Dunn's salamander (*Plethodon dunni*) and Van Dyke's salamander (*Plethodon vehiculum*) which are both candidates for state listing. Amphibian surveys were conducted by WDFW in the vicinity of the FRE facility and temporary reservoir between 2014 and 2017. Terrestrial-breeding amphibians detected include ensatina (*Ensatina eschscholtzii*), western red-backed salamander (*Plethodon vehiculum*), Dunn's salamander, and Van Dyke's salamander (Hayes et al. 2017).

Dunn's and Van Dyke's salamanders inhabit cool, moist microclimates in forested habitats (Larsen 1997). The Willapa Hills region is one of three disjunct distributional centers for Van Dyke's salamander, which is endemic to western Washington (Olson and Crisafulli 2014). Dunn's salamanders' range extends from northeastern California to western Oregon and the Willapa Hills in southwestern Washington. Both species occupy wet, rocky substrates or woody debris with several inches of duff. Occupied sites are heavily shaded and can include seeps and stream banks. Both species are often found in riparian zones, but have been documented further upslope in appropriate, stable microclimates (Larsen 1997).

3.3.2 Birds

The marbled murrelet (*Brachyramphus marmoratus*) is a federally and state-listed species that occurs within Reach A of the Mitigation Area. Though primarily an ocean-dwelling species that spends more than 90 percent of life at sea, marbled murrelets nest inland in old-growth conifer-dominant stands from central California to the Aleutian Islands of Alaska. Suitable nesting habitat for marbled murrelets consists of mature conifers (>15 inches diameter at breast height [dbh]) situated in contiguous conifer-dominant (>60 percent) stands with at least one suitable nesting platform at least 33 ft (10 m) off the ground (Hamer and Nelson 1995). Nesting platforms are at least four inches wide and are typically composed of a wide branch covered with moss, lichen, mistletoe, witches' brooms (a dwarf mistletoe infected tree limb), or other deformities (Hamer and Nelson 1995).

As coastal forests undergo clear-cutting and development, marbled murrelets are forced to search further inland for suitable nesting habitat. Timber harvest, development, and an overall increase in wildfires also increase habitat fragmentation and the creation of edge habitat that can lead to an increase in nest predation by predators like corvids (Hamer and Nelson 1995). These and other threats like changes in oceanic conditions have caused a rapid decline in the species' population thus resulting in marbled murrelets being listed as state-endangered in Washington, Oregon, and California and threatened under the federal ESA.

Within the Mitigation Area, pockets of suitable marbled murrelet nesting habitat with potential nesting platforms are present within patches of mature coniferous forest in the headwater areas of the upper Chehalis Basin and may be present within the vicinity of the proposed FRE facility temporary reservoir. While much of the area is in timber production and no old-growth forest is present, mature forest is present in linear patches along the stream corridors which may provide nesting habitat for marbled murrelets. Marbled murrelet activity has been documented in the upstream portions of the maximum temporary reservoir area. Additionally, circling marbled murrelets, which is indicative of nesting activity, were documented within a mile of the proposed temporary reservoir within the subcanopy of forest habitat.

Northern spotted owl is a federally and state-listed species that is strongly associated with old growth forest and requires large patches of suitable habitat for nesting. Based on the results of a number of surveys conducted during the last 17 years, the presence of the northern spotted owl in upper Chehalis headwaters of Reach A is extremely low and was limited to dispersing and foraging individuals.

3.3.3 Mammals

Mammals with federal or state threatened, endangered, or proposed status are not likely to occur in the Mitigation Area. Priority species that are not state or federally listed that may potentially occur in the area include Columbia black-tailed deer (*Odocoileus hemionus columbianus*), Roosevelt elk (*Cervus canadensis roosevelti*), Keen's myotis (*Myotis evotis keenii*), Townsend's big-eared bat (*Corynorhinus townsendii*), and roosting concentrations of big brown bats (*Eptesicus fuscus*), and myotis bats (*Myotis spp.*) (Ecology 2020).

Columbia black-tailed deer and Roosevelt elk are traditionally important food sources for Indigenous people. The upper Chehalis Basin offers habitat preferred by deer and elk including productive grasslands, meadows, and clearcuts, interspersed with closed-canopy forests (WDFW 2022a).

The Willapa Hills elk herd is distributed throughout its historic range, although its distribution is not uniform. There is not a formal population estimate for the Willapa Hills Roosevelt elk herd, but WDFW estimates the herd size to be between 8,000 and 10,000 elk (WDFW 2016). One of the Game Management Units (GMU) with the highest density of elk is located on the west side of the FRE facility temporary reservoir (GMU 506); however, elk numbers are managed in portions of that GMU to minimize agricultural damage from foraging elk (WDFW 2014b). WDFW conducted survey flights during March of 2020 that covered the southern portion of the herd area. A total of 1,524 elk were observed, and the total elk abundance for the southern portion of the herd area was estimated to be 2,984. The calf-to-cow ratio measured 34 calves per 100 cows, which indicates good recruitment (WDFW 2021). Willapa Hills elk reportedly move down from Bawfaw Peak and other high elevation areas into winter range areas that include the flats of the West and East Forks of the Chehalis River, in the vicinity that includes the temporary reservoir site (PHS 2022).

Population trends of black-tailed deer in Washington are difficult to ascertain because of the habitat they occupy and changes in hunting regulations and intensity (WDFW 2014a). However, estimates derived from harvest reports for black-tailed deer in the Willapa Hills Black-tailed Deer Management Zone indicate that the population was stable between 2005 and 2015 (WDFW 2016). Black-tailed deer habitat has been reduced over time in western Washington because of human encroachment, reduced timber harvest, and natural forest succession (WDFW 2014a). Data is being analyzed from research to determine black-tailed deer fawn production and survival, and additional research is ongoing (WDFW 2021).

Keen's myotis is associated with mature coastal conifer forests but may move to mid-elevations during winter. Townsend's big-eared bat occur at low densities throughout their range, which includes the Mitigation Area. Big brown bats' and myotis bats' ranges also include the Mitigation Area (WDFW 2022a).

In addition to priority species, other mammal species likely to occur throughout the basin include those common to western Washington such as Douglas squirrel (*Tamiasciurus douglasii*), racoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), beaver (*Castor canadensis*), coyote (*Canis latrans*), and various bat species.

3.4 Limiting Factors

Mitigation actions under this Draft FRE HMP were identified and prioritized in terms of suitability to provide compensatory ecological lift within the capacity of the physical environment and in consideration of limiting factors to aquatic habitat and species. The following limiting factors represent potential opportunities to generate ecological lift while addressing specific potential effects of the Proposed Action on terrestrial and aquatic habitats and species studied for the Existing Baseline Condition Assessment (Appendix A1).

Loss of Access to Fish Spawning and Rearing Habitat due to barriers that prevent salmonids from reaching suitable spawning and/or rearing habitat. Additional factors that may restrict access include low stream flow or temperature conditions that constitute barriers during some parts of the year.

Degraded Floodplain Conditions due to human activities such as filling, channel straightening, armoring, diking, road construction, and incision. These activities limit natural floodplain processes such as periodic inundation, lateral channel movement, flood water storage, sediment, large wood, and off-channel habitats such as sloughs, side-channels, and other features that provide important spawning and rearing habitat and refugia from high flow and temperature.

Invasive Species are found in the upper Chehalis River including aquatic invasives such as largemouth bass, smallmouth bass, and bull frogs that are more tolerant to stagnant, warm water conditions, and may displace, out-compete, or prey on juvenile salmonids, lamprey, and native aquatic amphibians (GHLE 2011). Invasive riparian species, including Himalayan blackberry (*Rubus armeniacus*) and reed canarygrass (*Phalaris arundinacea*) are also prevalent in riparian areas downstream of Pe Ell. These plant species provide reduced riparian function, including shade, overhanging cover, and soil retention as compared to native riparian shrubs and trees.

Changes in Sediment Condition resulting from variation in the input of fine and coarse sediment over time associated with landslides and floods and lack of adequate riparian cover.

Poor Quality Salmon Spawning Habitat resulting from a long history of land-use practices that have modified the river channel (channel widening and loss of channel and habitat complexity) and increased flood potential effects (bank destabilization, erosion, channel widening, and scour). As a result, the habitat lacks complexity. During summer, spring Chinook salmon holding and spawning are limited due to a lack of in-channel and overhanging cover, high water temperatures, and low dissolved oxygen.

Degraded Riparian Conditions due to riparian forest clearing and establishment of non-native species (i.e., reed canarygrass and Himalayan blackberry) as the predominant vegetation in some reaches. These non-native species reduce riparian function with respect to native riparian species including the ability to provide species diversity, structural complexity, shade, nutrients, soil retention, bank stability, and LWM.

Degraded Water Quality and Quantity resulting from degraded riparian habitat structure and lack of shade, channel inability to absorb or adjust ongoing and anticipated changes to the seasonal hydrograph and related channel-forming processes, access to suitable habitats, and suitability of existing habitats (high summer temperature and low dissolved oxygen relative to Ecology standards [WAC 2022] for support of native aquatic species).

3.4.1 Future Conditions Without the Proposed Action

Physical processes that contribute to habitat quality and quantity as well as aquatic species use of habitat within the upper Chehalis River are dynamic. Some processes, like changes to stream flow, temperature, and associated habitat suitability, occur on a continuum affected by climate change, while other dynamic processes are human driven such as water rights, forest practices and schedules of timber harvest, rural infrastructure development, and other land uses.

Climate change models for the Puget Sound area scaled to the Chehalis River Basin predict increased precipitation and decreased summer flows (Mauger et al. 2016). The model developers indicate that warmer winter temperatures would mean less snow and more heavy rain events which are expected to increase the risk of winter flooding, and increase sediment transport, erosion, and landslides. With less snowpack to melt and less summertime precipitation expected, lower summer stream flows and warmer water temperatures are predicted for the Chehalis Basin. This section summarizes the best available data on future conditions within the Impact Area without consideration of Proposed Action. Modeling efforts provide predicted future scenarios for stream flow, habitat suitability, and in-river temperature. Forest practices that result in timber harvest in watersheds within the Impact Area and potential Mitigation Area are also scheduled and permitted well into the future and are summarized here as well.

3.4.1.1 Stream Flow

The information contained in the Chehalis River Basin Hydrologic Modeling technical memorandum combined with USGS flow records were used to develop flow predictions under future climate change conditions. The flows were input to the RiverFlow2D model to estimate flooding conditions under future climate change conditions. Peak flow increases due to climate change were estimated to range from 12% at mid-century to 26% by late-century (WSE 2019). The SEPA DEIS presents analysis of increased flows under climate change scenarios to predict the likelihood of major (>38,000 cfs) and catastrophic (>75,100 cfs) floods as measured at the Grand Mound USGS Gage. These flood likelihood calculations, presented in Table 3.4-1, are important for considering likely frequency of operation of the proposed FRE facility under future stream flow conditions, and potential impacts to aquatic habitats and species.

Table 3.4-1
Modeled Future Baseline Conditions for Flood Occurrence Frequency Under Mid-century and Late-century Time Frames

QUALITATIVE FLOOD CATEGORY (DEIS)	TIME FRAME	CHANCE OF ANNUAL OCCURRENCE[1]	ASSOCIATED FLOOD-YEAR TERM	FLOW (GRAND MOUND)	REFERENCE FLOOD
Major Flood	Current	14%	7-year	38,800 cfs	2009
	Mid-Century	20%	5-year		
	Late-Century	25%	4-year		
Catastrophic Flood	Current	1%	100-year	75,100 cfs	1996
	Mid-Century	2%	44-year		
	Late-Century	4%	27-year		

Source: SEPA DEIS Table N-5. Ecology 2021.
Notes:
1. % chance a flood of this size would occur in any given year.

Stream flow outside of peak flow periods were analyzed by WSE to determine the change in average monthly flows throughout the modeled period of record, projecting that flows will increase 4 and 5% during winter (November-April) and will decrease 11% and 16% during summer (May-October) based on mid- and late-century models, respectively.

3.4.1.2 Stream Temperature

Future-conditions modeling for the SEPA DEIS (PSU 2017) and by the Applicant (Appendix F) for this FRE HMP include predicted changes to hydrological and meteorological conditions associated with climate change. Climate change is projected to increase stream temperatures because of increases in air temperature, changes in dew point temperature, changes in hydrology, and lower summer flows throughout Washington State, including the Chehalis River (Mauger et al. 2016). The SEPA DEIS included the influence of climate change in the estimate of the Proposed Action's impacts on water temperature; however, it did not report what portion of the increase in water temperature could be attributed to climate change without the Proposed Action.

The Applicant used the existing 2-dimensional CE-QUAL-W2 temperature model to project long-term climate change effects on stream temperature in the Impact Area without the Proposed Action (Appendix D, Chehalis River Basin Flood Control Zone District [FCZD] 2021). Model results suggest that surface water temperatures, accounting for climate change, would be warmer than under current conditions, with an increase in water temperatures proportional to the increase in air temperatures and associated decreases in summer stream flow (FCZD 2021). These changes in baseline climate result in water temperatures that are 3°C to 5°C higher than current conditions.

3.4.1.3 Forest Practices

Forest Practices including road construction and timber harvest can have wide-spread impacts on the landscape, receiving waters, and habitats and species therein, but also to larger ecosystem functions that support the productive capacity of streams for fish and other wildlife. Removal of vegetation near streams increases solar radiation contributing to increased water temperature, primary production, and re-radiation, while decreasing input of organic matter to streams, bank stability, and wood supply that can serve as substrate for invertebrates, trap for sediment, and factor in formation of meso-scale habitat (Richardson and Béraud 2014).

Much of the land use in the higher elevation portions of the Mitigation Area is managed timber harvest, including a majority of the watershed upstream of the proposed FRE facility. These forestlands are owned by entities including private companies (industrial, non-industrial, and tribal) and agencies such as the WA DNR, U.S. Forest Service, and the Bureau of Land Management that manage forestlands on behalf of the public. In Lewis County, an average of 393,200 thousand board feet have been harvested annually over the past 20 years with an average of 45% harvested by private timber companies (FIRP 2022).

Most of the habitat within the Proposed Action area around the FRE facility and temporary reservoir is privately-owned evergreen forest that has been managed for many decades typically operating on a 40- to 50-year harvest cycle. Based on analysis of satellite imagery from 2018, approximately 12% of the upland area within 0.25 miles of the mainstem Chehalis River between the proposed FRE facility and upper inundation extent of the temporary reservoir was clearcut/bare of vegetation, 5% was in early regrowth period, and 83% was mature upland forest. Planned timber harvest activities above the proposed FRE facility will likely continue to impact aquatic and wildlife habitat, water quality, LWM input, and other ecosystem processes.

Current Forest Practices rules are in place to protect riparian areas and promote the development of the riparian forest and processes for recruitment of LWM. Riparian protection provided by these rules are site specific, with some flexibility to allow harvest outside the core buffer zone of 50 feet, but generally consist of 50 to 200-foot buffers (WAC 2001). While not all riparian tree stands are fully functioning, within the core zone, they are on a trajectory to mature and become a source of LWM in the future.

3.4.1.4 Habitat Suitability

The Ecosystem Diagnosis & Treatment (EDT) model was used to evaluate the biological significance of environmental changes with regard to the potential of the Chehalis Basin to support spring- and fall-run Chinook salmon, coho salmon, chum salmon, and steelhead (“modeled species”) at basin and sub-basin scales as a result of flood damage reduction and habitat restoration actions. The actions were evaluated under current climate conditions and under projected future climate conditions in the Chehalis Basin.

The EDT model (McConnaha et al. 2017) reported the following principal findings relative to the baseline and future conditions of aquatic habitat in the Chehalis.

- Future climate greatly reduced habitat potential for all modeled species throughout the Chehalis Basin independent of the FRE facility options or ASRP.
- Under future climate conditions, habitat potential for most local populations of spring-run Chinook salmon was eliminated under a low climate scenario with only 85% of existing habitat remaining by the year 2040. Under a high climate change scenario, all habitat potential for spring Chinook salmon would be gone, affecting all local populations in the basin. These model results suggests that this species may not be viable under future climate conditions without substantial habitat restoration.
- Under a high climate change scenario, all habitat potential for coho salmon upstream of the South Fork Chehalis was eliminated.
- For fall Chinook salmon, habitat potential was eliminated for three sub-basins under the high climate change scenario. However, due to increase winter flow and channel width, fall Chinook salmon habitat potential actually increased for five of the local population downstream of the confluence with the Skookumchuck River.
- As modeled, the negative effect of future climate conditions depended on the length of a species' exposure to the conditions in the Chehalis watershed, in particular to increased summer water temperatures for spawning salmon. Chum salmon and fall-run Chinook salmon spend the least amount of time in the watershed and experience substantially less exposure to warmer water. Steelhead and coho salmon spawn higher in the system where project temperature increases were less. Spring-run Chinook salmon spend months in the river as pre-spawners and spawners, and will have the greatest exposure to lower summer flow and warmer summer temperatures.

4 REGULATORY AND NON-REGULATORY CONTEXT

4.1 Environmental Preview/Permits and Approvals

The Proposed Action is subject to federal, state, and some local jurisdictions for permitting and approval for project construction, operation, and maintenance. Federal, state, and local agencies with jurisdiction must also comply with SEPA and NEPA by preparing an environmental review of the Proposed Action. In the following sections the agencies that have jurisdiction and the permits and consultations required at each level of government are described as they would relate to environmental impact mitigation.

4.1.1 Federal

Under Section 404 of the Clean Water Act, the Corps is the federal agency with jurisdiction over the Proposed Action. The Corps is required to review the potential environmental impacts of the Proposed Action under NEPA by preparing an EIS. The Corps issued its DEIS on September 28, 2020, which identified potential impacts to terrestrial and aquatic resources for the Proposed Action. The EIS may then be used by any other federal agency that may have jurisdiction.

Section 7 of the Endangered Species Act (ESA) requires that the Corps ensure that any action they authorize for the Proposed Action does not jeopardize the continued existence of any endangered or threatened species, or result in the destruction or adverse modification of designated critical habitat for such species. The Corps must consult with NMFS and/or USFWS if the agency determines that the action may affect ESA-listed species or designated/proposed critical habitat. Further, the Magnuson-Stevens Act (MSA) requires an assessment of project-related effects on designated EFH for Chinook and coho salmon.

The following federal permits, licenses, and approvals would be required for the Proposed Action.

Section 404 Clean Water Act Permit (Corps): Section 404 requires discharges of dredged/fill material to waters of the U.S. be done only under the authorization of a permit. As part of this approval, Endangered Species Act and Section 106 of the National Historic Preservation Act consultations would also be required.

Endangered Species Act Consultation (USFWS): The Proposed Action could affect listed species or designated critical habitats. USFWS would evaluate the effects on listed and proposed species and critical habitats, and require compensatory mitigation for unavoidable impacts.

Federal Explosives License/Permit (Federal Bureau of Alcohol, Tobacco, and Firearms): Required for blasting activities during construction.

Letter of Map Revision, Conditional Letter of Map Revision, or Physical Map Revision (Federal Emergency Management Agency [FEMA]): To comply with 44 Code of Federal Regulations 65.3, National Flood Insurance Program, participating communities must provide FEMA with technical information related to changes to the Special Flood Hazard Area. This would apply from the area inundated in the FRE facility temporary reservoir downstream to near the city of Montesano. Conditional approvals by FEMA are needed prior to construction of the project.

Magnuson-Stevens Fishery Conservation and Management Act Provisions; Essential Fish Habitat: Governs marine fisheries management in U.S. federal waters; federal agencies are required to consult with NOAA Fisheries on activities that may affect essential fish habitat.

Section 106 of the National Historic Preservation Act (Corps): Section 106 requires the Corps to consider the effects of the Proposed Action on historic properties as part of the federal permitting process. This includes consultation with interested and affected tribes, the State Historic Preservation Officer at the Washington State Department of Archaeology and Historic Preservation (DAHP).

4.1.2 State

Ecology prepared a DEIS issued on February 28, 2020, using the SEPA requirements in Washington Administrative Code 197-11. Ecology's DEIS evaluates the probable significant adverse impacts on the environment from the Proposed Action and alternatives and considers the future conditions when the project is proposed to be constructed and operated.

The following state permits, licenses, and approvals would be required for the Proposed Action.

Application for Exploration Reclamation Permit (WA DNR): Required for exploration and reclamation of exploration sites for the FRE facility structure site and the potential quarry sites, because trees may have to be removed and disturbance to the forest floor could occur.

Aquatic Lands Lease and Use Authorization (WA DNR): Construction of the FRE facility may require a lease from WA DNR and use authorization for construction and operation.

Coastal Zone Management Program Consistency (Ecology): Construction and operation of the FRE facility may be subject to the federal consistency provision of the Coastal Zone Management Act and the state's Coastal Zone Management Program.

Dam Safety Construction Permit (Ecology): Required before constructing, modifying, or repairing any dam or controlling works for storage of 10 or more acre-feet of water at the dam crest elevation.

Fish Transport Permits (WDFW): Required to transfer live fish as part of the trap-and-transport process during construction and operation.

Forest Practices Applications (WA DNR): Activities for construction and operation of the FRE facility taking place on private or state forestland, including timber harvest, development of quarries, and expanding, maintaining, or abandoning roads, would be subject to Forest Practices Act Rules. Forests and Fish Law (WAC 2001) provides direction on how to implement the Forest Practices Act.

Hydraulic Project Approval (WDFW): Required because the Proposed Action would use, divert, obstruct, and change the natural flow and bed of freshwaters of Washington State and would include work in and adjacent to waters of the state.

National Pollutant Discharge Elimination System (NPDES) Construction Stormwater Permits (Ecology): Required because construction of the FRE facility and airport levee changes would result in more than 1 acre of ground disturbance and involve stormwater discharges to surface waters as well as operational activities that may include landslides and erosion of slopes and roads.

NPDES Industrial Stormwater Permit (Ecology): Required because operation of the FRE facility would result in releases of water. All wastewater and stormwater generated from the Proposed Action and potentially discharged would be evaluated and characterized by Washington State.

NPDES Sand and Gravel Permit (Ecology): Required because FRE facility construction would require quarry development to provide aggregate for the FRE facility. The permit requires a Stormwater Pollution Prevention Plan and BMPs to control pollutants from process water, mine dewatering water, and stormwater.

Scientific Collection Permit (WDFW): Required for relocation or collection of wildlife species or handling or collection of fish species.

Section 401 Clean Water Act Water Quality Certification (Ecology): Because a federal (Corps Section 404) permit would be needed to construct the Proposed Action, a Section 401 Clean Water Act Quality Certification from Ecology would be needed to document Washington State's review of the project and its concurrence that the Applicant has demonstrated that the Proposed Action will meet state water quality standards.

Shoreline Conditional Use Permit (Ecology): The FRE facility would be considered an in-water structure within Lewis County's Shoreline Management Plan (SMP), which is a conditional use within the Rural Conservancy shoreline environment designation. Ecology has final approval for these permits.

Surface Mining Reclamation Permit (WA DNR): Required for the establishment and reclamation of the three potential quarries (North Quarry, South Quarry, and Huckleberry Ridge Quarry).

Washington State Explosives License (Department of Labor and Industries): Required for blasting with explosives.

Water Rights Permits (Ecology): Required because the Proposed Action would involve temporary withdrawals of water from the Chehalis River for the construction of the FRE facility and would involve storage of Chehalis River flows during major floods as part of FRE facility operations.

4.1.3 Local and Regional

Air Discharge Permit (Southwest Clean Air Agency): Required for quarrying, rock processing, operation of the concrete batch plant, and blasting during construction of the FRE facility.

Building Permit (Lewis County): Required activities to construct, enlarge, alter, repair, move, demolish, or change the occupancy of a building or structure.

Comprehensive Plan Update and Rezone (Lewis County): Required to resolve inconsistency with the current Forest Resource Lands land use designation and zoning district for the construction and operation of the FRE facility. This could require a rezone for the affected area.

Critical Areas Review (Lewis County, Pacific County, and City of Chehalis): Required because the Proposed Action is within, abutting, or likely to adversely affect a critical area or buffer.

Earth-moving Permit (City of Chehalis): Required for land disturbance that would be necessary to construct the airport levee changes.

Fill and Grade Permit (Lewis County): Required for excavating soil and rock for the FRE facility foundations and related structures and quarries, and for placing waste materials in three designated locations.

Flood Hazard Zone Permit (Lewis County): Required because construction of the FRE Facility and airport levee changes are in an area of special flood hazard.

Local Land Use and Development Permits (Lewis County and City of Chehalis): Required because the FRE facility would affect water-related resources regulated by Lewis County and the airport levee changes would affect water-related resources regulated by the City of Chehalis under SMPs, Critical Areas Ordinances, and floodplain and stormwater management codes.

Open Burning Permit (Southwest Clean Air Agency): Required for burning debris after land clearing during construction of the FRE facility.

Permit for Nonroad Engines (Southwest Clean Air Agency): Required for operation of nonroad engines with an aggregate horsepower exceeding 500 horsepower and for construction work lasting 1 year or more. This permit would be required for construction activities proposed for both the FRE facility and the airport levee changes.

Shoreline Substantial Development Permit, including shoreline critical areas review (Lewis County): Required for development of the FRE facility because it occurs within shorelines of Washington State.

Shoreline Conditional Use Permit (Lewis County): The FRE facility would be considered an in-water structure within Lewis County's SMP, which is a conditional use within the Rural Conservancy shoreline environment designation. Ecology has final approval for these permits.

Storm Drainage Approval (Lewis County): Approvals are required for any construction that would change the point of discharge of surface waters, discharge surface waters at a higher velocity and/or quantity than that prior to development, or increase pollution of surface waters.

4.2 Tribal Consultation

Concurrent with the Washington SEPA review process, the Corps, as federal lead agency, is conducting a review of the Proposed Action under NEPA. This includes consulting under Section 7 of the federal Endangered Species Act with the USFWS and NOAA Fisheries and under Section 106 of the National Historic Preservation Act with tribes, DAHP, and the Applicant.

Washington's salmon and steelhead fisheries are managed cooperatively in a co-management relationship. Co-management of fisheries occurs through government-to-government cooperation. One government is the State of Washington, and the other is Indian tribes whose rights were preserved in treaties signed with the federal government in the 1850s. Tribal governments have consultation authority for the Proposed Action, but do not issue any required permits.

4.3 Regulatory Compatibility

There are several complementary programs and developed plans that are currently operating or implemented within the Chehalis Basin that share not only regulatory responsibility and permitting requirements, but long-term strategies for restoration, conservation, mitigation, and benefit to the public. These programs include, in part:

Aquatic Species Restoration Plan: The ASRP is a key component of the Chehalis Basin Strategy and is a science-based plan designed to help restore aquatic habitat and enhance local economies.

Salmon Recovery Funding Board: Chehalis Basin lead entity leads the process for salmon recovery funding in the basin to implement restoration and protection projects for healthy salmon habitat.

Brian Abbott Fish Barrier Removal Board: The program provides funding to identify and remove impediments to salmon and steelhead migration.

Family Forest Fish Passage Program: The program assists private forest owners in removing culverts and other fish barriers.

Washington Wildlife and Recreation Program: This program provides matching funds to create new parks, protect wildlife habitat, and preserve working lands.

Washington Coast Restoration and Resiliency Initiative: This programs funds projects that address priority ecological protection and restoration needs while stimulating economic growth and creating jobs in coastal communities.

Chehalis Basin Partnership Streamflow Restoration Plan: This plan focuses on offsetting future impacts to instream flow through acquisition of water rights, promoting conservation, and habitat projects in areas where projected development may impact shallow groundwater resources.

Growth Management Act (1971, WAC 365-197-202) requires all countries and municipalities to plan for and manage population growth by identifying and protecting critical areas and natural resource lands, designing urban growth areas, and preparing and implementing comprehensive land use and zoning plans.

Forest Practices Habitat Conservation Plan (FPHCP) covers state and private forestlands in Washington State to ensure compliance with the federal ESA to protect habitat, support healthy and economically viable forests, and create regulatory stability for landowners.

4.4 Mitigation Policy Goal

The Applicant has made a formal commitment to achieve no-net-loss of aquatic and terrestrial habitat function due to the construction and operation of the Proposed Action in the upper Chehalis River Basin. This commitment was approved by the Chehalis River Basin Flood Control Zone District's Board of Supervisors on August 19, 2021. The commitment would apply to effects attributable to the construction and operation of the proposed FRE facility and temporary reservoir.

The Kleinschmidt team has assessed estimated Proposed Action effects on aquatic and terrestrial habitat based on the Existing Baseline Conditions Assessment and limiting factors in the proposed Mitigation Area. Based on this assessment, the Applicant proposes mitigation that is technically feasible and economically practicable, and has documented that sufficient opportunities are available to mitigate the anticipated Proposed Action effects on aquatic and terrestrial habitats and species.

Habitat in the Chehalis Basin has been degraded due to past and ongoing land practices including forestry, agriculture, and rural development. As described in Section 3 (Existing Conditions), the stream corridor lacks channel complexity, instream structure, and large reaches have been scoured out to bedrock. Extensive reaches of the riparian corridor consist of invasives such as reed canarygrass and Himalayan blackberry. Other reaches have loss of vegetation in the riparian corridor due to logging and access roads, agricultural crops, and impervious surfaces, all of which limit riparian habitat values.

The water quality in the upper basin also is impaired, with warm summer temperatures above thermal tolerance for cold water species, including for salmon spawning and incubation, and associated low dissolved oxygen conditions during summer. As described in the Mitigation Opportunities Assessment Report (Kleinschmidt 2020), there are hundreds of potential opportunities for habitat conservation and enhancement that would improve the quality of the stream habitats and increase the habitat potential to support native species.

As described in more detail under Section 6.2 (Mitigation Objectives), mitigation actions that fall within the categories described in the following section are being evaluated for site-specific feasibility and potential ecological lift to ensure that sufficient mitigation would be available to result in net ecological gain to the upper Chehalis River ecosystem.

4.4.1 Identified Mitigation Categories and Objectives

Aquatic Habitat Access: Fish passage improvements include removal of small dams or replacing fish passage barrier culverts with passable stream crossings, opening access to salmon spawning and rearing habitat and resident fish habitat.

Aquatic Habitat Enhancement: Proposed mitigation to offset potential project effects on fish and aquatic species includes increasing fish access to suitable habitat and implementing aquatic habitat enhancements. Increasing available habitat and improving the condition of existing habitat to fishes and other aquatic species in the upper Chehalis River would result in dramatically improved habitat productivity and offset potential losses associated with flood storage.

Riparian/Stream Buffer Expansion Downstream of FRE Facility: Conservation and enhancement of specific habitats matching the requirements of focal fish and wildlife species. Establish forest vegetation along channel margins to provide shade and other riparian forest ecological functions.

Wildlife Habitat Conservation: Removing forest from harvest rotations and expanding riparian buffers will allow for natural processes to return enhancing ecological functions including nutrient cycling and long-term habitat use for forest-dwelling species. This mitigation would protect riparian habitats with currently developed and maturing trees that would be available into the future and would reduce the Proposed Action's potential effect on loss of wildlife breeding, foraging, resting and overwintering habitat, and specifically for marbled murrelet habitat, western toad breeding habitat, and Van Dyke's and Dunn's salamander habitat. This mitigation would reduce the potential indirect effects that could lead to wildlife mortality.

Large Woody Material Recruitment and Placement: The VMP describes actions that would reduce the Proposed Action's potential impacts on large woody material including retention of existing trees to the maximum extent possible and selective harvest of trees that pose a safety hazard. However, potential residual impact may occur due to episodic flood retention and change in forest composition to a flood-tolerant community. Thus, the Applicant is proposing two types of mitigation: 1) Expansion of Riparian Buffer and 2) Wood Placement within Aquatic Habitat Enhancements. These actions would expand riparian forests and wood installation that would offset loss of ecological functions provided by the levels of wood currently in the system that would otherwise be degraded due to Proposed Action operations.

Surface Water Quality: The objective of this mitigation type is the development of a water quality monitoring program to document the effectiveness of mitigation measures at offsetting temperature, dissolved oxygen, and turbidity effects resulting from FRE facility operation. Surface water quality is a metric that would be applied to all appropriate mitigation action types, and therefore, no site selection analysis was completed for this metric specifically.

Uncertainty of performance, temporal loss, and realized differences in functions and values would be addressed through monitoring and adaptive management. A framework for the Monitoring and Adaptive Management Plan (M&AMP) is provided in Section 9. This plan will be further developed as specific mitigation action and sites are developed.

4.5 Connection to Broader Chehalis Basin Strategy

The Chehalis Basin Strategy (CBS) is a collaborative, science-based process that was created to address the dual challenges of extreme flooding and degraded aquatic habitat. The CBS goal is to make the Chehalis Basin a safer place for families and communities impacted by flooding, and to improve aquatic habitat. Three approaches have been developed to meet this goal: 1) habitat restoration for salmon and other species through projects identified in the ASRP, 2) local landowner and community projects to adapt to and limit flooding impacts, and 3) large-scale measures to prevent potentially disastrous flood episodes.

The Proposed Action complements the goals of the CBS by providing feasible actions to limit flood impacts and disastrous flood episodes. Further, the implementation of the FRE HMP would provide substantial opportunities to improve aquatic and terrestrial habitat to support a variety of species. The FRE HMP would operate in concert with the ASRP to remove barriers and improve fish passage, implement floodplain reconnection projects, and improve overall aquatic, riparian, and vegetative habitat in the upper Chehalis River.

5 PROPOSED ACTION DRAFT IMPACTS

5.1 Summary of Draft Impacts

The potential for project effects on stream and terrestrial habitat in the Action Area, as described in the SEPA DEIS (Ecology 2020) and NEPA DEIS (Corps 2020), were used to estimate potential mitigation obligations for this Draft FRE HMP. The impacts presented in the NEPA DEIS are slightly different than those identified in the SEPA DEIS. This document considers the greatest impacts identified in either the SEPA DEIS or the NEPA DEIS, and they are collectively referred to as the SEPA/NEPA-DEIS identified impacts. At this time, only 'significant' or 'major' impacts to stream and terrestrial habitats due to the construction or operation of the proposed FRE facility were considered. The impacts identified in the SEPA/NEPA-DEIS were characterized as conservative to account for the inherent uncertainty of actual impacts during the environmental review. As such, impacts described in the SEPA/NEPA-DEIS were not reduced by taking into consideration limitations that would be required by various state and federal regulatory standards for avoidance, minimization, and mitigation measures commonly employed. Since the release of the SEPA/NEPA-DEIS, the Applicant has completed a significant body of work to assess appropriate avoidance, minimization, and mitigation measures, and has committed to the employment of these measures as part of the Proposed Action implementation. A summary of these measures is given in Sections 6.1.1 and 6.2.1. Implementation of these measures will measurably reduce the potential effects of the Proposed Action and reduce the Applicant's mitigation requirement.

The SEPA/NEPA-DEIS-identified impacts are summarized in Table 5.1-1 and pertain to the Impact Area, defined as:

- FRE facility and temporary reservoir,
- The 20-mile segment of the mainstem Chehalis River extending from the FRE facility site at RM 108.5 downstream to the South Fork Chehalis River confluence at RM 88.1.

Table 5.1-1
Summary of SEPA/NEPA-DEIS-Identified Impacts Including the Phase of Proposed Action (Open Circles), and the Duration of the Estimated Effect (Solid Circles)

ESTIMATED IMPACT	PHASE		DURATION		
FRE FACILITY AND TEMPORARY RESERVOIR IMPACT AREA	CONSTRUCTION	OPERATION	EPISODIC	TEMPORARY	PERMANENT
Temporary dewatering of the river and in-water work during construction.	○			●	
Removal of 90% of the trees in the 600-acre temporary reservoir.	○				●
Episodic temporary flooding of up to 847 acres (maximum flood pool).		○	●	●	
Water temperature increases of up to 9°F (5°C) related primarily to the loss of shade along 6 miles of river and 11 miles of tributary streams in the temporary reservoir, likely to result in an increased number of days when temperature and DO standards would be exceeded in summer months, and an increased risk to spawning and rearing salmon. This predicted temperature increase combines potential Proposed Action effects with temperature increase attributed to climate change.		○	●	●	
Permanent loss of approximately 11 acres of wetlands and 333 acres of wetland buffers located in the 847-acre temporary reservoir, expected to reduce wildlife habitat, including western toad breeding habitat.		○			●
Permanent elimination of 17 miles of stream channel and 441 acres of stream buffers. "Permanent elimination" entails habitat degradation and loss of ecological function along approximately 6 miles of the mainstem Chehalis River channel and 11 miles of tributary stream channel in the temporary reservoir. This includes loss of salmon, steelhead, and other native fish spawning and rearing habitats, and would result in a reduction in the overall salmon and steelhead abundance, productivity, diversity, and spatial structure in the basin.		○			●
Degraded riparian function and reduced nutrient availability associated with degradation of 17 miles of stream channel and 441 acres of stream buffer.		○			●
Increase in sediment loading in the temporary reservoir from increased risk of erosion and landslides. Also, reduction in sediment transport because sediment storage in the temporary reservoir would increase, likely to result in fining and shallowing of the riverbed upstream of the FRE facility.		○	●	●	
Permanent elimination of 0.32 acres of the Chehalis River channel at the site of the FRE facility.	○				●
Loss of 11.4 acres of Chehalis River floodplain associated with the FRE structure, associated facilities, and spoil areas.	○				●
Temporary fish passage interruption during FRE facility construction.	○			●	
Increase in sediment loading during the 5-year construction period if the capacity of the diversion tunnel (2.8-year flood level or 7,000 cfs) is exceeded.	○		●	●	

ESTIMATED IMPACT	PHASE		DURATION		
FRE FACILITY AND TEMPORARY RESERVOIR IMPACT AREA	**CONSTRUCTION**	**OPERATION**	**EPISODIC**	**TEMPORARY**	**PERMANENT**
Elimination of upland, wetland, and riparian habitat and impacts on wildlife species from: • Removal of 90% of tree cover in the 600-acre temporary reservoir area during construction of the flood retention facility, • Tree removal on 847 acres from inundation of the temporary reservoir and periodic tree removal, • Inundation of up to 847 acres in the temporary reservoir area, • Decreased habitat functions, • Increased water temperatures, • Invasive species colonization, • Noise during construction, • Mortality of species unable to move during inundation of the temporary reservoir, like amphibians or nesting birds, • Mortality of species due to loss of habitat, and • Decreased distribution of native species and increased habitat for non-native species.	○	○	●		●
IMPACT AREA OF THE CHEHALIS RIVER WITHIN 20-MILES DOWNSTREAM OF THE FRE FACILITY					
Water temperature increase of up to 5.4ºF (1.8ºC) in the Impact Area downstream of the FRE facility (including the combination of potential project effects of climate change), related primarily to the loss of shade along the river and tributary streams in the temporary reservoir area.		○	●	●	
Decreased dissolved oxygen downstream about 20 miles from loss of riparian shading in the FRE temporary reservoir.		○	●	●	
Exceedances of turbidity when water is released from the temporary reservoir and during subsequent storms		○	●	●	
Interruption and alteration of sediment delivery downstream of the FRE facility, likely to result in changes to the composition of bed substrate, and possible changes to the elevation of the mainstem river channel and tributary confluences in the mainstem river. Downstream transport of woody material would be interrupted during operations, and the size range of recruited LWM that could pass the FRE facility would be limited.		○	●	●	
Changes in the movement of sediment, large woody material, nutrients, and water resulting in unquantified potential effects on fish habitat.		○	●	●	
Reduced groundwater recharge due to decreased area of floodplain engagement during major or larger floods.		○	●	●	

5.2 Analyses and Measures to Reduce Impacts

A number of modifications to the Proposed Action configuration and construction method have been put forth by the Applicant to avoid and minimize impacts, and individual plans to mitigate residual impacts have been submitted to Ecology and the Corps as the basis for recalibrating impacts for the FEISs. These efforts would be taken into consideration in determining the quantity and location of mitigation actions required to compensate for potential Proposed Action impacts and are described briefly in Sections 5.2.1-5.2.4 below.

5.2.1 Vegetation Management Plan

The Draft VMP (Appendix C) for the FRE facility temporary reservoir was developed to avoid and minimize potential effects from operation of the facility on aquatic and terrestrial resources to the extent practical. Vegetation communities in the Impact Area, specifically streamside riparian vegetation, help moderate local water temperatures, intercept runoff and rainfall, and take up nutrients that may affect downstream water quality parameters like temperature and turbidity. Vegetation also provides habitat for wildlife. Functions provided by vegetation affect various habitats and species that are regulated at the federal, state, and local levels (HDR 2021a).

Under the VMP, which was developed after the SEPA/NEPA-DEIS were issued, the Applicant proposes to not remove any trees prior to a major flood event other than what is required for construction and safety. Tree retention is proposed to help limit temporal potential effects on shading and stream temperature associated with tree removal and to reduce the risk of landslides and erosion potential and the associated risk of increased turbidity. Reductions in the potential effect of the Proposed Action on physical habitat parameters would also reduce the potential effect of water quality on fish passage and survival, as well as survival of freshwater mussels and aquatic plants.

Construction of the proposed FRE facility would require removal of trees and shrubs from within the FRE facility footprint, construction access and staging areas, quarry site, and new temporary roads. Vegetation that could pose a hazard to operations personnel, especially those responsible for wood material collection and transport, would also be removed. Woody vegetation in other areas of the temporary reservoir would not be removed before FRE facility operation during a flood event.

The VMP encompasses the FRE facility temporary reservoir from the lowest elevation of retention at 425 feet MSL up to the maximum flood pool elevation of 620 feet which would correspond to a scenario like the 2007 catastrophic flood (Appendix C). The maximum flood pool would not be more than 808 acres in area during a catastrophic flood (<1 % chance of occurrence) and would be as few as 425 acres during a major flood. As described in Section 2.3.4, the FRE facility temporary reservoir was divided into three evacuation and management zones based on hydrology modeling and anticipated duration of inundation (Table 2.3-1).

The 159-acre Final Reservoir Evacuation Area consists mainly of deciduous riparian forest with some conifers, mixed coniferous/deciduous transitional forest, and open water land cover classifications. The

Final Reservoir Evacuation Area would be inundated for between 26 and 32 days during a flood, and trees in this area would be fully submerged. It is unlikely that any trees would be able to survive in this area after prolonged inundation and full submergence. Therefore, this area would require complete conversion to highly flood-tolerant plant species, and all trees in this area would need to be removed and replaced over time to minimize safety risks.

The 122-acre Debris Management Evacuation Area consists primarily of mixed coniferous/deciduous transitional forest, dominated by Douglas fir, red alder, and big leaf maple, and deciduous riparian forest with some conifers, including species such as red alder, Western red cedar, Western hemlock, black cottonwood, willows, and big leaf maple. The Debris Management Evacuation Area would be inundated between 20 and 25.2 days during a flood, and most trees throughout this area would be partially or fully submerged for the duration of this time. Submergence introduces additional novel stresses to trees, decreasing their likelihood of survival. Therefore, all tree species that are not highly tolerant of flooding (i.e., all species except for willows and black cottonwood) would be expected to experience flood stress and may not survive this level of flooding. Douglas fir would likely perish; therefore, areas dominated by Douglas fir would be targeted for pre-operational in-planting of more flood tolerant species. If die-off does occur, most dead trees would be removed and replaced with trees and shrubs showing higher tolerance post-flooding. Some snags would be retained for habitat, and root wads and shrubs would not be removed.

The 238- to 527-acre Initial Reservoir Evacuation Area consists mainly of coniferous forest, dominated by Douglas fir, and mixed coniferous/deciduous transitional forest, dominated by Douglas fir, red alder, and big leaf maple. The Initial Reservoir Evacuation Area would be inundated between 6 to 11 days during a flood, and some trees could be partially submerged, depending on the severity of the flood. As such, species with low anticipated flood tolerance (e.g., Douglas fir) would likely exhibit signs of flood stress and some mortality from a single flood. These trees would be monitored and removed if they exhibit significant injury or mortality following a flood. As supported by data from Mud Mountain Dam, a similar temporary floodwater storage facility on the White River in Western Washington, species with moderate flood tolerance are not expected to experience significant mortality in the Initial Reservoir Evacuation Area from a single flood, but would be monitored for signs of flood stress over time.

To reduce potential effects associated with stream shading including increased temperature, reduced dissolved oxygen, increased turbidity, and losses to wildlife habitat, the Applicant proposes to begin planting flood-tolerant species (e.g., cottonwood, willow) at the start of construction, allowing the flood-tolerant trees and shrubs to grow prior to facility operations during a major flood. In-planting trees at the start of construction could also assist in the establishment of flood-tolerant species that may require shade during establishment, such as Western red cedar. To facilitate the establishment of canopy cover, especially in the riparian zone of the Chehalis River and its tributaries, dense plantings (3 feet-on-center) are proposed. Dense planting is expected to result in 80 to 100 percent cover after a period of 5 to 10 years.

Based on an assessment of the cover types present, planting of flood-tolerant species would occur in 115 acres of the Final Reservoir Evacuation Area and 105 acres of the Debris Management Area (Table 5.2-1). The vegetation management approach would entail a concerted effort to plant the riparian zones with flood-tolerant species of woody plants after facility construction begins. The remaining acres in the Final Reservoir Evacuation Area and Debris Management Evacuation Area would initially be in-planted and converted over time to more flood-tolerant species but trees would only be removed following events that result in tree death.

The Initial Reservoir Evacuation Zone would be inventoried and monitored after construction. Flood-tolerant species, such as black cottonwood and Oregon ash, would be in-planted along the riparian fringe and in flat areas that may accumulate sediment during floods that inundate lower portions of the temporary reservoir. Once the FRE facility is operational, monitoring would determine the need for tree replacements and in-planting.

Table 5.2-1
Acreages of Proposed Planting within the FRE Temporary Reservoir Area

REPLANTING AREA	ACRES OF PLANTING PER INUNDATION AREA	
	FINAL RESERVOIR EVACUATION AREA (WSEL 500–425 FEET)	DEBRIS MANAGEMENT EVACUATION AREA (WSEL 528–500 FEET)
Riparian Treatment	83	67
Wetland Mix	3	1
Final Evacuation Area Treatment	29	0
Debris Management Area Treatment	0	37
Total	115	105

As part of the VMP, the Applicant has incorporated an adaptive management plan in anticipation of the dynamic changes that would occur in the temporary reservoir following the commissioning of the FRE facility and the potential effects on vegetation. After a flood-retention event, vegetation in the temporary reservoir would be assessed, and trees that were deemed dead or likely to die would be targeted for removal. Larger dead vegetation would be selectively removed during the dry part of the year, and the area would be replanted as needed during the planting season (October-March). Some dead trees, which would not pose a hazard to the FRE, would be left in place as downed wood or snags to enhance wildlife habitat. Other removed trees would be used for the construction of mitigation measures to resupply LWM and function to aquatic habitats below the FRE facility. Where feasible, the slash generated from tree removal would be retained on-site and used to augment habitat enhancement efforts.

In the absence of the draft VMP which was developed following the issuance of the SEPA/NEPA-DEIS, Ecology assumed the permanent removal of 90% of the trees within 600 acres of the temporary reservoir and the associated potential effect on stream temperatures, dissolved oxygen, landslide potential, turbidity, and aquatic and terrestrial habitat. The VMP was developed by the Applicant to avoid and minimize SEPA/NEPA-DEIS-identified impacts at the FRE facility in the following ways.

- Retention of existing trees and shrubs; dense in-planting of flood-tolerant species (e.g., willow and cottonwood) in 220 acres at the onset of construction; and ongoing monitoring and replanting following major flood operations would maintain forested tree cover and significantly reduce Proposed Action effects associated with stream shading including increased temperature and reduced dissolved oxygen, both above and below the FRE facility.
- Reduction of tree loss and limitation of flood intolerant tree removal to only those trees that die off naturally following major flood operations (if they pose a safety hazard) would reduce the risk of landslides and reduce erosion potential and the associated risk of increased turbidity.
- Shade loss in the temporary reservoir would be reduced by initiating vegetation replacement with appropriate flood-tolerant species in the riparian areas and mixed wetland species in the wetlands. These actions, implemented at the onset of construction, would reduce the loss of riparian, wetland, and upland habitat for terrestrial species, retain ecological function of the existing vegetation, and enhance the vegetation community's ability to adapt to a new flood regime. Potential effects on ecological function would be further reduced by retention of dead standing trees that do not pose a safety risk, root structures, and placement of large woody material.
- Ongoing monitoring and planting of appropriate species to maintain riparian and wetland habitat with forested buffers would reduce the effects of the loss of wetland, wetland buffer, and stream buffer habitat. While the hydrologic regime would change during major flood operations, and the plant communities may be altered over time, these areas would continue to provide ecological function and wildlife habitat.
- Dense planting of a variety of species expected to have success at each inundation level would reduce the risk of future potential tree mortality and maintain canopy cover.
- Exclusive use of native, site-adapted, and flood-tolerant species for planting, potentially with seeds or cuttings sourced from the site, would maintain local native diversity and reduce the risk of future potential mortality.
- Reductions in the potential effect of the Proposed Action on physical habitat parameters would also reduce the potential effect of water quality on fish passage and survival, as well as survival of freshwater mussels and aquatic plants.

Because the VMP relies upon planting and management of native species with high tolerance for inundation, the vegetation would be expected to survive even if the FRE is triggered at a greater frequency than the current expectations based on historic hydrologic records. The seasonal timing of inundation is important with respect to plant survival, inundation that occurs during the winter months or the non-growing season has been found to be less of a concern for flood tolerant plants as compared to inundation during the summer. The flood tolerance of species proposed for planting is described in the VMP (Appendix C).

5.2.2 Fish Passage Plans

Since the release of the DEIS, the Applicant has updated the Project Description to include a plan for fish passage during the construction phase as described in Section 2.4.1. A separate plan for fish passage during operations would include constructed and operation of the CHTR. In combination, these plans detail how fish passage would be provided in a manner consistent with WDFW and NMFS passage criteria and survival standards.

5.2.3 Temperature Sensitivity Analysis

The Applicant conducted a sensitivity analysis of modeled water temperature changes forecasted for the future that was included in the SEPA/NEPA-DEIS. This analysis was undertaken to understand the sensitivity of model results with respect to assumptions regarding vegetation and shading (HDR 2021b; Appendix F). It also separated the projected water temperature effects due to long term climate change from the effects of the proposed project. For this analysis, the Applicant used information from the updated Vegetative Management Plan to refine the water quality model that was used in the water temperature impacts analysis reported in the SEPA/NEPA-DEIS (PSU 2017). The model was applied to the Impact Area and headwaters upstream of the proposed FRE facility. The only refinements to the model from the SEPA/NEPA-DEIS version were the vegetation/shade inputs.

The scenario inputs for the height of target tree species were: 90 feet tall for the Initial Evacuation Zone; 60 feet tall for the Debris Management Zone; and 20 feet tall for the Final Evacuation Zone. Mature tree heights assumed a 30-year growth timeline. Results of the Footprint Model are summarized below, in Table 5.2-2, and in Appendix F.

- Vegetation heights influence Proposed Action potential effect on water temperature, as predicted in the CE-QUAL-W2 Footprint Model.
- Refined shade inputs in accordance with the VMP would result in water temperature that averages 0.3°C higher under a 'high vegetation' scenario, and 1°C higher under a 'low vegetation' scenario relative to the updated baseline scenario under both current and future climate change conditions upstream of the FRE facility location (Table 5.2-2).
- Within a mile downstream of the FRE facility, the high vegetation scenario would result in an approximately 0.3°C average water temperature increase, and 0.4°C maximum water temperature increase, and the low vegetation scenario would result in an approximately 0.9°C average water temperature increase, and 1.1°C maximum increase.
- Higher riparian vegetation achieved by implementing the VMP would minimize water temperature increases in the temporary reservoir and downstream of the FRE facility.
- Review of the Mud Mountain analog example confirms that greater vegetation heights than previously assumed in the SEPA/NEPA-DEIS are likely to result from implementation of the VMP, this includes standing vegetation that would survive inundation in the Final Evacuation Zone.

Table 5.2-2
Water Temperature Results at the FRE Facility During Low Flow of Summer (June 20 to September 22)

	WATER TEMPERATURE CHANGE[1] (°C)			
SCENARIO	MINIMUM	MEDIAN	AVERAGE	MAXIMUM
Low Vegetation Scenario under Current Conditions minus Updated Baseline Scenarios under Current Conditions	0.7	1.0	1.0	1.4
High Vegetation Scenario under Current Conditions minus Updated Baseline Scenarios under Current Conditions	0.1	0.3	0.3	0.5

Notes:
1. Water temperature results from the model calculated as 7-DADMax.

5.2.4 Sediment Dynamics

The SEPA/NEPA-DEIS attributed significant impact to project-related changes in sediment transport, yet it does not quantify the amount of sediment that the river would be expected to transport annually during periods when the FRE is not operation. To improve understanding of changes to sediment dynamics associated with the Proposed Action, the Applicant developed a qualitative conceptual site sediment model (CSM, Appendix E). The CSM identified and described the channel morphology, hydrology, hydraulics, and sediment dynamics in the Chehalis River between a point about two miles upstream of the FRE temporary reservoir downstream to RM 85. The CSM would be used as a conceptual framework for future quantitative analysis to refine the characterization of ecological potential effects from future FRE facility operations on sediment dynamics in the Impact Area.

The conceptual site model addresses three primary types of potential effects from the Proposed Action related to sediment dynamics:

- Sediment deposition and reworking in the temporary reservoir footprint effect on aquatic habitat in the river channel and adjacent overbank areas.
- Erosion of sediment deposited during flood retention effect on water quality by increasing turbidity out of phase with the hydrograph.
- Delay of fine sediment delivery downstream of the FRE facility potential effect on channel morphology and coarsening of the riverbed sediment.

Flood control operations at the FRE facility are anticipated to occur on a 7-year flood recurrence-interval. During a catastrophic flood event, such as that which occurred in 2007, the temporary reservoir would hold flood water for a maximum of 32 days. Therefore, about 98 percent of the time on average over a 7-year period, the FRE facility would not retain water, nor would it affect downstream sediment transport. During the majority of the time that the FRE is not operating, including during floods up to and after the FRE gates closure, the river will be moving large volumes of sediment. An estimate of up to 100,000 tons of sediment per day can be assumed, based on a sediment transport capacity curve provided in support of the NEPA EIS using flows at the Doty gage (Watershed GeoDynamics and Anchor QEA 2017).

The FRE facility was designed to retain floodwater on the rising limb of the hydrograph until it reaches peak storage and to release it on the falling limb, creating a temporary reservoir. Once the temporary reservoir storage peaks, the FRE facility would operate to release water so that the temporary reservoir inflow would match outflow. During evacuation of the temporary reservoir on the falling limb at WSEL above 528 feet MSL, drawdown would be adjusted and regulated to a rate of 10 feet per day to minimize risk of erosion to side slopes. When the flood pool in the temporary reservoir reaches WSEL of 528 feet MSL, the outflow would be adjusted to a drawdown rate of 2 feet per day to allow about 2 weeks of boat access for cleanup of floating debris. When the flood pool reaches WSEL of 500 feet MSL, the outflow from the temporary reservoir would be returned to the 10 feet per day drawdown rate until run-of-river operation is resumed.

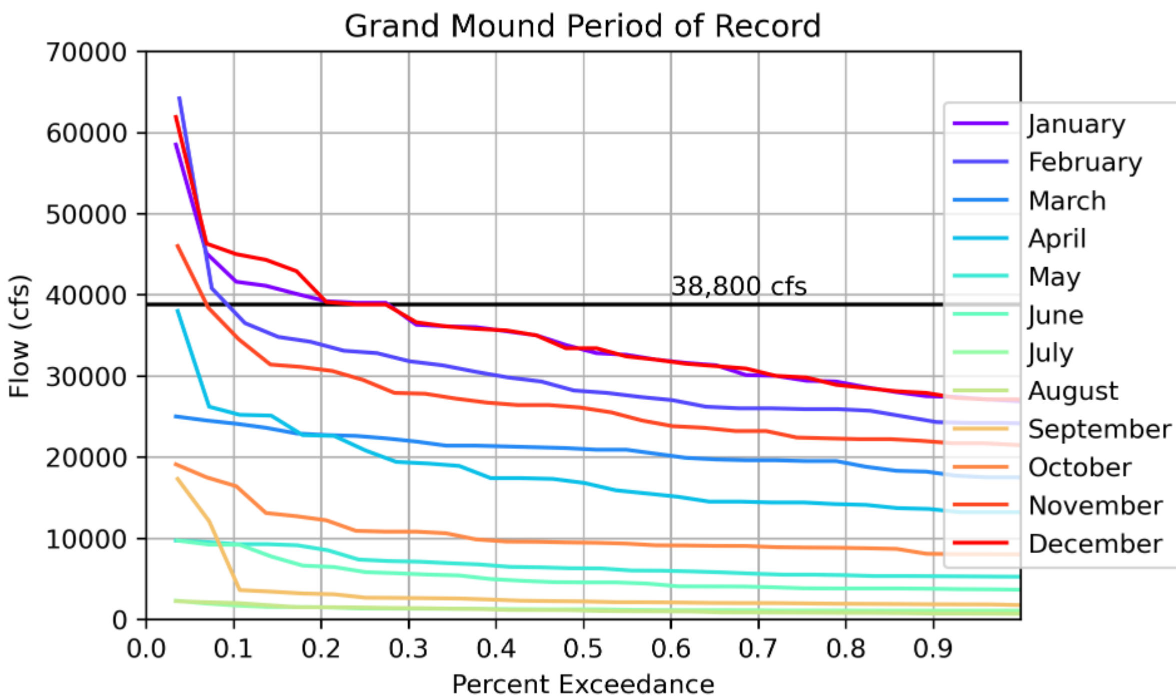
As the temporary reservoir fills during the rising limb of a flood, the flood pool would expand upstream to inundate up to 6 miles of the Chehalis River. Bedload and coarse-grained suspended sediment entering the pool would be deposited as flow velocity decreases. Silt and clay-sized sediment would remain suspended for longer and be distributed more broadly throughout the temporary reservoir. The finest material might remain in suspension long enough to be transported downstream during drawdown. As the temporary reservoir is drawn down during the falling limb of the flood hydrograph, sediment transport and deposition would continue. As the flood pool elevation decreases, sediment deposited in the primary deposition zone would be eroded and transported downstream into the receding pool. The progressive flushing of fine sediment during this period would increase turbidity.

The FRE facility conduits would be open during the period between floods, and water and sediment would move freely down the river channel. Sediment deposited during the preceding FRE operation would be reworked by small and moderate floods that do not trigger operation of the FRE and transported downstream. Erosion and transport of any fine sediments deposited in the temporary reservoir may cause changes in the timing and severity of turbidity at points downstream.

5.2.5 Spawning Habitat Analysis

Based on Chehalis basin historical hydrology (Figure 5.2-1), the FRE facility would operate once on average every 7 years, with the greatest chance of operation during the months of December, January, February, and November in decreasing order of occurrence. Based on existing climate prediction available at the time of this draft, under future climate change projections the FRE facility would be expected to operate once every 4 to 5 years.

Figure 5.2-1
Hydrograph for the Mainstem Chehalis River at Grand Mound Showing Percent Exceedance by Month. Flows Triggering Operation of the Facility (>38,800 cfs) Occurred Most Frequently in December, January, February, and November Over the Period of Record (1987-2022)



Operation of the FRE facility would likely overlap with the spawning periods for coho salmon and steelhead and, due to the depth of the flood pool, would have the potential to functionally eliminate spawning habitat under the temporary reservoir. Once the water has been released, depending on the month of flood induced operation, coho salmon and steelhead habitat potentially would be in a degraded condition until the river has had a chance to rework sediments deposited in the temporary reservoir. Because the facility is not anticipated to operate between June and August, the existing spawning habitat would be available for spring-run Chinook salmon during all years. However, for a period after temporary reservoir drawdown, the quality of that habitat might be reduced until the river reworks any sediment that was deposited near the head of the temporary reservoir.

5.3 Summary of Updated Impacts

The implementation of the Vegetation Management Plan and Fish Passage Plans, and consideration of the sensitivity analysis of thermal potential effects of the Proposed Action, allows various SEPA and NEPA-identified impacts to be updated in terms of scale, duration, and severity. Updates to applicable impacts are summarized in Table 5.3-1.

Table 5.3-1
Updates to SEPA/NEPA-DEIS-Identified Impacts Including the Phase of Proposed Action (Open Circles), and the Duration of the Estimated Effect (Solid Circles). Impacts for Which No Update Is Available Are Gray Font

ESTIMATED IMPACT	PHASE		DURATION		
FRE FACILITY AND TEMPORARY RESERVOIR IMPACT AREA	CONSTRUCTION	OPERATION	EPISODIC	TEMPORARY	PERMANENT
Temporary dewatering of the river and in-water work during construction	○			●	
Removal of 90% of the trees in the 600 acres of the temporary reservoir.	○				●
Update→ *The Applicant proposes not removing any trees prior to a major flood event other than what is required for construction and safety. Trees will be allowed to die naturally, and removal of dead trees will occur to allow for safe operation of the FRE. In addition, replanting and vegetative maintenance of flood-tolerant species within the temporary inundation zone as describe in the VMP would result in temporary and episodic impacts on water temperature and erosion as planted flood-tolerant trees mature. The estimated time to reach full shade canopy is 30 years (HDR 2022). Tree species composition changes would occur in 220 acres of the temporary reservoir.* ***Impacts shifts from Permanent to Episodic and Temporary.***			●	●	
Episodic temporary flooding of up to 847 acres (maximum flood pool)		○	●	●	
Update→ *Episodic flooding would cause the inundation of 808 acres (HDR 2021a). No update for impact phase or duration.*					
Water temperature increases of up to 9°F (5°C) related primarily to the loss of shade along 6 miles of river and 11 miles of tributary streams in the temporary reservoir, likely to result in an increased number of days when temperature and DO standards would be exceeded in summer months, and an increased risk to spawning and rearing salmon. This predicted temperature increase combines project potential effects with temperature increase attributed to climate change.		○	●	●	
Update→ *The VMP replanting plan would result in a temporary potential effect on water temperature. This was modeled to be a maximum of 2.5°F (1.4°C) under low vegetative conditions (volunteer willows only) and estimated to be 0.9°F (0.5°C) under high vegetative conditions (mature vegetation was 20, 60, and 90 ft for final, debris, and initial evacuation zone, respectively (HDR 2021b). No update for impact phase or duration.*					
Permanent loss of approximately 11 acres of wetlands and 333 acres of wetland buffers located in the 847-acre temporary reservoir, expected to reduce wildlife habitat, including western toad breeding habitat.		○			●

ESTIMATED IMPACT	PHASE		DURATION		
FRE FACILITY AND TEMPORARY RESERVOIR IMPACT AREA	**CONSTRUCTION**	**OPERATION**	**EPISODIC**	**TEMPORARY**	**PERMANENT**
Permanent elimination of 17 miles of stream channel and 441 acres of stream buffers. "Permanent elimination" entails habitat degradation and loss of ecological function along approximately 6 miles of the mainstem Chehalis River channel and 11 miles of tributary stream channel in the temporary reservoir. This includes loss of salmon, steelhead, and other native fish spawning and rearing habitat and would result in a reduction in the overall salmon and steelhead abundance, productivity, diversity, and spatial structure in the Basin.		○			●
Update→ *This habitat degradation would be minimized due to the VMP (HDR 2021a). Impacts associated with water temperature, erosion, and landslides would continue to be reduced over time with forest maturation. Additionally, the period of flow exceedance that would trigger the operation of the FRE facility do not overlap temporally with the spawning of spring-run Chinook salmon, therefore, spawning habitat may be temporarily degraded at multi-year intervals, but unlikely to be permanently lost.* ***Impact shifts from permanent to temporary****.*				●	
Degraded riparian function and reduced nutrient availability associated with degradation of 17 miles of stream channel and 441 acres of stream buffer.					
Update→ *This habitat degradation would be minimized due to the VMP (HDR 2021a). Impacts associated with water temperature, erosion, and landslides would continue to be reduced over time with vegetative maintenance and forest maturation. No update for impact phase or duration.*					
Increase in sediment loading in the temporary reservoir from increased risk of erosion and landslides. Also, reduction in sediment transport because sediment storage in the temporary reservoir would increase, likely to result in fining and shallowing of the riverbed upstream of the FRE facility.		○	●	●	
Permanent elimination of 0.3 acres of the Chehalis River channel at the site of the FRE facility.	○				●
Loss of 11.4 acres of Chehalis River floodplain associated with the FRE facility structure, associated facilities, and spoil areas.	○				●
Temporary fish passage interruption during FRE facility construction.	○			●	
Update→ *Fish passage designed to NMFS and WDFW criteria standards would be provided via bypass and trap and haul operations during construction (HDR 2022). No update to duration.*				●	
Increase in sediment loading during the 5-year construction period if the capacity of the diversion tunnel (2.8-year flood level or 7,000 cfs) is exceeded.	○		●	●	

ESTIMATED IMPACT	PHASE		DURATION		
FRE FACILITY AND TEMPORARY RESERVOIR IMPACT AREA	**CONSTRUCTION**	**OPERATION**	**EPISODIC**	**TEMPORARY**	**PERMANENT**
Elimination of upland, wetland, and riparian habitat and impacts on wildlife species from: • Removal of 90% of tree cover in the 600-acre temporary reservoir area during construction of the flood retention facility. • Tree removal on 847 acres from inundation of the temporary reservoir and periodic tree removal. • Inundation of up to 847 acres in the temporary reservoir area. • Decreased habitat functions. • Increased water temperatures. • Invasive species colonization. • Noise during construction. • Mortality of species unable to move during inundation of the temporary reservoir, like amphibians or nesting birds. • Mortality of species due to loss of habitat. • Decreased distribution of native species and increased habitat for non-native species.	○	○	●		●
Update→ *Loss of upland and riparian forest and shade related impacts would be minimized by planting flood-tolerant species as indicated in the VMP (HDR 2021a). This would, in turn, reduce potential for impacts to wildlife habitat and species. No update for impact phase or duration.*					
IMPACT AREA OF THE CHEHALIS RIVER WITHIN 20-MILES DOWNSTREAM OF THE FRE FACILITY					
Water temperature increase of up to 5.4°F (1.8°C) in the Impact Area downstream of the FRE facility (including the combination of project potential effects and potential effects of climate change), related primarily to the loss of shade along the river and tributary streams in the temporary reservoir area.		○	●	●	
Update→ *The VMP replanting plan would result in a temporary potential effect on water temperature, modeled to be a maximum of 2°F (1.1°C) under the low vegetative condition (volunteer willows only) and estimated to be 0.7°F (0.4°C) under high vegetative condition with mature vegetation at 20, 60 and 90 ft for final, debris, and initial evacuation zone respectively (HDR 2021b). No update to impact phase or duration.*					

ESTIMATED IMPACT	PHASE		DURATION		
FRE FACILITY AND TEMPORARY RESERVOIR IMPACT AREA	**CONSTRUCTION**	**OPERATION**	**EPISODIC**	**TEMPORARY**	**PERMANENT**
Decreased dissolved oxygen downstream about 20 miles from loss of riparian shading in the FRE temporary reservoir.		○	●	●	
Update→ *Shade related impacts would be minimized by planting flood-tolerant species as indicated in the VMP (HDR 2021a). This would, in turn, reduce potential for temperature and dissolved oxygen impacts. No update to impact phase or duration.*					
Episodic increase in turbidity when water is released from the temporary reservoir after floods: an unspecific amount of sediment deposited in the temporary reservoir would be remobilized and flushed downstream during drawdown.		○	●	●	
Update→ *Stream buffer losses would be minimized by planting flood-tolerant species as indicated in the VMP (HDR 2021a). This would, in turn, reduce sediment deposition in the temporary reservoir during floods. No update to impact phase or duration.*					
Interruption and alteration of sediment delivery downstream of FRE facility likely to result in changes to the composition of bed substrate, and possible changes to the elevation of the mainstem river channel and tributary confluences in the mainstem river. Downstream transport of woody material would be interrupted during operations, and the size range of recruited LWM that could pass the FRE facility would be limited.		○	●	●	
Update→ *FRE facility operations allow sediment transport during regular operation up to 38,800 cfs. Sediment transport model development is pending currently. No update to impact duration.*					
Changes in the movement of sediment, large woody material, nutrients, and water resulting in unquantified potential effects on fish habitat.		○	●	●	
Reduced groundwater recharge due to decreased area of floodplain engagement during flooding.		○	●	●	

6 MITIGATION APPROACH

The Applicant intends to follow a mitigation sequencing approach, working first to avoid and minimize Proposed Action potential effects on stream and terrestrial habitat, then restoring or rehabilitating the affected environment, and finally, compensating for unavoidable impacts.

6.1 Actions and Measures

This section summarizes specific measures that the Applicant has incorporated into the design, construction process and operation of the FRE facility to avoid, minimize, restore, and compensate for unavoidable impacts from the Proposed Action.

The Proposed Action would require the removal of vegetation during construction, staging, and access to and around the FRE facility; creation of temporary access roads and improvements to existing roads; temporary fish collection and bypass procedures and infrastructure; and selective vegetation removal and replanting in the temporary reservoir before the FRE facility is complete. On average, the project is anticipated to operate during a current 7-year flood interval, an interval which may decrease to once every 4-5 years with projected climate change. Operation of the FRE facility would require temporary storage of flood water; management of large woody material; and operation of the CHTR fish passage facility. Maintenance activities would include routine vegetation management in the temporary reservoir to ensure that the FRE facility could be safely operated, and that large woody material and sediment are safely transported downstream.

6.1.1 Avoidance

The Chehalis River Basin has a history of chronic flooding and flood damage from the Chehalis River and its major tributaries. Flooding has become more frequent in the Chehalis-Centralia area in recent years. Three recent floods in 1996, 2007, and 2009, were the largest on record (1923-2022) and caused extensive physical, economic, and emotional damage. These catastrophic floods caused the loss of homes, farms, and businesses, and floodwater inundation resulted in the closure of Interstate 5 for several days.

While the FRE facility cannot be constructed to fully avoid the Regulatory Floodplain, it was designed to minimize the necessary footprint and potential effects on the environment. To the extent possible, the Applicant would avoid creating new impervious surfaces by using existing roads for access to the construction site and the temporary reservoir; and anticipates that overhead or buried power and data lines would be installed along existing roads. To avoid or minimize risk to the FRE facility from earthquake-generated landslides, the FRE facility and appurtenant structures would be designed to withstand shaking on the Cascadia Subduction Zone and other nearby faults considered to have the most potential effect (including the Doty Fault). The design would be based on applicable seismic design standards and approved by the Office of Dam Safety.

The bottom of the FRE facility structure includes five 270-foot-long unlit conduits designed to convey normal river flow, provide upstream and downstream fish passage, and, while not in operation, allow downstream movement of sediment and woody material up to 15 feet in length and 3 feet in diameter. In addition to allowing volitional fish passage when the FRE facility is not operating, the design includes a Temporary Trap and Transport (TTT) system that would operate during construction to pass adult salmonids upstream, and a bypass tunnel to allow downstream fish passage. Finally, a fish trap and transport facility (CHTR) would function during FRE facility operation to prevent upstream passage delay. As previously described, the TTT and CHTR would be designed to meet NMFS passage and holding criteria, and pass all life stages of resident, anadromous, and lamprey species that currently occupy the Impact Area of the Chehalis River.

6.1.2 Minimization

Protecting natural resources from erosion, sedimentation, excess clearing, and pollutant discharge is a necessary aspect of construction and would be a crucial element of Proposed Action site-control requirements. The Applicant proposes a comprehensive set of impact minimization measures and best management practices (BMPs) to minimize construction-related impacts at the FRE facility. Detailed construction BMPs, which also include protections for marbled murrelets, are presented in Appendix H). In addition, the Applicant proposes minimization measures during operations and maintenance of the FRE facility to provide fish passage during construction, limit sediment and turbidity in the temporary reservoir, downstream geomorphological impacts, and landslide potential. These measures are described in Sections 6.1.2.1-6.1.2.9 below.

6.1.2.1 Temporary Trap and Transport for Upstream Fish Passage

A bypass tunnel would be built to divert the river around the FRE facility and CHTR construction sites that would provide downstream fish passage during the 32-month long construction period of the FRE facility. Due to expected high water velocity in the tunnel, it would not meet standards for upstream fish passage. Therefore, a TTT facility would be constructed and operated to provide upstream passage for fish during construction. The TTT facility would be installed and commissioned prior to any other in-water work.

All anadromous and resident species known to occur in the Action Area would be targeted for upstream passage. These species include juvenile spring-run and fall-run Chinook salmon, coho salmon, winter steelhead, cutthroat trout, Pacific and Western brook lamprey, and 14 other resident fish species. The intake for the TTT facility would conform to the most current NMFS and WDFW fish passage and screening design guidelines and criteria. Once construction is complete and the FRE facility begins normal run-of-river operation (Appendix B).

6.1.2.2 Sediment and Turbidity Control and Instream Temperature Attenuation

Minimization measures to limit sediment and turbidity and attenuate instream temperatures include the following:

- Development of a Surface Water Quality Monitoring Plan prior to construction, pursuant to the requirements of the future 401 Water Quality Certification, which describes measures to be implemented to monitor and mitigate impacts to water quality from fine sediments in the temporary reservoir and downstream.
- Implementation of the VMP and associated adaptive management plan:
  - No tree removal in the temporary reservoir area prior to flood control operations.
  - Planting of flood-tolerant species that are expected to be viable at each inundation level below 528 feet. Plantings would occur, where feasible, to maintain vegetation along the streambanks in the temporary reservoir footprint to minimize shade loss and limit runoff and erosion.
  - Monitoring tree survival following flood retention operations and selectively removing trees that could pose a hazard to the FRE facility.
  - Retaining legacy habitat components (e.g., snags, root wads, large woody material [LWM]).
  - Continued monitoring of vegetation success and revegetating bare areas with trees that could withstand periodic inundation (e.g., partially submerged in the temporary reservoir).
- Maintaining a flood pool drawdown rate that limits slope instability, currently proposed to be five inches per hour in the Initial Reservoir Evacuation Area (above an elevation of 528 feet MSL). This would reduce the risk of initial landslides. The flood pool drawdown rate would then be slowed to one inch per hour in the Debris Management Evacuation Area (500-528 feet MSL) for 14 days, then increased to five inches per hour in the Final Reservoir Evacuation Area (425-500 feet MSL) once debris management is complete (Shannon & Wilson 2014).
- Sediment would be allowed to move freely through the bypass tunnel during construction. Any sediment build-up that occurs related to flow events greater than tunnel capacity would be addressed with a Construction Sediment Management Plan.

6.1.2.3 Geomorphologic Conditions

Long-term potential effects on geomorphology include modifications to sediment transport quantities and timing, modifications to large wood recruitment and transport, and channel and bank erosion. To avoid and minimize these long-term potential effects on geomorphology, the following measures would be implemented:

- The FRE facility would allow the continuous passage of suspended sediment load and bedload, at all times except during operation.
- During a major flood, some woody material would likely be swept into the temporary reservoir. A Large Wood Management Plan would be implemented to ensure that LWM would not impact FRE facility operations or cause damage to the FRE facility, and instead would be removed as the

temporary reservoir recedes. Wood pieces would be stored for use in wood loading and mitigation enhancements downstream.

6.1.2.4 Vegetation Management in the FRE Facility Temporary Reservoir

As described in Section 5.2.1, the Applicant has developed a Draft VMP to avoid and minimize the potential effect on vegetation communities to the extent practical at the FRE facility and in the temporary reservoir. Vegetation communities in the project area, specifically streamside riparian vegetation, could help moderate local stream temperatures, intercept runoff and rainfall, and uptake nutrients that may affect downstream water quality parameters like stream temperatures and turbidity. Vegetation also provides habitat for wildlife. Functions provided by vegetation affect a variety of natural resources that are regulated at the federal, state, and local levels.

The VMP includes the following avoidance and minimizations:

- Retain trees and shrubs within the temporary inundation zone to the extent practicable.
- Limit initial tree and shrub removal to only areas necessary for construction access and staging areas for the new temporary reservoir and vegetation that could pose a hazard to operations personnel, especially those responsible for wood material collection and transport.
- Proactively plant 115 acres of the Final Reservoir Evacuation Area and 105 acres of the Debris Management Evacuation Area with flood-tolerant plant and shrub species at the onset of construction to allow them to grow and begin producing shade prior to FRE operations.
- To facilitate the establishment of canopy cover, especially in the riparian zone of the Chehalis River and its tributaries, densely plant (3 feet-on-center) trees and shrubs. Dense planting is expected to result in 80 to 100 percent cover after a period of 5 to 10 years.
- Plant a variety of species expected to have success at each inundation level.
- Exclusively use native, site-adapted, and flood-tolerant species for planting, potentially with seeds or cuttings sourced from the site.
- Include planting of test plots with potential flood-tolerant species and permanent plots for monitoring.
- Survey and monitor the temporary reservoir area following flood retention events and limit tree removal to trees that are deemed dead or likely to die that present a potential hazard to the FRE facility or safety of personnel. Remove trees during the dry part of the year.
- Replant affected areas as needed during the planting season (October-March).
- Retain select trees that do not survive inundation as legacy habitat components (i.e., snags, root wads, LWM).
- Retain the slash generated from tree removal on-site where practical to augment habitat enhancement efforts.
- Use removed trees for the construction of instream aquatic habitat mitigation measures.
- Implement an adaptive management plan to provide for the ongoing monitoring of vegetation succession to ensure survival of plants and desired canopy cover.

Tree removal would be guided, but not limited, by the following BMPs to avoid and minimize the potential effect on aquatic and riparian functions, wetland functions, and temporal loss of tree canopy:

- Retention of snags where feasible.
- Leave any retained trees with large root systems embedded in the bank.
- Remove trees while retaining stumps, minimizing ground disturbance and potential sedimentation.
- Avoid disturbing stumps and root systems and any logs embedded in the bank.
- Leave high stumps as necessary to prevent felled and bucked large woody material from entering the water.
- Avoid disturbing understory wetland, riparian, and upland vegetation.
- Use reasonable care during timber yarding to minimize damage to any vegetation providing shade to the stream or open water areas, and to minimize disturbance of understory vegetation, stumps, and roots.
- Minimize the release of sediment to waters downstream from the yarding activity.
- Conduct tree removals from existing access roads to the greatest extent feasible to avoid potential effect on adjacent understory vegetation.
- Avoid burning removed trees.

The Applicant would conduct 20 percent of the total proposed tree removal each year during the 5-year FRE facility construction period.

6.1.3 Restoration

The Applicant intends to restore and revegetate all areas cleared for construction staging and access that are not part of the permanent FRE facility. This includes approximately 9,100 linear feet of temporary gravel access roads that would be built on the active construction site. Temporary roads would also provide access to the selected quarry site and material processing and production areas. Currently, the Applicant proposes to decommission all temporary roads after construction and restore habitats to pre-construction conditions. In the temporary reservoir area, native flood-tolerant species would be used for replanting.

6.1.4 Compensation

Following implementation of avoidance, minimization, and restoration measures, the construction and operation of the FRE facility would have unavoidable long-term potential effects on physical processes of the river channel and floodplain including hydrology, hydraulics, sediment transport dynamics, recruitment and transport of Large Woody Material, and geomorphology. Changes in these processes may produce both negative and beneficial potential effects on water quality, aquatic habitat, and terrestrial habitat on the floodplain, and thus indirectly cause long-term potential effects on aquatic, riparian, and floodplain-dependent species.

To address the potential for unavoidable potential effects from the construction and operation of the FRE facility on environmental conditions, including those on EFH for Pacific salmon, the Applicant commits to implementing a suite of aquatic, riparian, and upland habitat mitigation and enhancement actions in the Chehalis River Basin from the headwaters downstream to the Newaukum Basin. Mitigation project types are described conceptually in Section 8. Specific projects would be identified during the permitting process.

6.2 Mitigation Goal

The Applicant is making a formal commitment to achieving no net loss of aquatic and terrestrial habitat function due to the construction and operation of the proposed FRE facility in the upper Chehalis Basin. In fact, the Applicant would agree to plan, secure funding for, and implement a suite of mitigation actions that would lift the ecological value of upper Chehalis River basin habitats by replacing lost habitat or enhancing currently degraded habitats to support native aquatic and terrestrial species. To achieve this lift in the dynamic and evolving ecosystem of the Chehalis River, the Applicant would apply mitigation ratios of 2.5:1 (2.5 units of habitat mitigated for 1 unit of habitat degraded) for the planned mitigation, would develop and implement long-term monitoring plans to ensure the sustainability of actions over time, and would develop and implement adaptive management plans to ensure that the goals of specific mitigation actions are met and to provide an opportunity for adjustment under future uncertainties. These components of the Applicant's mitigation plan would be developed further as the project proceeds through the NEPA process and permitting, in collaboration with regulatory agencies.

For this Draft Conceptual Mitigation Plan, defining the functional value of habitats and the species that use them in the Impact Area of the Chehalis Basin was based on an analysis of existing data including basin wide surveys on fish, wildlife, and habitat conducted by WDFW since 2014; water quality and flow analyses conducted by Ecology and USGS for over 20 years; studies completed by various entities under the Chehalis Basin Strategy (Chehalisbasinstrategy.com); climate change modeling for Washington State and the Pacific Northwest by regional universities (University of Washington, Portland State University); and historic studies on sediment, groundwater, flood inundation, etc. (i.e., Glancy 1971). Based on this information about the current Existing Condition and the estimated potential effect on these conditions by the Proposed Action, the Applicant prioritized mitigation actions that would provide ecological lift specific to those habitats and species with potential to be affected by the project in the Impact Area. The fundamental objectives of these actions, as they provide lift to estimated degradations associated with the Proposed Action, are described as follows.

6.2.1 Mitigation Objectives

The Applicant seeks to identify sufficient feasible project opportunities to provide ecological lift that would offset the potential effects of the Proposed Action on Existing Baseline Conditions in the Impact Area, and effectively implement those projects to achieve the ultimate mitigation goal of achieving no net loss.

The fundamental objectives developed to support the achievement of no net loss are:

1. Improve water temperature conditions for aquatic species through vegetative management by limiting tree removal and re-planting of native trees and shrubs in the temporary reservoir as described in the VMP and improve stream shading in riparian corridors throughout the Impact Area by replanting to expand riparian buffers.
2. Improve water temperature conditions through instream and off-channel habitat projects that create cold water refugia, improve groundwater and tributary cold-water retention (pools), and improve access to cool water habitat.
3. Improve water quality in the temporary reservoir and Chehalis River downstream by managing vegetation for slope stability (turbidity, erosion), managing flood pool drawdown to control sediment transport, and implementing BMPs for construction to avoid contamination.
4. Improve aquatic habitat by restoring previously degraded habitat. Habitat features would be selected to work with reach-level geophysical processes to improve habitat complexity and diversity in the upper Chehalis River. Further, these improvements would increase the amount of habitat that could support salmon spawning and rearing, native fishes, and amphibian rearing and reproduction.
5. Remove fish passage impediments (e.g., impassable culverts) to increase connectivity of stream habitat and the amount of quality habitat available to support native fish spawning and rearing.
6. Improve riparian function in the upper Chehalis River by removal of invasive riparian species and replanting with native trees and shrubs to increase value of this habitat for nutrient cycling and to support native amphibians, birds, and mammals.
7. Improve wildlife habitat in the temporary reservoir area by changing land use, enhancing, and conserving hundreds of acres of forest. Forested acreage would be removed from active timber harvest and either managed to establish a mixed forest of native species or conserved as coniferous forest to increase ecological function such as nutrient cycling and provide long term habitat for forest dwelling birds and mammals.

6.3 Summary

As mitigation concepts and opportunities advance to the project planning phase, site-specific assessments of ecological function and value would be conducted, including field surveys to characterize habitat conditions and species use of proposed project sites.

Agency and Tribal representatives have expressed particular concern for the local populations of spring Chinook salmon in the upper Chehalis Basin. The EDT modeling program has been used to project future expectations for Chehalis River salmon populations. For spring-run Chinook salmon, the model predicts a future total loss of local populations in the basin due to climate change (i.e., thermal exclusion from habitat). By implementing mitigation actions such as improving existing habitat and restoring access to quality spawning areas and rearing habitat, the Applicant’s mitigation plan specifically addresses the concern that the Proposed Action could accelerate this projected loss to the upper Chehalis River spring Chinook salmon population. The Applicant would develop a mitigation-based EDT model to predict and evaluate salmon habitat potential and equilibrium salmon population abundance consistent with Viable Salmonid Population parameters (abundance, productivity, diversity, and spatial structure). This mitigation EDT model would be one tool to help prioritize mitigation sites and evaluate success.

7 MITIGATION SITE SELECTION

Mitigation planning described in this draft FRE-HMP considers federal and state regulatory requirements and mitigation guidance (WDFW 2000). Standard Mitigation sequencing is a process for avoiding, minimizing, or compensating for the potential effects of an action on the environment. Avoidance and minimization measures proposed under this CMP are discussed in Section 6.1.1 and 6.1.2. Compensatory mitigation actions were identified that prioritize actions that are on-site and in-kind in favor of actions that are off-site or out-of-kind. All mitigation actions proposed were deemed to be feasible. To the extent that feasible on-site/in-kind mitigation would not of sufficient quantity to meet the mitigation objectives, off-site/out-of-kind mitigation would be proposed.

7.1 Mitigation Actions

Based on the potential effects of the Proposed Action and considering related liming factors currently present in the upper Chehalis River, the Applicant developed a set of mitigation actions (Table 7.1-1). Existing information for the overall basin was then reviewed and locations where each of the mitigation actions could be implemented were identified (Mitigation Opportunities Assessment Report [MOAR], Kleinschmidt 2020). More than 400 potential locations were identified and are listed in the MOAR report (Kleinschmidt 2020).

Table 7.1-1
Proposed Mitigation Action Types

MITIGATION	ACTION TYPE	DESCRIPTION
Fish and Aquatic Species and Habitats: Aquatic Habitat Access	Barrier Removal and Habitat Enhancement	Opening access to currently inaccessible or partially blocked fish habitat including removal of barriers and rehabilitating the impacted stream reach.
Fish and Aquatic Species and Habitats: Aquatic Habitat Enhancements	Water Temperature Improvements	Instream, bank, and off-channel habitat modifications to intercept or expand areas of cool water inflow and create cool water refuge habitat for aquatic species.
	Instream Modifications	Habitat features in the perennial wetted channel to serve ecological purposes such as enhancement, restoration, inducement, or creation of habitat forming processing such as complexity, cover, hydraulic diversity, pool formation, cold water refuge, and spawning gravel retention.
	Off-Channel Modification	Off-channel habitat enhancements including side channel and floodplain actions to reconnect, enhance, and expand off-channel habitat.
	Gravel Retention Jams	Larger instream structures composed of large wood pieces and rock located and designed to provide hydraulic roughness and promote accumulation and retention of salmonid spawning gravels and the creation of hydraulically sheltered gravel deposits in steep channels draining landslide/debris-flow prone hillslopes. Instream structures may include gravel augmentation in areas with limited gravel budgets.
	Wetland Enhancement	Enhancement, restoration, or expansion of floodplain wetlands to benefit wildlife species and increase water table/exchange between river and wetlands.
Riparian/Stream Buffer Downstream	Riparian habitat Enhancement Downstream of FRE	Expand and enhance the riparian buffer with planting native shrubs and trees to increase shading, bank stability, nutrient cycling, habitat complexity and structure, habitat function for native species.
Wildlife Forest Habitat	Upland Forest Conservation	Conservation and enhancement of forested riparian habitats to support wildlife species.
	Riparian Forest Expansion	Expand the existing riparian forest corridor to enhance habitat for native wildlife.
In-channel LWM	Riparian Buffer Expansion	Expand and enhance forest no-cut buffers areas and degraded riparian habitats downstream to increase mature wood available for recruitment.
	Wood Placement	Enhance habitat diversity and complexity and improve ecological function using in-channel wood for aquatic habitat enhancements.

7.2 Mitigation Site-Selection

While the MOAR identified 404 potential mitigation sites based on remote assessment, this preliminary list of potential sites needed to be screened to advance sites that are feasible within the natural processes operating on the Chehalis River. To advance the preliminary MOAR sites, the Applicant provided a geomorphic assessment that considered how reach scale attributes would affect project performance by mitigation action type. For example, projects that provide habitat that is formed under dynamic channel-shifting conditions are most likely to function properly when sited where hydraulic and sediment transport processes favor both deposition of sediments and channel migration-- segments that also tend to be geomorphically active. Alternatively, projects that provide instream habitat structure would function best when sited in reaches where sediment transport and channel movement are in relative equilibrium (i.e., geomorphically inactive). A summary of potential mitigation project subtypes and favorable reach-scale attributes is provided in Appendix A3 which also includes results of the Geomorphic Assessment.

In addition to the MOAR site dataset, the Applicant reviewed existing databases that identified current barriers to aquatic habitats, and riparian stream segments degraded with respect to shade conditions. These data bases provided numerous opportunities for mitigation and required screening to reduce the data with respect to the Applicant's mitigation goals. The analyses used for screening potential mitigation opportunities is described below.

7.3 Site Selection Analysis

To identify potential mitigation sites, the Applicant reviewed and analyzed separate data sets: 1) two WDFW barrier databases and the Washington Department of Transportation culvert database were reviewed for potential habitat connectivity projects, 2) a database of riparian canopy condition by Chehalis River stream segment (Beechie et al. 2021), and 3) the Applicant's previous data set of conceptual mitigation opportunities (Kleinschmidt 2020). In addition to site-specific analyses for identification of aquatic and riparian enhancements, the Applicant is pursuing the conservation of upland terrestrial habitat (Section 8.5). The mitigation project types and limiting factors addressed by each site-selection approach are listed in Table 7.3-1. The following sections present methodologies for each approach the Applicant pursued to identify mitigation sites. Results of these site-selection analyses are described in Section 8.0 and Appendices A2 and A3.

Table 7.3-1
Mitigation Site Selection Analysis

SITE-SELECTION ANALYSIS	MITIGATION PROJECT TYPES	LIMITING FACTORS ADDRESSED
Habitat Access Assessment	Habitat access improvement Instream modifications	Loss of connectivity with fish spawning and rearing habitat
Geomorphic Analysis	Water temperature Improvements	Degraded water quality and quantity Poor quality spawning and summer rearing habitat Loss of access to spawning and rearing habitat
	Instream modifications	Degraded floodplain conditions Changes in sediment conditions Reduction of wood transport below the FRE Loss of habitat complexity and function Degradation of fish spawning and rearing habitat
	Off-channel modifications	Degraded floodplain conditions Changes in sediment conditions Degraded water quality and quantity Loss of stream channel in the temporary reservoir Reduction in groundwater recharge
	Gravel retention jams	Loss of stream channel in the temporary reservoir Degradation of salmon spawning habitat Loss of habitat complexity and function
	Wetland enhancements	Loss of wetland habitat in the temporary reservoir Reduction in groundwater recharge/exchange
Riparian Habitat Assessment	Riparian buffer expansions Riparian planting	Degraded riparian conditions Degraded water quality/temperature Low level LWM Degraded turbidity due to storm related erosion

7.3.1 Aquatic Habitat Access Assessment

As discussed in Section 3.1.2.3, there are hundreds of natural and manufactured fish passage barriers throughout the Chehalis Basin including culverts, fishways, and natural blockages that may preclude fish access to potential spawning and rearing habitat. Barriers in the Chehalis Basin have been assessed and prioritized by WDFW and other entities using methods described in the Fish Passage Inventory, Assessment, and Prioritization Manual (WDFW 2019d). Review of both the Washington Department of Fish and Wildlife Prioritized Chehalis River Barriers database (WDFW 2020a) and the WDFW Statewide Fish Passage Barrier Assessment database (WDFW 2022b) identified potential opportunities to remove barriers and enhance stream habitat to open access to aquatic habitat in general and for coho and Chinook salmon and steelhead. The linear mileage of affected stream habitat was calculated for each mitigation reach.

Selection of fish passage barriers for removal requires field surveys to corroborate survey results, assess the quality of habitat available, and identify limitations or constraints to project implementation and landowner approval, where applicable. The results of field surveys would be used to update mitigation opportunities to open access to habitat. The updated information would be used to select sites that address species-specific potential effects (i.e., anadromous salmon) and are most likely to provide long-term ecological value.

7.3.2 Reach Scale Geomorphic Analysis: Water Temperature Enhancements

The Applicant performed reach-scale geomorphic analysis in mainstem Mitigation Reaches A-D to identify feasible mitigation sites based on the habitat complexity driven by physical processes (DeVries and Aldrich 2015). The reach scale screening analysis identified locations for mitigation projects intended to increase instream and off-channel habitat quantity and quality for fish. Quantitative, process-based analyses relied upon hydraulic and sediment transport modeling and simplified, measurable, process-based changes in morphology. This analysis supported assessing the feasibility of site-specific projects and evaluating constraints posed by larger reach-scale natural processes (DeVries and Aldrich 2015). Details about the reach-scale geomorphic analysis can be found in Appendix A3 and includes criteria used to evaluate feasibility of the action types (Table 7.1-1) at specific locations in the upper Chehalis River mitigation reaches.

7.3.3 Riparian/Stream Buffer Habitat Analysis

Potential increase in water temperature is a major impact identified by the SEPA/NEPA-DEIS. Improvements to riparian structures that provide shade to the river channel would help to minimize potential temperature increases. Due to degradation of the riparian conditions along the Chehalis River, various opportunities exist to establish forest vegetation along channel margins, providing shade and enhancing other riparian forest ecological functions. Washington State’s 2006 Forest Practices Habitat Conservation Plan (HCP) includes measures intended to protect and restore the riparian buffer zone for shade, reduce summer water temperatures, prevent fine sediment delivery from surface erosion, and provide a source of large woody material. Riparian buffer zones in the mainstem and tributaries upstream of the proposed FRE facility appear consistent with the HCP requirements; however additional buffer beyond HCP requirements around the edge of the temporary reservoir and in lower tributary reaches could help to minimize potential Proposed Action impacts. Downstream of the FRE facility, there are significant reaches of the Chehalis River with floodplain edge open areas that would benefit from riparian reforestation and buffer expansion through plantings and installation of flood fencing. Flood fencing can also benefit land use by trapping debris and sediments that farmers would otherwise have to remove after major floods, and thus represent a potential ‘win-win’ mitigation action.

To evaluate locations where riparian buffer enhancement would increase shade and reduce potential temperature increase, the Applicant used the output from NOAA’s process-based analysis for quantifying historical, current, and future habitat conditions of the Chehalis Basin (Beechie et al. 2021). The Applicant conducted a reanalysis of the NOAA data to help identify stream reaches where the riparian canopy has undergone considerable change. For this analysis, a threshold of a 30 degree change in canopy angle opening was used to indicate degradation from historic conditions. NOAA data show a change of canopy angle of 30 degrees was associated with stream temperature increases of over 1^{o}C.

Selection of riparian areas for targeted replanting or restoration efforts would require field surveys to corroborate data from aerial maps or outdated GIS vegetation layers, and to identify limitations or constraints to project implementation and land ownership, where applicable. The results of field surveys would be added to the existing list of available riparian buffer expansion opportunities to select sites for projects that address potential effects and are most likely to provide long-term mitigation value.

7.4 Mitigation Requirements

As the draft FRE HMP moves toward a final mitigation plan, the types, quantities, and locations of compensatory mitigation needed to offset unavoidable impacts will be further quantified. Mitigation requirements will also be informed by state and federal guidelines pertaining to aquatic and terrestrial species and habitats, and by consideration of the jurisdictions of federal, state, and local regulatory agencies and tribes. The on-site Mitigation Area, includes the Impact Area, which was defined as the FRE facility, temporary reservoir, and the 20-mile segment of the mainstem Chehalis River between the FRE facility (RM 108.5) and the South Fork Chehalis River confluence at RM 88.1. The off-site mitigation area proposed by the Applicant includes the portion of the Chehalis Basin upstream of the Newaukum River confluence that is outside of the on-site mitigation area. Existing Conditions of the Mitigation Area, which is divided into Mitigation Reaches A-D are described in Section 3.0.

7.5 Climate Change

Implications of future climate change on the potential effects of the Proposed Action on aquatic habitat as well as baseline changes to conditions in the Chehalis Basin due solely to climate change are important to the long-term potential effectiveness of mitigation planning under the Stream and Terrestrial Mitigation Plan. The Monitoring and Adaptive Management Plan (Section 9.0) addresses climate change in the context of long-term monitoring and adaptive management.

7.6 Summary of Selected Sites

A review of existing barrier datasets identified total of over 252 barriers and other impediments to fish habitat access in the Mitigation Area. This provides opportunity for reconnecting more than 375 miles of potential linear habitat suitable for anadromous salmonid and other native fishes.

The reanalysis of existing riparian shade conditions from Beechie and others (Beechie et al. 2021) identified a total of 18.3 miles of stream channels upstream of the temporary reservoir and 145.7 miles downstream with degraded riparian habitat conditions. These areas with degraded canopy cover provide mitigation opportunities for riparian enhancement and improved thermal buffering.

The MOAR identified a total of 404 aquatic mitigation opportunities. The application of geomorphic criteria to the identified sites was limited by the spatial extent of the modeled hydraulic and sediment transport processes, resulting in 212 mitigation action opportunities that were able to be evaluated in the reach scale screening analysis. Of these, the most common project types in the model extent were water temperature improvements (132), and off-channel modifications (32). The potential mitigation actions evaluated were more abundant in Mitigation Reaches A (62) and D (88) with fewer sites evaluated in Reaches B (24), and C (38).

The application of geomorphic criteria to evaluate the feasibility of identified opportunities in the MOAR resulted in advancements of selected sites from a status of ‘mitigation opportunity’ to a status of ‘geomorphically vetted mitigation site.’ These actions are presented in this conceptual plan as potential habitat enhancement mitigation and include the advancement of 64 of the 212 (30.2%) actions at 41 of the 106 sites (38.7%). Sites advanced for further evaluation included 36 actions identified at primary sites (all criteria met for the proposed action), and 28 actions identified at secondary sites (suitable for the proposed action but conditions may not be ideal). The geomorphically vetted habitat enhancements, are presented in Section 8 below.

8 COMPENSATORY MITIGATION

As described in Section 5.0 (Proposed Action Draft Impacts), and 6.0 (Mitigation Approach), the Applicant has identified information that further refines potential effects from the Proposed Action and has developed actions that would help avoid and minimize the potential effects; however, unavoidable potential effects to stream and terrestrial habitats remain a concern (Table 5.3-1). To identify appropriate mitigation, the Applicant has reviewed existing information on existing and future conditions and limiting factors in the Impact Area, and has identified 11 mitigation action types that would replace ecological functions lost or impaired by anticipated effects of the Proposed Action on stream and terrestrial habitat. The potential Proposed Action impacts identified in the SEPA and NEPA DEIS (Corps 2020; Ecology 2020) are summarized in Table 5.1-1.

The mitigation action types are defined in Table 7.1-1, and available opportunities for each in the Mitigation Area are described in subsequent sections. At this conceptual stage, the Applicant is not committing to implementing all the mitigation actions presented below. Rather, the intent is to demonstrate that there are adequate opportunities to fully mitigate unavoidable impacts within the Mitigation Area, also allowing for the uncertainty of mitigation effectiveness. Some of these opportunities may be screened out during permitting and future mitigation plan development due to factors such as site access and permission, or other challenges to obtaining mitigation sites by purchase or easement. The required amount of mitigation and specific mitigation projects would be determined during the permitting process.

Mitigation actions would be carried out in an integrated reach-scale approach by combining multiple mitigation techniques to produce high-value, properly functioning ecological communities, optimize ecological benefits, and achieve cost efficiencies. After specific mitigation projects have been identified, the existing conditions at each site and the amount and extent of anticipated ecological lift would be determined.

8.1 Mitigation Quantity

There is no set of standardized mitigation ratios for aquatic or terrestrial impacts. Regulatory agencies apply mitigation ratios, typically during permitting, aimed at ensuring no net loss of ecological functions and values. Mitigation ratios often result in a larger area or amount of mitigation compared to the area or amount of impact. In practice, mitigation ratios for impacts on aquatic habitat typically vary between 1:1 and 2:1 (WDFW 2000). Additionally, Bradford (2017) suggested that a multiplier of 1.5:1 or 2.5:1 is sufficient for addressing uncertainty when offsetting impacts to freshwater fish productivity.

In addition, recent analyses by the Applicant, and ongoing analyses by the Corps and Ecology are expected to refine potential effects of the Proposed Action. Thus, for this draft FRE HMP, mitigation ratios have not yet been defined nor are mitigation quantities specified. Rather, it is the intent of this document to demonstrate that enough feasible sites exist in the Mitigation Area to mitigate Proposed Action potential effects at a ratio of 2.5:1.

As described in Section 7, the Applicant used distinct analytical approaches to evaluate the quantities of available feasible mitigation by category, including Aquatic Habitat Access, Aquatic Habitat Enhancements, Riparian/Stream Buffer Expansion, and Wildlife Habitat Conservation. The results of those analyses represent feasible quantities and are presented for each mitigation category below.

8.2 Fish and Aquatic Species and Habitat

Proposed mitigation to offset potential project effects on fish and aquatic species includes increasing fish access to suitable habitat and implementing aquatic habitat enhancements. Increasing and improving the current habitat available to fishes and other aquatic species in the upper Chehalis River would result in dramatically improved habitat productivity and offset potential losses associated with temporary flood retention.

8.2.1 Aquatic Habitat Access

This mitigation category entails the removal of impediments to fish use of aquatic habitat through barrier removal, replacement, or alteration to increase the amount of habitat available to salmonids and resident fish.

8.2.1.1 Overall Goals and Objectives

The goal of this mitigation category is to mitigate for the following impact identified in the SEPA/NEPA-DEIS:

> *Permanent elimination of 17 miles of stream channel, entailing habitat degradation and loss of ecological function along approximately 6 miles of the mainstem Chehalis River channel and 11 miles of tributary stream channel in the temporary reservoir.*

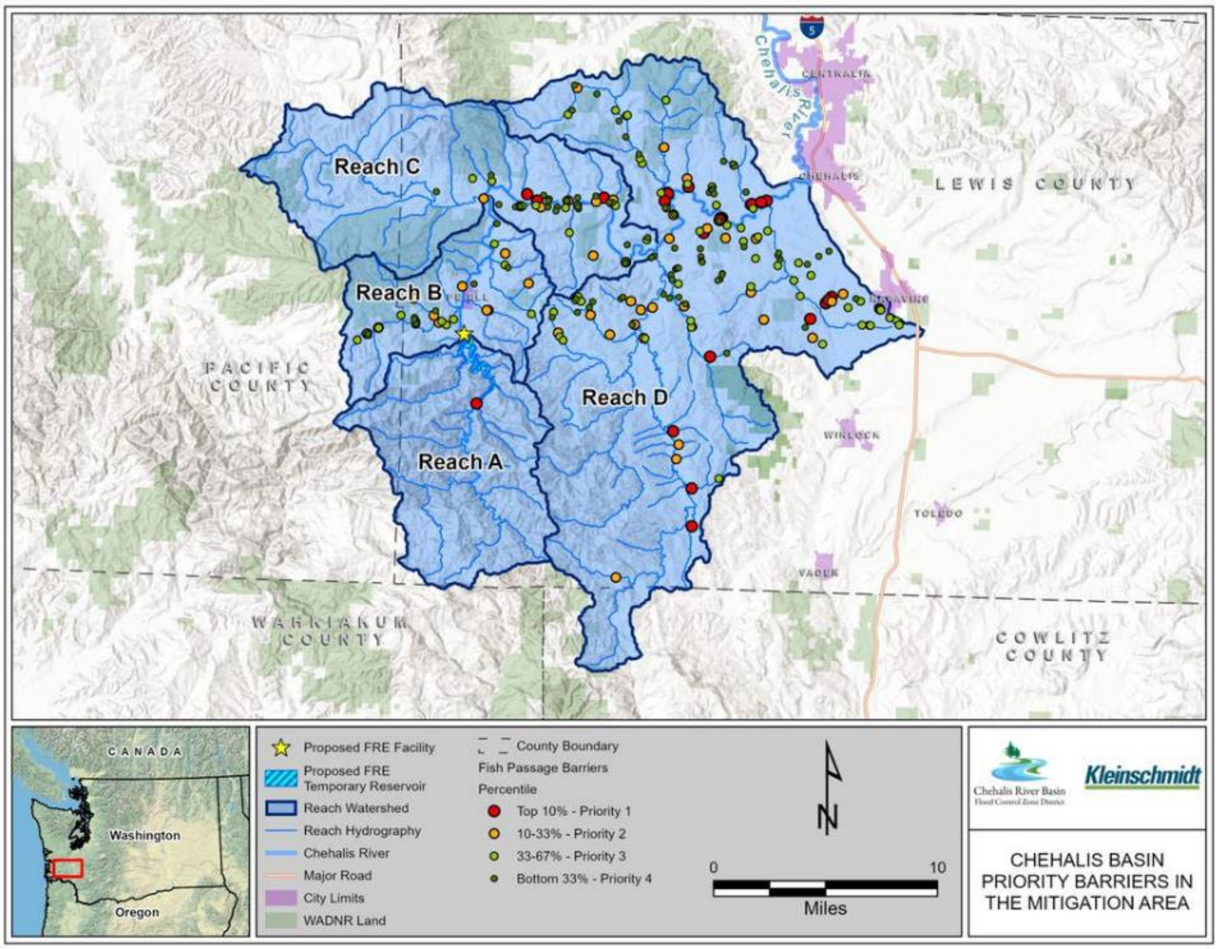
The objective is to remove impediments to fish use of aquatic habitat through barrier removal, replacement, or alteration. Barrier removal would increase habitat connectivity and increase the amount of habitat available for all life stages of native fishes. Barrier corrections that could result in improvements to habitat available for coho salmon, steelhead, and spring-run Chinook salmon spawning are especially desirable.

Site-specific and quantitative targets for the number of barrier corrections required to mitigate the degradation of fish habitat in the temporary reservoir would be determined following issuance of the final SEPA/NEPA EIS and during the subsequent permitting process. Based on the SEPA/NEPA-DEIS impacts noted above, the Applicant would open access to 42.5 miles (17 miles at a mitigation ratio of 2.5:1) of habitat suitable for spawning and rearing of salmon, steelhead, and other native fishes to offset any potential reductions in salmon and steelhead abundance, productivity, or spatial structure in the Impact Area.

8.2.1.2 Site Restoration Potential

Based on a review of both the WDFW Prioritized Chehalis River Barriers database (WDFW 2022a) and the WDFW Statewide Fish Passage Barrier Assessment database (WDFW 2022b) the Applicant identified a total of 252 opportunities to remove barriers and other impediments to fish habitat access in the Chehalis Basin in Mitigation Reaches A-D, with nearly 375 miles of potential linear habitat gain opportunity for anadromous salmonids. Figure 8.2-1 displays the WDFW prioritized culverts in the Chehalis Basin.

Figure 8.2-1
Chehalis Basin Priority Barriers in the Mitigation Area. Source: WDFW Prioritized Barriers in the Chehalis Basin (WDFW 2022a)



The number of potential projects identified by the Applicant in each Mitigation Reach is presented in Table 8.2-1. Barriers listed in the WDFW Statewide Fish Passage Barrier Inventory database (WDFW 2020b) do not include the survey data on fish presence; therefore, fish use was assumed based on species distributions and contains some uncertainty. As indicated in Table 8.2-2, there are 365.2, 239.9, and 2.6 miles of stream habitat that could be opened for coho salmon, steelhead, and spring-run

Chinook salmon, respectively, by removal of barriers within Mitigation Reaches A-D. The actual extent of suitable habitat by species would need to be further evaluated to estimate species-specific habitat quantities at these second-tier barriers. A comprehensive index of fish passage barriers in the proposed Mitigation Area including percent blockage, ownership, available salmonid habitat above the barrier, and priority status is provided in Appendix A1, Attachment 1. It is likely that sufficient projects would be identified within the proposed Mitigation Area; however, if necessary, additional opportunities exist in off-site areas of the upper Chehalis Basin.

Table 8.2-1
Number of Aquatic Habitat Access Improvement Opportunities in Mitigation Reaches A-D and Species Observed (Prioritized and non-prioritized culvert data sets combined) (Sources: WDFW Prioritized Barriers in the Chehalis Basin [WDFW 2022a], and WDFW Statewide Fish Passage Barrier Inventory [WDFW 2022b])

REACH	A	B	C	D	TOTAL
Total Number of Projects	2	40	55	156	252
Chinook Salmon			1		1
Coho Salmon	2	34	50	152	238
Steelhead	2	36	50	153	241
Trout	1	36	50	153	240

Table 8.2-2
Estimated Linear Gain (Miles) of Salmonid Habitat Upstream of Passage Barriers in Mitigation Reaches A-D (Sources: WDFW Prioritized Barriers in the Chehalis Basin [WDFW 2022a], and WDFW Statewide Fish Passage Barrier Inventory [WDFW 2022b])

REACH	A	B	C	D	TOTAL
Chinook Salmon	0	0	2.58	0	2.58
Coho Salmon	4.01	18.72	32.45	309.99	365.16
Steelhead	3.89	15.92	29.23	190.91	239.95
Trout	2.50	19.31	32.45	309.51	363.76

8.2.1.3 Plan

Verification of site potential for barrier removal opportunities identified in Appendix A1, Attachment 1 would require field sampling to corroborate database records, species presence, and quality of affected upstream habitat. Barrier correction projects would be prioritized to occur in suitable locations where the greatest number of anadromous species would benefit from access. The type of action at each site would be selected to align with the species assemblage, type of access improvement (i.e., culvert removal, barrier correction, habitat restoration), and suitability of accessible habitat for different life stages of affected species. A plan would be developed that would include rationale for site selection, a functional assessment of each site prior to mitigation, the parameters to be monitored, and the adaptive management approach to ensure long term potential effectiveness.

WDFW has guidelines for road culvert design to ensure effective fish passage including requirements for the type, sizing, site preparation, and installation of culverts that facilitate stream crossings in Washington State (WDFW 2003). When anadromous fish are present or potentially present, BMPs established by the Corps include use of “Stream Simulation,” an ecological approach to providing passage for aquatic organisms at road crossings (USDA 2015). Further, the Applicant would consider all flood-scenarios including projections on future flood flows when designing habitat access improvement projects.

8.2.1.4 Expected Functional Lift

Up to 6 miles of mainstem and 11 miles of tributary spawning habitat for coho salmon and steelhead potentially would be affected during FRE facility operation and degraded post-operation for some period of time. The six miles of mainstem also includes spring-run Chinook salmon spawning habitat that would be degraded episodically during operations. The ecological lift provided from opening access to spawning habitat in tributaries would be related to increased habitat quantity and quality over time as tributaries would be selected that either 1) are not currently or expected to be thermally limited for salmonids, or 2) are also selected for riparian/stream buffer enhancement projects described below in Section 8.3.

If the amount of mitigation needed to offset the Proposed Action potential effects on spring-run Chinook salmon spawning habitat exceeds available opportunities in the proposed Mitigation Area, habitat access improvement projects could be expanded to off-site areas such as the lower Skookumchuck River.

8.2.1.5 Project Constraints

Project constraints include landowner engagement for access, acquisition, and/or easement, limitation associated with in water work for projects in salmon bearing streams, and WSDOT jurisdiction.

8.2.1.6 Timeline

Once identified, projects to reconnect aquatic habitats could begin immediately to reduce the duration of impacts associated with loss of stream habitat in the FRE temporary reservoir. The proposed timeline for implementation is as follows:

- Landowner engagement/easement: 2022-2024,
- Riparian assessment of prioritized sites: 2022-2023,
- Barrier removal and passage rehabilitation plans: 2024-2025,
- Project Implementation: 2025-2028,
- Monitoring: Year 1, 3, 5, 7, 10. After Year 10, 5-year check ins would be sufficient up to Year 30, followed by 10-year check ins to Year 50.

8.2.2 Aquatic Habitat Enhancements

Aquatic habitat enhancements considered for mitigation include the following mitigation actions:

- Water temperature improvements,
- In-stream modifications,
- Off-channel modifications,
- Gravel retention jams.

8.2.2.1 Aquatic Habitat Enhancement Goals and Objectives

The goals of this suite of mitigation action types are to mitigate for the following impacts on aquatic habitat identified in the SEPA/NEPA-DEIS:

- Permanent elimination of 17 miles of stream channel, entailing habitat degradation and loss of ecological function along approximately 6 miles of the mainstem Chehalis River channel and 11 miles of tributary stream channel in the temporary reservoir.
- Water temperature increase of up to 5.4°F (1.8°C) in the Impact Area downstream of the FRE facility (including the combination of Proposed Action potential effects and potential effects of climate change), related primarily to the loss of shade along the river and tributary streams in the temporary reservoir area.
- Interruption and alteration of sediment delivery downstream of FRE facility, likely to result in changes to the composition of bed substrate, and possible changes to the elevation of the mainstem river channel and tributary confluences in the mainstem river.
- Interruption in downstream transport of woody material during operations, and limitation of the size range of recruited LWM that could pass the FRE facility.
- Changes in the movement of sediment, large woody material, nutrients, and water resulting in unquantified potential effects on fish habitat.
- Reduced groundwater recharge due to decreased area of floodplain engagement during major or larger floods.

The objective of this suite of mitigation action types is to improve the functional value of existing aquatic habitat through habitat enhancements that increase channel and habitat complexity, engage the floodplain, and provide thermal refugia for aquatic species. Objectives specific to mitigation types and subtypes are described below.

Site-specific and quantitative targets for the number and size of projects required to mitigate aquatic habitat degradation would be determined following the publication of the final SEPA EIS, subsequent permitting, and development of the final FRE HMP.

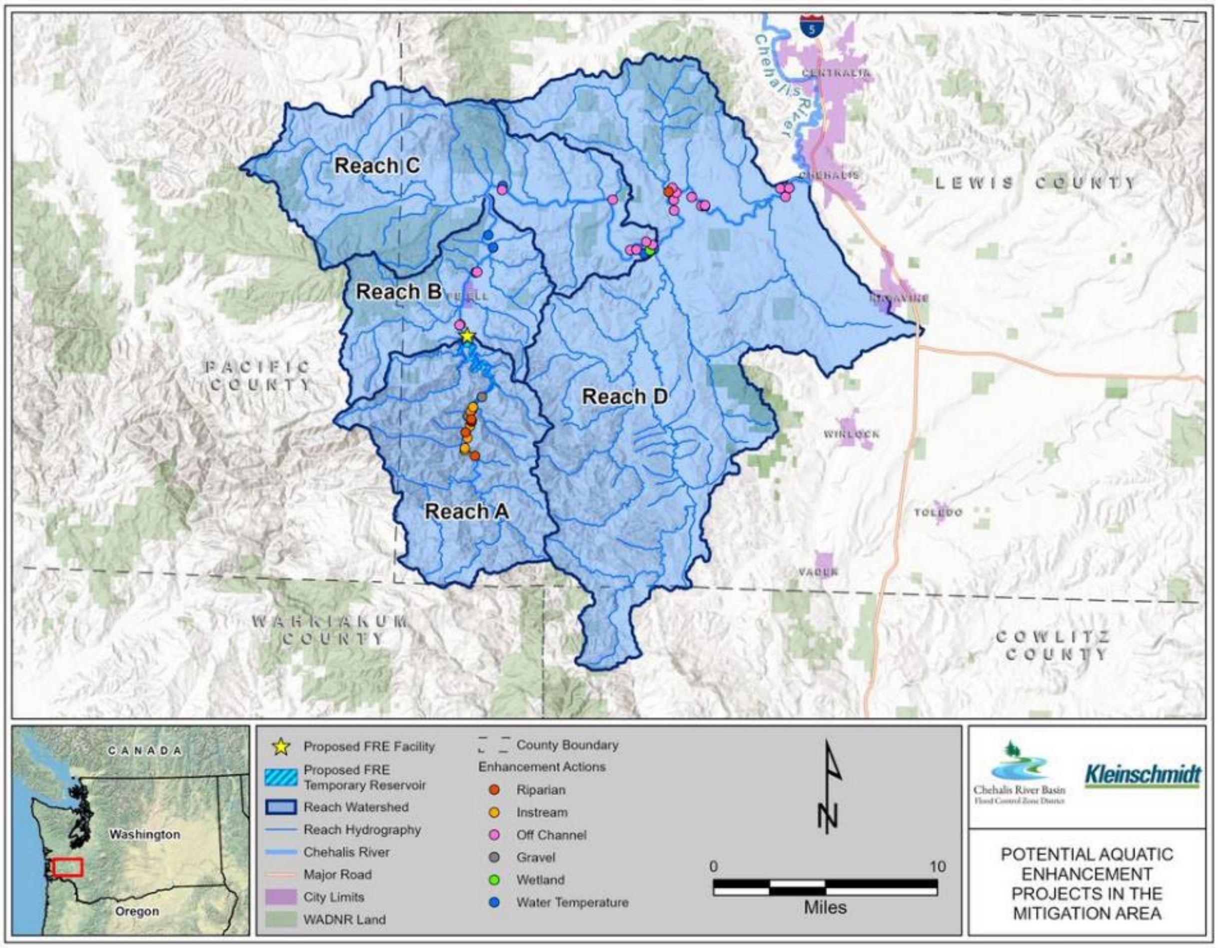
8.2.2.2 Aquatic Habitat Enhancement Site Restoration Potential

As previously described, the mainstem Chehalis River downstream of the FRE is highly degraded from past and current land uses. It is currently a single thread incised river that lacks habitat complexity and interaction with the floodplain. It is CWA 303(d)-listed for temperature, DO, and bacteria and has also experienced exceedances of turbidity criteria for salmonids and nutrients. There are many opportunities in the mainstem Chehalis River within the Impact Area to enhance and restore degraded habitats that would benefit aquatic species. There are also opportunities above the FRE to improve spawning habitat and complexity. Based on the geomorphic assessment described in Section 7.4.2 and Appendix A3, a total of 56 aquatic habitat enhancements at 49 sites have been advanced for site-specific field study (Table 8.2-3, Figure 8.2-2). These enhancement actions would benefit habitats suitable for spawning and rearing of salmon, steelhead, other native fishes, and amphibians to offset any loss in overall species abundance and aquatic habitat productivity from the Proposed Action. Anticipated species-specific lift associated with aquatic enhancement mitigation action types is provided in Appendix G.

Table 8.2-3
MOAR Opportunities Advanced as Enhancement Actions Based On Reach Scale Attributes Conducive To Function and Persistence

REACH	INSTREAM MODS	OFF CHANNEL MODS	GRAVEL RETENTION JAMS	WATER TEMPERATURE IMPROVEMENTS	WETLAND ENHANCEMENTS	TOTAL ACTIONS	TOTAL SITES
A	7	0	7	7	0	21	18
B	0	2	0	5	0	7	7
C	0	6	0	3	2	11	10
D	0	14	0	1	2	17	14
Total	7	22	7	16	4	56	49

Figure 8.2-2
Aquatic Habitat Enhancement Opportunities in the Mitigation Area



8.2.2.3 Water Temperature Improvements

Water temperature improvements include instream and bank modifications designed to increase access or expand the extent of cool water areas. Cold water retention projects involve structure placement and/or channel modifications to increase access or extent of cool water habitats such as floodplain channels, backwater alcoves, channel margin pockets, and cool water tributary inflows.

Several types of actions are proposed based on various channel and floodplain landforms.

8.2.2.3.1 Goals and Objectives

The goal of the water temperature retention projects is to mitigate for the potential impact on water temperatures identified in the SEPA/NEPA-DEIS:

- Permanent elimination of 17 miles of stream channel, entailing habitat degradation and loss of ecological function along approximately 6 miles of the mainstem Chehalis River channel and 11 miles of tributary stream channel in the temporary reservoir.

- Water temperature increase of up to 5.4°F (1.8°C) in the Impact Area downstream of the FRE facility (including the combination of Proposed Action potential effects and potential effects of climate change), related primarily to the loss of shade along the river and tributary streams in the temporary reservoir area.

The objective of the water temperature retention projects is to improve water temperature conditions for native species by providing near-term and sustained thermal refugia in the Impact Area. Cool water refugia would also provide suitable dissolved oxygen conditions to support native species.

8.2.2.3.2 Site Restoration Potential

The mainstem Chehalis River below the FRE facility is impaired for water temperatures that frequently exceed the criteria for salmon and steelhead (WAC 173-201A) during the summer (Ecology 2020). Stream temperatures have been affected by lack of riparian stream shade, low summer base flows, lack of habitat diversity, and limited cool water refugia. Excessive stream temperatures limit the amount of habitat available for salmonids while providing suitable conditions for bass and other non-native species. While the Chehalis River above the FRE facility is not considered temperature impaired, it is relatively warm compared to other headwater streams in western Washington.

Thermal mitigation could be achieved in the riverine environment primarily by modifying and capitalizing on existing geographic locations and morphologic features that already actively capture cool water. It also could be expanded to increase retention time in tributaries, off-channel habitats, smaller seeps, or spring-fed pools. Thermal mitigation opportunities that capitalize on groundwater and cooler surface water sources may also exist at the interface with surface waters, usually on smaller tributaries.

The fluvial geomorphic features that are most conducive to facilitating cold water refuge habitat improvements include the following:

- Lateral cool water inputs that could be enlarged,
- Pools with vertical-stratification where the area or volume could be enlarged,
- Straightened alluvial reaches that could be re-meandered,
- Cool water tributary inflow that could be captured,
- Paleo channels that could be reactivated,
- Channel alcoves that could be enlarged or created.

The reach scale geomorphic analysis prioritized nineteen water temperature improvement actions in three mitigation reaches (7 in Reach A, 5 in Reach B, 3 in Reach C, and in 1 in Reach D) (Table 8.2-3). The area for typical water temperature improvement sites is assumed to be 200-300 feet in length (Kleinschmidt 2020).

8.2.2.3.3 Plan

Field sampling would need to occur to confirm site characteristics and the types of potential water temperature enhancement projects feasible on-site. The type of action at each site would be selected to align with the geomorphic attributes of that site. Sampling plans would be developed as part of the Applicant's M&AMP (Section 9) that would include rationale for site selection, a functional assessment of each site prior to mitigation, design, the parameters to be monitored, and the adaptive management approach to ensure long term potential effectiveness.

These types of mitigation actions would require instream construction. The thermal refugia that would result from this action are intended to function at low flow conditions, so complete avoidance of in-water work is not possible. To the degree possible, work in the ordinary high-water mark (OHWM) would attempt to minimize the amount and duration of in-water work. Construction timing would comply with applicable local in-water construction windows. Conventional BMPs for in-water work would be applied during construction including standard erosion and sediment control measures, isolation of in-water work areas, fish salvage, and fish exclusion measures.

8.2.2.3.4 Expected Functional Lift

The upper Chehalis River in the Impact Area frequently exceeds maximum temperature thresholds in summer for salmon and steelhead including the 7-day consecutive mean daily max temperature (7-DADMax) criterion of 16°C in stream reaches designated as core summer salmonid habitat in WAC 173-201A-602 and the 13°C criteria applied September 15 to July 1 in stream reaches designated with supplemental spawning/incubation criteria (Anchor QEA 2014). Data has also shown acute impairment that exceeds Washington's lethality guidelines (Anchor QEA 2014).

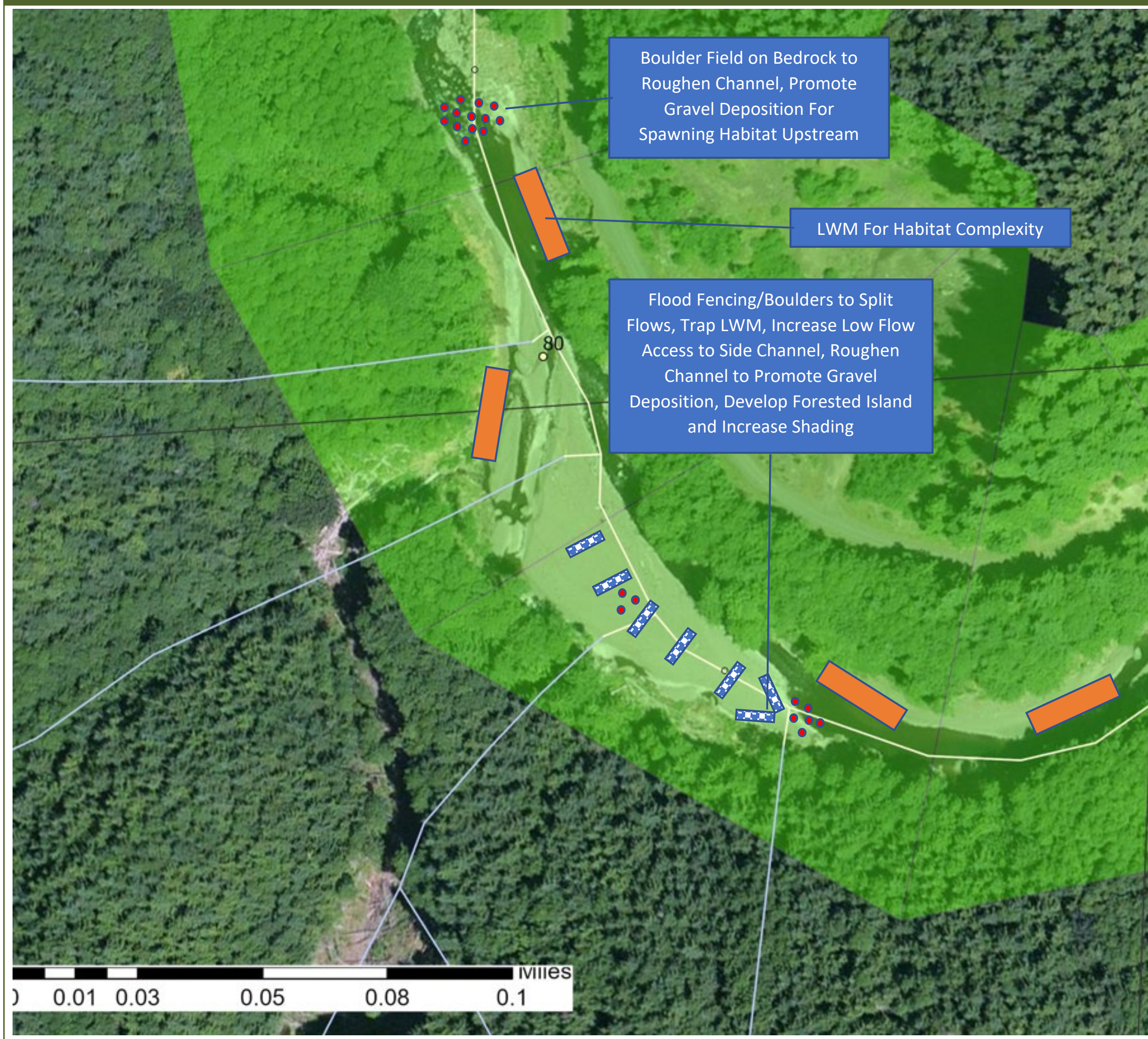
Water temperature appears to be a driver of fish distributions in the Chehalis River. During the summer Riverscape study on the Chehalis, the fish species assemblage was more consistently associated with stream temperatures in August than physical habitat characteristics (Winkowski et al. 2018). The authors suggest that warm summer stream temperatures limit the rearing potential, habitat use, and spatial distribution of aquatic species, especially Pacific salmon. More specifically, temperature has been implicated as a limiting factor for spring-run Chinook salmon (*O. tshawytscha*) (Winkowski et al. 2018).

Effective mitigation would establish strategically distributed pockets of accessible cold water habitat during summer when average water temperatures can be detrimental or lethal to salmonid species. Cold water refugia distributed throughout the Impact Area would improve adult spring-run Chinook salmon holding habitat quality, juvenile salmon and native fish rearing habitat, and would also alleviate stress to native cold-water fishes that results from water temperatures that exceed thermal habitat suitability criteria.

Cold water retention structures would provide immediate and sustained ecological benefits, and the intended ecological function would be fully realized in 1 or 2 years following implementation. This strategy could be applied as an early action to provide immediate benefits during the longer time required to increase the extent of forested riparian zones that shade the drainage network and provide long-term water temperature reduction.

Additional ecological lift would come from sequencing these structures with instream modifications, gravel retention structures and/or aligning with riparian/stream buffer expansion and would result in overall increased habitat complexity for various species and life stages of aquatic organisms. A conceptual example of co-locating mitigation actions to address multiple limiting factors and attain greater lift is presented in Figure 8.2-3.

Figure 8.2-3
Example 1 of Conceptual Design for Co-located Habitat Enhancements



8.2.2.4 Instream Modifications

This measure involves construction of habitat features in the perennial wetted channel to enhance, restore, induce, or create habitat forming processes and habitat elements such as complexity, cover, hydraulic diversity, pool formation, and cold water refugia. Example instream modifications include installing large wood material as individual pieces, in arrays, and as distinct engineered log jam structures in various forms.

8.2.2.4.1 Goals and Objectives

The goal of this mitigation action type is to offset the potential Proposed Action impacts on habitat identified in the SEPA/NEPA-DEIS:

- Permanent loss of 0.3 acres of in-stream channel at the site of the FRE facility footprint.
- Permanent elimination of 17 miles of stream channel, entailing habitat degradation and loss of ecological function along approximately 6 miles of the mainstem Chehalis River channel and 11 miles of tributary stream channel in the temporary reservoir.
- Interruption and alteration of sediment delivery downstream of FRE facility, likely to result in changes to the composition of bed substrate, and possible changes to the elevation of the mainstem river channel and tributary confluences in the mainstem river.
- Interruption in downstream transport of woody material during operations, and limitation of the size range of recruited LWM that could pass the FRE facility.
- Changes in the movement of sediment, large woody material, nutrients, and water resulting in unquantified potential effects on fish habitat.

The objective of this mitigation action type is to offset habitat loss and degradation by enhancing the habitat in the Mitigation Area through increased habitat complexity and habitat diversity, and restore wood to the stream channel to repair related ecological processes.

8.2.2.4.2 Site Restoration Potential

Sites suitable for instream modifications would have a neutral aggradation/degradation tendency, negligible channel migration, and the absence of a large-scale reach slope break upstream. These characteristics minimize the potential for burial, scouring, or abandonment of the modification. A higher slope upstream of a potential project is associated with greater likelihood of burial or abandonment, while a lower slope is associated with scouring of a structure.

Seven areas with suitable geomorphic features were identified in Mitigation Reach A upstream of the temporary reservoir and three were identified in Reach D (Table 8.2-3). It is anticipated that these structures would be strategically located in the vicinity of gravel retention jams to improve habitat complexity for adult and juvenile salmon, as well as other native fishes and amphibians. The assumed quantity for typical instream modification sites is 500 feet in length (Kleinschmidt 2020).

8.2.2.4.3 Plan

Field sampling would need to occur to identify specific mitigation sites within the suitable areas identified in Reaches A and D. The selected mitigation action at each site would align with the flow regime and site-specific geomorphic attributes. A plan would be developed to include rationale for site selection, a functional assessment of each site prior to mitigation, design, a list of the parameters to be monitored, and the adaptive management approach to ensure long-term potential effectiveness.

The mitigation actions discussed here would require instream construction. To the degree possible, work within the ordinary high-water mark (OHWM) would be minimized. Construction timing would comply with applicable local in-water construction windows. Conventional BMPs for in-water work would be applied during construction, including standard erosion and sediment control measures, isolation of in-water work areas, fish salvage, and fish exclusion measures.

Instream modification project design, implementation, and adaptive management would be incorporated into the M&AMP to be developed for the Proposed Action.

8.2.2.4.4 Expected Functional Lift

Instream modifications are intended to provide multiple benefits to aquatic species with particular focus on salmonids. High-quality salmon habitat for winter spawners and spring-run Chinook salmon would be affected and potentially degraded in the Impact Area above the FRE facility. Currently, salmon habitat upstream of the temporary reservoir primarily supports coho salmon and steelhead. Increasing instream structures would improve the quality of these habitats including increased habitat diversity and complexity for all three species of salmonids present upstream of the FRE facility as well as for other aquatic species.

The mainstem Chehalis River channel below the proposed FRE facility is degraded, the habitat has been simplified, and LWM recruitment potential is low. Addition of habitat complexity will add cover, facilitate gravel sorting and deposition of fine sediment in pools. Wood structures would also provide substrate for macroinvertebrate species and could increase secondary production.

Additional ecological lift would come from sequencing these structures with gravel retention jams and/or aligning with riparian/stream buffer expansion and would result in overall increased habitat complexity for various species and life stages of aquatic organisms.

8.2.2.5 Off-channel Modifications

Off-channel habitat enhancements include actions to reconnect, enhance, and expand off-channel habitat through side channels and floodplain water bodies. Forested riparian buffers would be established along off-channel modification actions where existing vegetation lacks forest cover.

8.2.2.5.1 Goals and Objectives

The goal of this mitigation action is to mitigate for the potential impacts of the Proposed Project identified in the SEPA/NEPA-DEIS:

- Permanent loss of 0.3 acres of in-stream channel at the site of the FRE facility footprint.
- Permanent elimination of 17 miles of stream channel, entailing habitat degradation and loss of ecological function along approximately 6 miles of the mainstem Chehalis River channel and 11 miles of tributary stream channel in the temporary reservoir.
- Interruption in downstream transport of woody material during operations, and limitation of the size range of recruited LWM that could pass the FRE facility.
- Changes in the movement of sediment, large woody material, nutrients, and water resulting in unquantified potential effects on fish habitat.
- Reduced groundwater recharge due to decreased area of floodplain engagement during major or larger floods.

The objective of this mitigation action type is to enhance the habitat in the Mitigation Area by improving habitat complexity and water temperature, and specifically to provide additional high quality rearing habitat for fish, amphibians, and other floodplain wildlife species.

8.2.2.5.2 Site Restoration Potential

The mainstem Chehalis River below the proposed FRE facility is degraded, and the habitat has been simplified into a single channel thread associated with decades of land uses including agriculture, timber harvest, and rural development. Very little off-channel habitat exists.

The reach-level geomorphic assessment identified 23 potential off-channel modification project sites across three Mitigation Reaches (2 in Reach B, 6 in Reach C, 14 in Reach D) (Table 8.2-3). At least three of these sites include wetlands that could also be enhanced. For the selected sites, wetland and riparian buffer enhancements would be co-located to the extent possible. The assumed quantity for typical off-channel modification sites is 2000 feet in length (Kleinschmidt 2020).

8.2.2.5.3 Plan

Field sampling would need to occur to identify specific mitigation sites. This action type is often intended to be wetted during moderate to high flow conditions, but perennial flow conditions may be achievable at some sites, especially where the side channel receives perennial flow from springs, tributaries, or hyporheic flow. The selected mitigation actions at each site would align with the flow regime and site-specific geomorphic attributes. In general, this type of project functions better and lasts longer where floodplain channel connectivity occurs at the 2-year flood level so there is an increased likelihood of flood water accessing and/or enlarging floodplain channels.

A plan would be developed to include rationale for site selection, a functional assessment of each site prior to mitigation, design, a list of the parameters to be monitored, and the adaptive management approach to ensure long-term potential effectiveness.

Off-channel modifications would require minimal in-water construction typically limited to the upstream and downstream connections with the main river or stream channel. For many sites it may be possible to conduct all necessary work within the OHWM in dry conditions by timing work to coincide with low flow. Where in-water work is necessary, construction timing would comply with applicable local in-water construction windows. Conventional BMPs for in-water work would be applied during construction, including standard erosion and sediment control measures, isolation of in-water work areas, fish salvage, and fish exclusion measures.

Off-channel modification project design, implementation, and adaptive management would be incorporated into the M&AMP to be developed for the Proposed Action.

8.2.2.5.4 Expected Functional Lift

The upper Chehalis River is a highly incised single channel where off-channel habitats are rare. This limits interaction with the floodplain, and overall channel length, and habitat types suited for rearing of juvenile salmon and native fishes. Off-channel modifications provide multiple ecological benefits to aquatic and terrestrial species. The creation of off-channel habitat would increase stream length, increase habitat complexity and diversity, and improve water quality and surface – groundwater interactions as well as improve opportunity for nutrient inputs commonly seen in smaller channels with healthy riparian vegetation.

The benefits provided by individual actions would vary from site to site depending on the water surface elevation and corresponding flow frequency that engages flow in these off-channel features. Generally, greater benefits may be realized at off-channel enhancement sites that engage flow multiple times per year and not just during less frequent flooding events. Off-channel enhancements provide highly productive rearing and foraging habitat, velocity refugia during high flow events, and may be configured to incorporate hyporheic exchange enhancement for thermal refugia, typically at the downstream connection point with the main channel. Some specific off-channel modifications may be designed to benefit western toad and other still-water breeding amphibians.

8.2.2.6 Gravel Retention Jams

This action involves constructing instream LWM structures or installing boulder roughness elements to provide hydraulic roughness and hydraulic sheltering to capture and retain spawning gravels.

8.2.2.6.1 Goals and Objectives

The goal of this action is to mitigate for the potential Proposed Action impacts identified in the SEPA/NEPA-DEIS:

- Permanent loss of 0.3 acres of in-stream channel at the site of the FRE facility footprint.

- Permanent elimination of 17 miles of stream channel, entailing habitat degradation and loss of ecological function along approximately 6 miles of the mainstem Chehalis River channel and 11 miles of tributary stream channel in the temporary reservoir.

The objective of gravel retention structures is to enhance salmon habitat and more specifically create high quality spawning habitat in Mitigation Reach A, the coolest reach in the Mitigation Area. The structures would also provide riffle habitat for stream-spawning amphibians.

8.2.2.6.2 Site Restoration Potential

Reaches with an aggradation tendency are most suitable for the creation, function, and persistence of gravel retention jams. The longer the section of river with a tendency for aggradation, the greater the likelihood that spawning habitat could be improved. Further, the presence of gravel bars upstream and locally with gravel that is too large for suitable spawning could mean a higher likelihood for recruiting gravels that are suitable for spawning.

The reach level geomorphic assessment identified seven gravel retention target sites, all located in Mitigation Reach A, upstream of the temporary reservoir. Mitigation Reach A is a sediment transport reach. As such, the natural gravel transport in this reach is anticipated to be adequate to form the desired spawning habitat without any need for placement of additional spawning gravel.

It is anticipated that these gravel retention structures would be in sequence with installation of instream modifications to maximize ecologic benefits for adult and juvenile salmonids, resident native fishes, and amphibians. The assumed quantity for typical off-channel modification sites is 900 feet in length (Kleinschmidt 2020).

8.2.2.6.3 Plan

The M&AMP would be developed to include a functional assessment of each site prior to mitigation, design verification, a list of the parameters to be monitored, and the adaptive management approach to ensure long-term potential effectiveness.

The creation of gravel retention jams would require instream construction. Gravel retention jams involve placement of large wood in the channel, with anchoring elements if needed to retain the jam at the selected location. To the degree possible, work within the OHWM would be minimized. Construction timing would comply with applicable local in-water construction windows. Conventional BMPs for in-water work would be applied during construction, including standard erosion and sediment control measures, isolation of in-water work areas, fish salvage, and fish exclusion measures. Additional construction activities may include minor earthwork to embed large wood pieces into the riverbed and banks, site work to provide access, and construction staging. Forested riparian buffers may be established at sites that lack them.

Gravel retention jam project design, implementation, and adaptive management would be incorporated into the Fish and Aquatic Species and Habitat Plan to be developed for the Proposed Action.

8.2.2.6.4 Expected Functional Lift

The upper Chehalis River habitat upstream of the Impact Area has reduced wood recruitment from historic and current land use practices. In addition, Reach A is considered a transport reach, meaning that instream sediment is mobile and is transported downstream depending on intensity of flow events (CBS 2017). Large substrate (cobble) input originates in the upper tributaries and is transported downstream to RM 80, while gravel from the same source is transported as far downstream as RM 73. With up to seven sites suitable for placement of gravel retention structures, the quantity and quality of spawning gravels above the FRE temporary reservoir could be increased substantially from current conditions.

Gravel retention jams would provide immediate and sustained ecological benefits, and the intended ecological function could be fully realized in 1 or 2 years after implementation depending on flow conditions and the natural delivery and accumulation of gravel material transported by the river. Additional ecological lift would come from sequencing these structures with instream modifications and/or aligning with riparian/stream buffer expansion and would result in overall increased habitat complexity for various species and life stages of aquatic organisms.

8.2.2.7 Aquatic Habitat Enhancement Project Constraints

Project constraints include landowner engagement for access, acquisition, and/or easement, and limitation associated with in-water work for salmon-bearing streams. Projects including areas upland from the OHWM (e.g., re-meandering channels, re-activating paleo channels, wetland or riparian enhancements) would require land acquisition or completion of a conservation easement.

8.2.2.8 Aquatic Habitat Enhancement Timeline

Once identified, projects to provide or enhance aquatic habitats could begin immediately to reduce the duration of impacts associated with loss of stream habitat upstream of the FRE facility and temporary reservoir. The proposed timeline for implementation is as follows:

- Landowner engagement/easement: 2022-2024,
- Riparian assessment of prioritized sites: 2022-2023,
- Barrier removal and passage rehabilitation plans: 2024-2025,
- Project Implementation: 2025-2028,
- Monitoring: Year 1, 3, 5, 7, 10. After Year 10, 5-year check ins would be sufficient up to Year 30, followed by 10-year check ins to Year 50.

8.3 Riparian/Stream Buffer Expansion Downstream of the FRE Facility

Riparian and stream buffer expansions include establishing forested buffers along stream and river margins that currently lack forest vegetation and conserving existing forests along streams and rivers. Establishing forested buffers along unshaded channel reaches would include developing and implementing an appropriate plant composition schedule and planting plan to establish a mix of native species of trees and shrubs that would develop into a forested buffer over time. Flood fencing is also a cost-effective way to jump start passive or active restoration of a riparian forest. Plant establishment may require initial watering, monitoring, and replacement of plants lost to mortality. Riparian plantings provide some immediate ecological benefits that increase over time as the forest matures and evolves. Establishing full ecological function of degraded riparian areas would require several decades from the time of initial planting.

8.3.1 Goals and Objectives

The goal of riparian/stream buffer enhancement and conservation projects is to mitigate for the following potential Proposed Action impacts identified in the SEPA/NEPA-DEIS:

- Permanent elimination of 17 miles of stream channel and 441 acres of stream buffers. "Permanent elimination" entails habitat degradation and loss of ecological function along approximately 6 miles of the mainstem Chehalis River channel and 11 miles of tributary stream channel in the temporary reservoir.
- Permanent loss of 333 acres of wetland buffers located in the 847-acre temporary reservoir, expected to reduce wildlife habitat, including western toad breeding habitat.
- Water temperature increase of up to 5.4°F (1.8°C) in the Impact Area downstream of the FRE facility (including the combination of Proposed Action potential effects and potential effects of climate change), related primarily to the loss of shade along the river and tributary streams in the temporary reservoir area.
- Interruption in downstream transport of woody material during operations, and limitation of the size range of recruited LWM that could pass the FRE facility.
- Changes in the movement of sediment, large woody material, nutrients, and water resulting in unquantified potential effects on fish habitat.

The objective of the riparian buffer expansion is to create, enhance, or expand forested buffers along 25.5 stream miles of the mainstem Chehalis River between the FRE facility and the South Fork Chehalis River confluence or tributaries entering this portion of the mainstem. This mitigation will provide shade for thermal modulation of air temperatures, intercept surface runoff and reduce erosion, improve nutrient cycling, and enhance native vegetative diversity and structural complexity for creating high quality terrestrial wildlife and amphibian habitat. Reducing potential for warm summer water temperatures also reduces potential for dissolved oxygen concerns. Where feasible, LWM removed from the FRE would be placed in riparian habitats to provide structurally complex habitat.

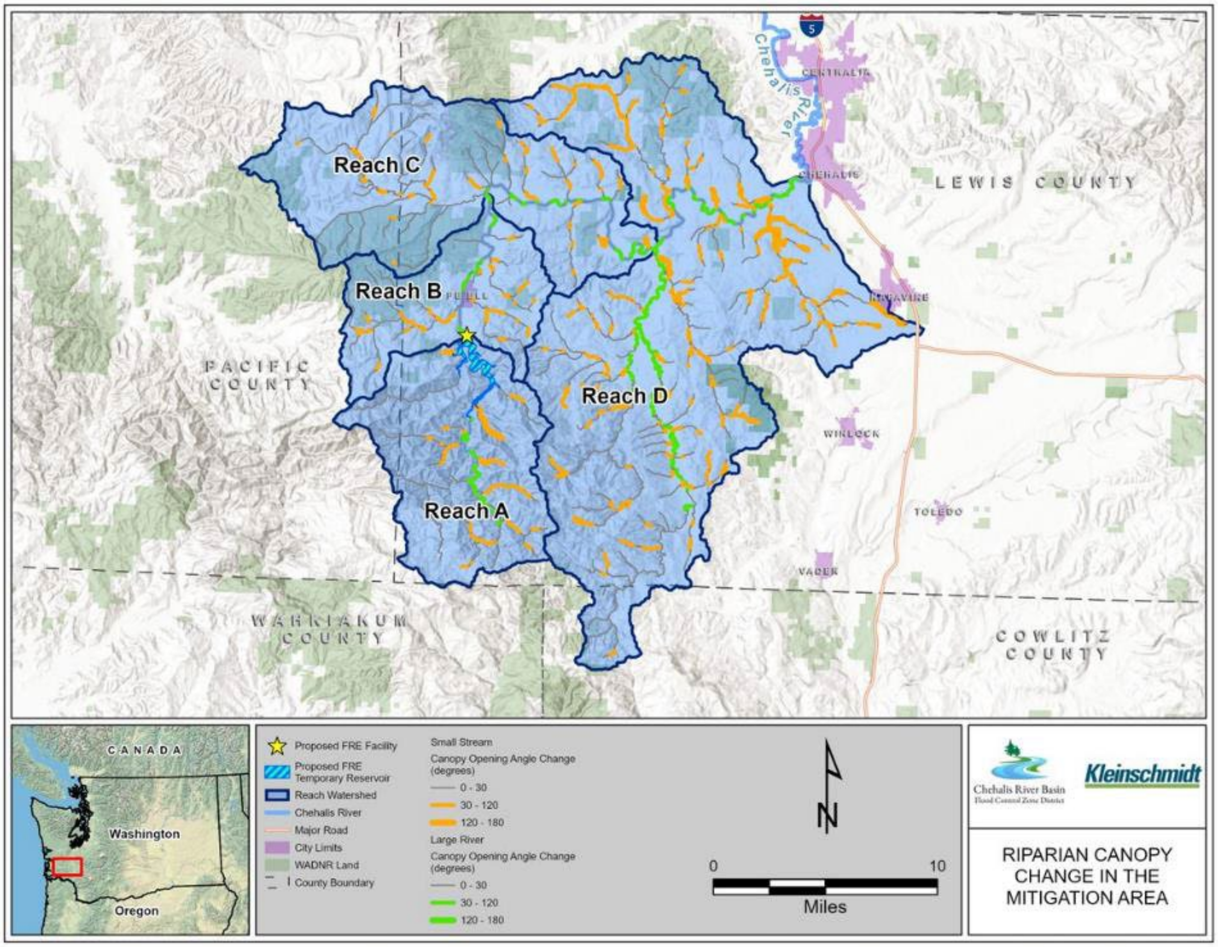
8.3.2 Site Restoration Potential

The upper Chehalis Basin is impaired for water temperature and dissolved oxygen and exceedances of turbidity criteria after storm events have also been documented. The water frequently exceeds maximum temperature thresholds in summer for salmon and steelhead. Data has also shown acute impairment that exceeds Washington's lethality guidelines (Anchor QEA 2014). Solar heating is the primary driver of water temperatures, and elevated stream temperatures in the Chehalis River are attributed to a lack of mature riparian forests and stream shading they would have provided historically (Ecology 2020).

As described in Section 7.3.3 and Appendix A2, to evaluate locations where riparian buffer enhancement would increase shade and reduce potential temperature increase, the Applicant used the output from NOAA's process-based analysis for quantifying historical, current, and future habitat conditions of the Chehalis Basin (Beechie et al. 2021). The Applicant conducted a reanalysis of the NOAA data to help identify stream reaches where the riparian canopy has undergone considerable change. Current canopy opening angles ranged between 0° (canopy completely closed) and 180° (both banks bare). For this analysis, a threshold of a 30-degree change in canopy angle opening was used to indicate degradation from historic conditions. NOAA data show a change of canopy angle of 30 degrees was associated with stream temperature increases of over 1^{o}C.

The Applicant's analysis of the existing riparian shade information identified a total of 145.7 miles of degraded riparian habitat (canopy opening angles greater than 30°) that provide mitigation opportunities for riparian enhancement and improved thermal buffering (Figure 8.3-1).

Figure 8.3-1
Change in Riparian Canopy Opening Angle in Mitigation Reaches



The opportunities to enhance riparian/stream buffers and improve shade are distributed throughout Mitigation Reaches B, C, and D, with 15.4 miles in the mainstem Chehalis River and 130.3 miles in tributary channels (Table 8.3-1). The extent of available opportunities would support meeting the objective of creation or enhancement of 25.5 miles of forested riparian buffer. Permanence of these reestablished forested buffers would be ensured by land acquisition or conservation easements. Conservation of existing forests would occur in locations where such forests could otherwise be removed or modified by timber harvest, agriculture, or land development.

Prioritization of site-specific riparian expansion would include the following considerations:

- Land ownership;
- Landowner engagement and access;
- Land cover;
- Buffer widths protected by Forest Practices Act or local zoning;
- Permitting (cultural resources, wetland impacts);

- Channel migration rates;
- Topography – if slopes/terrain provides shading:
    - on a vegetation scale, riparian canopy can provide shade,
    - on a geomorphic channel scale, steep banks can provide local pockets of shading,
    - on a regional and watershed scale, the orientation of the ridgelines and canyon walls with respect to the azimuth of the sun is a driver of shading;
- Co-location with other mitigation actions;
- Presence of fish, freshwater mussels, western toad, or other priority species;
- Presence of wetlands or other priority habitat.

Table 8.3-1
Summary of Changes in Canopy Opening Angle by Mitigation Reach

			EVALUATION AREA	CANOPY OPENING CHANGE >30 DEGREE	
	STREAM CATEGORY	REACH	STREAM LENGTH (MI)	NUMBER OF SEGMENTS (200 M EACH)	STREAM LENGTH (MI)
Mainstem Chehalis River	Large River	B	8.7	26	3.3
		C	12.7	39	4.8
		D	13.5	59	7.3
		Subtotal	34.77	124	15.4
Tributaries	Large River	B	0.6	0	0.0
		C	2.5	3	0.4
		D	36.5	176	21.9
	Small Stream	B	40.5	88	10.9
		C	86.8	114	14.2
		D	208.1	667	82.9
	Subtotal		375.1	1,048	130.3
Total			409.8	1,172	145.7

8.3.3 Plan

A Riparian/Stream Buffer Management Plan would be developed that would encompass all aspects of mitigation projects related to riparian areas, stream buffers, floodplain wetlands, and floodplain wetland buffers. A riparian habitat assessment of selected sites would be conducted once during the growing season to document pre-mitigation riparian functions, wetland management zone conditions, and adjacent upland habitat conditions as they pertain to vegetation community composition. The following functions would be assessed using the "Assessing Riparian Function" guidelines presented in Section 21, *Guidelines for Alternate Plans, in the Forest Practices Board Manual* (WA DNR 2000):

- Stream shading,
- Stream bank stability,
- Woody debris availability and recruitment,
- Sediment filtering,

- Nutrients and leaf litter fall.

In stream segments that lack shade, specific activities related to this mitigation action include installing flood fencing, developing and implementing an appropriate plant composition schedule, invasive plant species removal plan, and planting plan to establish a mix of native species of trees and shrubs that would develop into a forested buffer over time. Plant establishment may require initial watering, monitoring, and replacement of plants lost to mortality. Permanence of these reestablished forested buffers would be ensured by land acquisition or conservation easements. Conservation of existing forests would occur in locations where such forests could otherwise be removed or modified by timber harvest, agriculture, or land development.

Riparian buffer expansion would not require in-water work, and potential impacts to water quality and instream habitat are minimal. Construction activities focus primarily on invasive plant removal, LWM placement, augering cottonwood boles, planting and soil amendment, and watering to support plant establishment. Delivery of plant material and soil amendment would use existing transportation routes as much as possible, and any new routes required for site access would follow conventional erosion and sediment control requirements in addition to post-maintenance restoration.

Plant survivorship would be monitored over time to achieve an 80 percent survival rate after 5 years. Stream shading over time would also be documented. The Riparian/Stream Buffer Management Plan would include an adaptive management component to ensure that the goals for plant survivorship, stream shading and stream temperature mitigation goals are achieved.

8.3.4 Expected Functional Lift

As described in the draft VMP, riparian management and replanting in the riparian habitats would begin at the onset of construction. Temperature modeling completed by the Applicant has indicated that with implementation of the VMP, water temperature in the mainstem Chehalis River upstream of the FRE facility could potentially increase by a maximum of a 1.2^{o}C (Appendix D). To further reduce the potential for water temperature and dissolved oxygen degradation in the mainstem Chehalis River due to the loss of riparian forest, this mitigation type focuses on improving riparian conditions in channel reaches downstream of the FRE to the confluence of the South Fork Chehalis River and tributaries entering this reach.

The location selected for each action strongly affects the ecological benefits that may be achieved. For example, improving riparian buffers along unshaded channel reaches would provide more localized benefits to water quality than maintaining buffers that already provide adequate shading. Removal of invasive riparian species including Himalayan blackberry and reed canarygrass and the re-establishment of native shrubs and trees would improve bank stability, increase shade profile and improve riparian habitat for native species. Co-locating riparian enhancements with flood fencing would also increase ecological lift (Figure 8.3-2).

Figure 8.3-2
Example 2 of Conceptual Design for Co-located Habitat Enhancements

In their analysis, NOAA assigned each of the river segments a predicted change in temperature by mid-century (2040) due to increased stream shading through growth of the riparian canopy, as predicted by Seixas et al. (Seixas et al. 2018). These predicted temperature changes would provide a data set for quantifying the potential ecological benefits that could be attained with riparian shade enhancement by reach.

The ecological benefit associated with restoring stream canopy open angles would be increased stream shade, decreased solar radiation, and correspondingly reduced water temperatures. This would benefit all native aquatic species. The enhanced riparian forests also would act to locally buffer air temperatures for wildlife species and, over time, increase large wood for instream and wildlife habitat.

Riparian buffer expansion would provide the primary long-term means of mitigating impacts to water temperature related to the predicted loss of riparian shade in the temporary reservoir upstream of the FRE. In addition to providing shade, expanded forested riparian areas provide a future source for large wood recruitment, reduce soil erosion, and mitigate water quality impacts related to runoff from upslope land use activities. Expanding riparian areas would also provide additional habitat for a variety of riparian-dependent plant and animal species including amphibians, birds, and mammals.

Enhancement of existing riparian buffers has the potential to benefit multiple wildlife species including priority species such as the western toad, Dunn's salamander, and VanDyke's salamander. Riparian areas are often important migratory corridors and conservation of wide buffers may help mitigate impacts to species such as elk that migrate through the Mitigation Area. Targeted enhancement of existing forested riparian buffers such as large woody material placement could benefit terrestrial-breeding salamanders. Planting currently non-forested riparian buffers would also provide multiple long-term benefits to wildlife as the plantings mature. Enhancement of riparian habitat would begin prior to FRE operations, allowing more time for plants to become established and provide an ecological lift sooner.

8.3.5 Project Constraints

Expansion of riparian buffers would require land acquisition or completion of a conservation easement. Landowner engagement, approvals, and access would be primary constraints for riparian planting. No in-water work would be required for riparian planting.

8.3.6 Timeline

Once identified, riparian enhancement projects could begin immediately to reduce the duration of impacts associated with loss of stream habitat upstream of the FRE facility and temporary reservoir. The proposed timeline for implementation is as follows:

- Landowner engagement/easement: 2022-2024,
- Riparian assessment of prioritized sites: 2022-2023,
- Barrier removal and passage rehabilitation plans: 2024-2025,
- Project Implementation: 2025-2028,
- Monitoring: Year 1, 3, 5, 7, 10. After Year 10, 5-year check ins would be sufficient up to Year 30, followed by 10-year check ins to Year 50.

8.4 Wildlife Habitat Conservation

This mitigation action entails the conservation of 500 acres in the upper Chehalis Basin above the proposed FRE temporary reservoir by conserving and enhancing 100-ft wide forested buffers on each side of 20.6 miles of stream.

8.4.1 Goals and Objectives

The goal of this mitigation action is to mitigate for potential effects from the Proposed Action associated with the temporary inundation of up to 808 acres of riparian and upland forested lands once every 7 years on average under current hydrologic conditions; the permanent transition of 220 acres from a less flood-tolerant plant community to a highly flood-tolerant community within the temporary reservoir; and reduction of riparian shade in the temporary reservoir.

The objective is to conserve and enhance a 100-ft wide forested buffer (each side of the stream bank) along 20.6 stream miles (500 acres) in the upper Chehalis Basin outside the FRE temporary reservoir maximum flood pool elevation footprint.

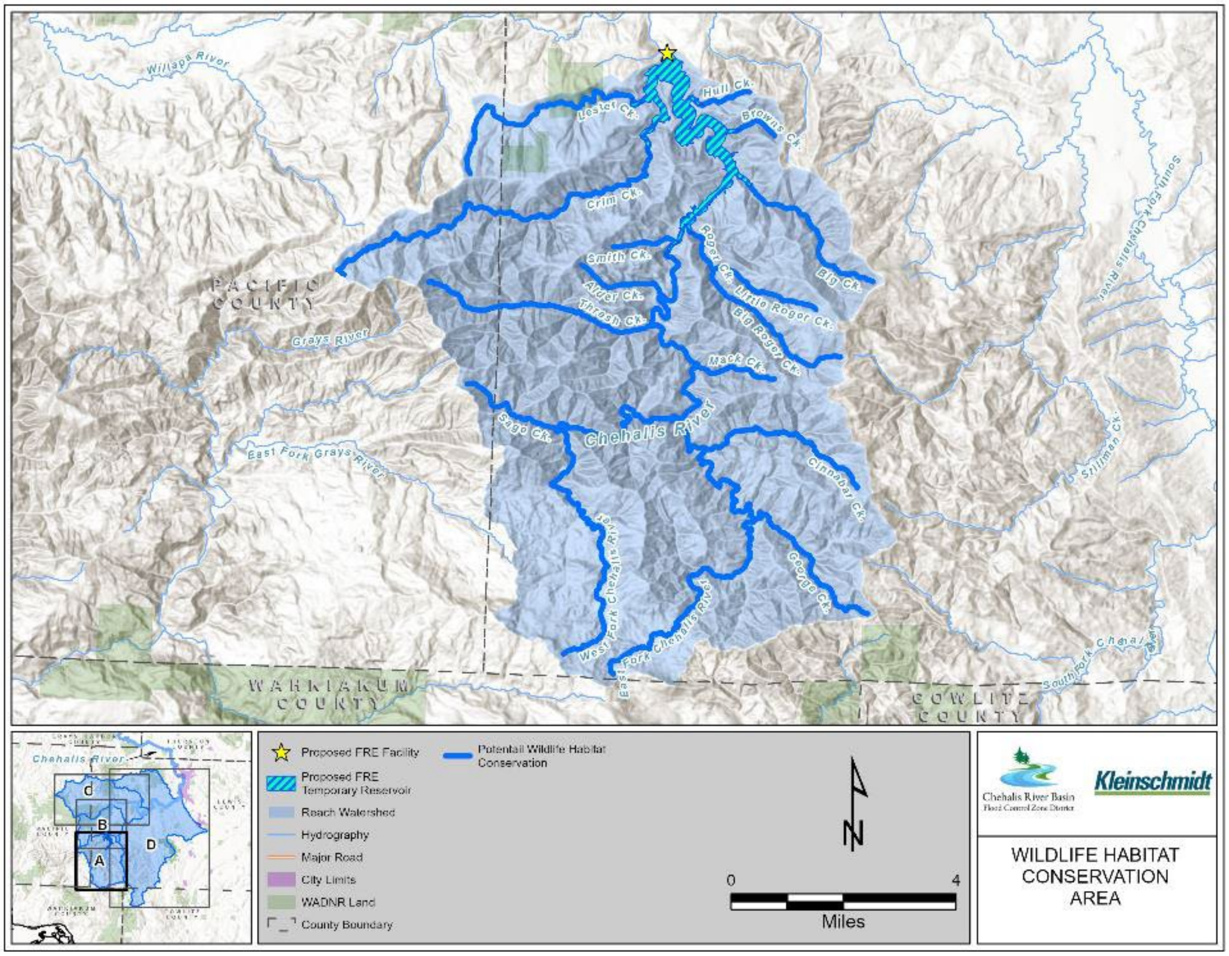
8.4.2 Site Restoration Potential

In general, historic logging practices have decreased the species diversity and structural complexity of native forests, degraded stream habitat, reduced LWM, and degraded water quality through reduced stream shading, increased erosion and increased sediment delivery. The land surrounding the FRE facility is used for commercial forestry; it was first logged in the 1940s and semi-regular intervals of second-growth harvest have continued. Forested stands in the upper Chehalis basin are dominated by second-growth even-aged stands of Douglas fir that are in various stages of rotation ranging from 5 to 50 years in age, with some older (Corps 2020).

Since the 1990s regulations have been in place to manage forest practices within riparian management zones (WAC 222-30-021). The required width of riparian management zones varies depending on the site class of the land, the management harvest option, and the bankfull width of the stream. They generally range from 50 to 200 feet wide on either side of the bank. There are three riparian management zones. The core zone is nearest to the water, the inner zone is the middle zone, and the outer zone is furthest from the water. No harvest is allowed within the 50-ft wide core zone, but varying amounts of harvest is allowable in the inner or outer zones as long as the stand requirements are met for number of trees per acre, the basal area, and the proportion of conifer in the combined inner zone and adjacent core zone so that the growth of the trees would meet desired future conditions. WAC 222-30-040 also limits the harvest of trees within 75 feet of the stream that provide shade.

Conservation of 500 acres would be intended to increase the stream buffer widths to at least 100 feet where no harvest would occur to provide wildlife habitat, provide additional protection to aquatic resources, and future LWM recruitment. Figure 8.4-1 shows the potential area where stream buffer widths could be increased beyond current forest practices and conserved.

Figure 8.4-1
Potential Area for 500 acres of Wildlife Habitat Conservation above the FRE Temporary Reservoir



In addition, the Applicant's reach scale geomorphic assessment, described in Section 7.3.2 and Appendix A3 identified four sites in the mainstem of the upper Chehalis River for riparian buffer expansion in Mitigation Reach A, upstream of the upper extent of the temporary reservoir. Permanence of these reestablished forested buffers would be ensured by land acquisition or conservation easements.

8.4.3 Plan

The Applicant intends to conserve forest areas adjacent to riparian areas of the headwater tributaries beyond what is protected by current forest practice rules. The Applicant would also consult with WDFW regarding the location of timber production parcels to conserve that may protect adjacent marbled murrelet nesting habitat or other priority species. The Applicant would negotiate with the landowner on the amount and location of the land to be purchased for conservation and enhancement. The existing stand composition and age would be assessed, and a management plan developed for accelerating the development of a structurally complex habitat composed of a diverse array of native species.

For stream segments with limited shade, specific activities related to this mitigation action include developing and implementing an appropriate plant composition schedule and planting plan to establish a mix of native species of trees and shrubs that would develop into a forested buffer over time. Plant establishment may require initial watering, monitoring, and replacement of plants lost to mortality. Enhancement activities in conserved areas may include thinning of stands currently in stem exclusion phase; selective harvest and planting to increase native species diversity; leaving dead and downed wood, and placement of large woody material where it is lacking.

Conservation and enhancement of the forested buffer would not require in-water work, and potential impacts to water quality and instream habitat are minimal. Plant survivorship would be monitored over time to achieve an 80 percent survival rate after 5 years. Stream shading over time would also be documented. The M&AMP would include monitoring and an adaptive management component to ensure that the goals for plant survivorship, stream shading, and stream temperature mitigation goals are achieved.

8.4.4 Expected Functional Lift

Current forest practices in Washington fully protect trees within the 50-foot core zone, but may allow for tree thinning within the inner and outer zones. Conserving 500 forested acres, or 20.6 miles of stream with a 100-foot buffer will ensure that these areas can develop into intact mature forests and will improve their ecological function. As the forests are allowed to mature, more natural processes will return enhancing functions including nutrient cycling, reduction of surface erosion, increased habitat complexity, and long-term use for riparian- and forest-dwelling wildlife species including marbled murrelets, bald eagles, and other raptors, and both Dunn’s and Van Dyke’s salamanders. Forested riparian areas are often important migratory corridors and conservation of wide buffers may help mitigate potential impacts to larger species such as elk.

Conserving a large contiguous block of forested land also would eliminate disturbance from timber harvest activities within the conservation area and minimize impacts from adjacent ongoing timber harvest activities. The conservation area would include stream and wetland buffer areas; provide a source for wood recruitment; reduce soil erosion; provide for moderated air temperatures in and around streams; offset potential water temperature increases and dissolved oxygen effects due to loss of shade; and offset water quality impacts related to surface runoff and erosion from upslope land use activities. Conservation and enhancement would provide multiple long-term benefits to wildlife as the forest stands mature with increased native species diversity and structural complexity.

Riparian plantings provide some immediate ecological benefits that increase over time as the forest matures and evolves. Full ecological function would require several decades from the time of initial planting.

The amount of ecological lift would vary based on the existing condition of the forested buffer. Sites that would provide the most benefit to wildlife species as well improve stream shade would be prioritized.

Conservation areas may be co-located with other aquatic habitat enhancement mitigation projects to improve the ecological benefit.

8.4.5 Project Constraints

Forest conservation and expansion in Mitigation Reach A would require land acquisition or completion of a conservation easement. Landowner engagement, approvals, and access would be primary constraints for planting. No in-water work would be required for riparian planting.

8.4.6 Timeline

- Land acquisition/easement: 2023,
- Riparian assessment of prioritized sites: 2023,
- Wildlife habitat assessment and planning: 2024,
- Planting and other habitat enhancements: 2025-2026,
- Monitoring: Year 1, 3, 5, 7, 10. After Year 10, 5-year check ins would continue to Year 30 followed by 10-year check ins to Year 50.

8.5 Large Woody Material Recruitment and Placement

As described above, the Applicant has proposed three types of mitigation, Riparian/stream Buffer Expansion below the FRE facility (Section 8.3), Wildlife Habitat Conservation above the FRE temporary reservoir (Section 8.4), and wood placement within Aquatic Habitat Enhancements (Section 8.2.2) that would expand riparian forests for future LWM recruitment and use LWM installations to offset reduction in downstream wood transport due to the Proposed Action.

8.5.1 Goals and Objectives

The goal of the mitigation projects that entail LWM is to mitigate for the potential impacts of the Proposed Action identified in the SEPA/NEPA-DEIS:

- Downstream transport of woody material would be interrupted during operations, and the size range of recruited LWM that could pass the FRE facility would be limited; and
- Changes in the movement of sediment, large woody material, nutrients, and water resulting in potential effects on fish habitat.

The following objectives would meet the goal of mitigating potential impacts for LWM recruitment and transport:

- Implementation of the VMP would retain trees to the maximum extent possible within the FRE temporary reservoir and plant 220 acres of the temporary reservoir area at the onset of construction to support future local LWM recruitment. Trees that are removed from the construction staging, access, and FRE facility sites would be used for mitigation projects downstream. LWM removed during debris management evacuation operations and stored in a sorting yard would provide a source of LWM to be used in enhancement projects.

- Wildlife Habitat Conservation of 500 acres upstream of the proposed FRE temporary reservoir to expand no-harvest buffers to a width of 100 feet (each side) along 20.6 stream miles and increase ecological function of these forested habitats. This corresponds to the width of the buffer zone determined in Washington State's Forest Practices HCP to be a primary recruitment source for large wood (as represented by tree height potential).
- Riparian/Stream Buffer Expansion downstream of the proposed FRE facility to create and enhance degraded forested riparian habitat along 25. 5 miles of stream channel in both the mainstem Chehalis River and tributary systems. Re-establishing expanded forest buffers along each side of the stream channel would include developing and implementing an appropriate plant composition schedule and planting plan to establish a mix of native species of trees and shrubs that would develop into a forested buffer over time. As the planted forest matures and natural senescence occurs the reforested/conserved riparian habitats will provide a source for large wood to fall into the river channel.
- Aquatic Habitat Enhancement projects would include LWM installations below the FRE facility from trees removed as part of the Proposed Action for the following types of habitat enhancement mitigation actions: summer water temperature improvements, instream modifications, and gravel retention jams. The objective is to improve the functional value of aquatic habitat through the LWM placements that promote habitat-forming processes, increase habitat complexity over the near term while riparian buffers are restored and expanded upstream, and provide thermal refugia for aquatic species within approximately 20 miles of the Chehalis River downstream of the proposed FRE facility.

8.5.2 Site Restoration Potential

Upstream of the proposed FRE location, timber harvest has occurred and is ongoing within 100 ft of the stream channel, consistent with Washington's Forest Practices guideline. Downstream of the proposed FRE location, both forestry and other land-use practices have reduced the amount of riparian forest from which LWM recruitment can occur. These practices have resulted in a reduction of wood available to recruit into the mainstem Chehalis River and current in-channel wood is lower in the Chehalis River compared with rivers of similar size (Corps 2020). Based on current canopy opening angles, the Applicant identified approximately 15.4 miles of mainstem Chehalis River habitat and 130.3 miles of tributary habitat with riparian canopies that are degraded from historic conditions.

There presently is relatively little in-channel wood in the mainstem Chehalis River compared with historic conditions or other similar river systems. The successful and effective addition of wood and corresponding site restoration potential depend on the geophysical processes that affect their stability, persistence, and functioning. The geomorphic reach assessment was used to identify locations where placement of specific types of large wood installations would be most compatible with reach scale sediment transport and flooding processes. Table 8.2-3 summarizes the number of MOAR opportunities that the analysis identified as most likely to be feasible in each Mitigation Reach. This analysis also indicated that additional feasible projects exist that were not identified in the MOAR, but could be added to the list of mitigation opportunities to choose from if needed.

8.5.3 Plan

8.5.3.1 Riparian/Stream Buffer Expansion and Wildlife Habitat Conservation

A Riparian/Stream Buffer Habitat Management Plan would be developed that would include all aspects of mitigation related to riparian conservation and reforestation. A habitat assessment of selected sites would be conducted once during the growing season to document pre-mitigation riparian functions and adjacent upland habitat conditions as they pertain to vegetation community composition. The following riparian functions would be assessed using guidelines presented in Section 21, *Guidelines for Alternate Plans, in the Forest Practices Board Manual* (WA DNR 2000):

- Stream shading,
- Stream bank stability,
- Large woody material availability and recruitment.

Site selection would be determined by accessible areas that would provide both short-term ecological lift associated with habitat enhancement as well as long-term potential for the development of future large wood resources. Sites higher in the Basin would receive higher priority in context of reducing cumulative downstream effects most effectively for fish habitat. Specific activities related to this mitigation action include developing and implementing an appropriate plant composition schedule and planting plan to establish a mix of native species of trees and shrubs that would develop into a forested buffer over time. Plant establishment may require initial watering, monitoring, and replacement of plants lost to mortality. The permanence of these reestablished forested buffers would be ensured by land acquisition or conservation easements. Conservation of existing forests would occur in locations where such forests could otherwise be removed or modified by timber harvest, agriculture, or land development.

Riparian buffer expansion would not require in-water work, and potential impacts to water quality and instream habitat are minimal. On timberlands upstream of the proposed FRE locations, actions would involve purchasing forest land for conservation and primarily plantings. Downstream of the proposed FRE location, actions would involve both augering cottonwood boles in the floodplain to form flood fences along the upper edge of riverbanks, and planting and soil amendment and watering to support plant establishment.

Flood fencing is a ‘win-win’ approach to resolving conflicting goals of farming and salmon restoration. Farmers historically cleared much of the riparian zone along riverbanks to maximize production area. Plantings do not address farmers’ flood damage concerns where they spend money annually clearing fields of wood and coarse sediments. It takes time for plantings to take hold and mature to the extent they can provide a comparable in addition to their biological benefits. Flood fences were conceived as an interim means for trapping woody debris and sediments before they reach the field and for providing physical protection for plantings and colonizing vegetative material until a mature riparian zone becomes established.

Delivery of plant material and soil amendment would use existing transportation routes as much as possible, and any new routes required for site access would follow conventional erosion and sediment control requirements in addition to post-maintenance restoration.

Plant survivorship would be monitored over time to achieve an 80 percent survival rate after 5 years. Stream shading over time would also be documented. The Riparian/Stream Buffer Habitat Management Plan would include an adaptive management component to ensure that the goals for plant survivorship and growth are being attained.

8.5.3.2 Aquatic Habitat Enhancement

The Applicant is proposing instream large wood material placement for the following types of habitat enhancement mitigation actions: summer water temperature improvements, instream modifications, and gravel retention jams. Construction activities would generally involve providing heavy equipment access and construction staging to perform earthwork that would be needed to embed large wood pieces into the riverbed and banks. The following information describes how LWM would be incorporated into these mitigation action types.

8.5.3.2.1 Summer Water Temperature Improvements

Large-scale reductions in summer water temperature are unlikely to be achievable through habitat enhancement actions. However, Chehalis River water temperatures can be enhanced locally to provide additional thermal diversity and expanded thermal refuge habitat by judicious placement of large wood to the river channel. Specific actions where LWM placement could have a measurable increase in thermal refuge habitat availability include: enlarging identified lateral cool water inputs along the channel margin; enlarging identified vertical-stratification volumes in pools; reducing mixing of cool water tributary inflows at confluences with the mainstem; increasing connectivity to off-channel side- and floodplain channels, backwater alcoves; and creating or enhancing isolated over-summering side pools with hyporheic flow and cover.

For enlarging existing cool water inputs, wood would be used to slow the mixing of the cool water with the warmer mainstem waterbody, and provide instream structure and overhead cover. For enlarging vertical-stratification area, large wood placement could be used to reduce mixing, and potentially raise the elevation of the thermocline. Wood placements would also occur within a re-meandered stream channel to create habitat complexity and encourage pool formation. For accessing off-channel habitats, large wood could be placed to alter hydraulic flow fields to route sediments away from or through the junction to reduce the rate of blocking sedimentation. In all of these cases, LWM would provide habitat cover as well. Large wood can also be used to increase gravel bar size through sorting processes and thereby increase area available for sub-surface flow.

8.5.3.2.2 Instream Modifications

Instream modifications would involve the construction of habitat features within the perennial wetted channel to achieve several ecological purposes such as enhancement, restoration, inducement, or creation of habitat-forming processes, all to add habitat complexity (Kleinschmidt 2020). Actions would involve the placement of LWM within the channel with or without anchoring mechanisms depending on the size of the channel, risk factors, and the intended function of the wood. Large wood structures can be designed to provide various functions and enhanced habitat for native fishes, including juvenile and adult salmon, such as hydraulic diversity, substrate diversity through sorting, instream cover, high flow refugia, pool formation, and gravel retention. Additional benefits include providing macroinvertebrate habitat for enhancing aquatic productivity at a local scale, and enhancing riverine habitat for riffle-dwelling amphibians and freshwater mussels.

8.5.3.2.3 Gravel Retention Jams

Gravel retention jams, in association with boulder fields, are designed to provide hydraulic roughness and promote deposition and accumulation of salmonid spawning gravels (Kleinschmidt 2020). Gravel retention jams would involve the placement of large wood within the channel, with anchoring mechanisms if needed to retain the jam at the selected location. Additional activities may include minor earthwork to embed large wood pieces into the riverbed and banks, site work to provide access, and construction staging. While gravel retention jams are a specific type of in-stream modification intended to enhance salmon spawning habitat, they also would provide multiple secondary benefits such as hydraulic diversity, substrate sorting, in-stream cover, high-velocity refugia, and pool formation. These attributes represent enhanced habitat for multiple aquatic species including juvenile salmonids, native fishes and stream-dwelling amphibians. The vertical hydraulic gradient created by gravel deposition upstream of the jam also can accentuate hyporheic flow and create localized thermal refugia for juvenile salmonids. Jams would need to be created in series to preclude development of sediment transport imbalances that lead to deep scour, and to reflect behavioral selection of larger patches for spawning. Prior to final selection of potential candidate sites, a sediment supply and transport assessment would be needed to establish whether the associated deposition could be expected to be of sufficient quality and quantity to support reproductive success.

8.5.4 Expected Functional Lift

Wood counts in the upper Chehalis River below the location of the proposed FRE indicate the system is degraded in this context when compared to similar sized rivers (Corps 2020). Only a few log jams were observed during a 2021 site reconnaissance float that covered the river from the highway bridge upstream of Pe Ell (RM 106) to the confluence with the South Fork Chehalis River (RM 88). In part due to low amounts of wood within the existing river channel, the mainstem upper Chehalis habitat is quite uniform lacking habitat complexity and diversity. Placement and stabilization of wood for habitat enhancement would provide an immediate increase in instream habitat structure and cover and should facilitate the enhancement, restoration, inducement, or creation of habitat-forming processes and promote hydraulic diversity, substrate diversity, high flow refugia, pool formation, and gravel retention in suitable reaches where it is installed. In addition, in-channel wood provides habitat for macroinvertebrates enhancing aquatic productivity at a local scale.

The creation and enhancement of riparian buffers will provide future local LWM recruitment. The expanded riparian river reaches would also enhance water quality by reducing water temperature, reducing soil erosion, reducing agricultural runoff, increasing nutrient cycling, and providing more complex and additional habitat for a variety of riparian-dependent plant and animal species.

Enhancement of existing riparian buffers also has the potential to benefit multiple wildlife species including priority species such as western toad, Dunn's salamander, VanDyke's salamander, and other riparian wildlife species. Targeted enhancement of existing forested riparian buffers such as large woody material placement could benefit terrestrial-breeding salamanders. Planting currently non-forested riparian buffers would also provide multiple long-term benefits to wildlife as the plantings mature and forest succession is reestablished.

8.5.5 Project Constraints

Landowner engagement, approvals, and access would be primary constraints for riparian enhancement and conservation. No in-water work would be required for riparian planting.

After identifying sites where the placement of large wood for aquatic habitat enhancement projects is consistent and compatible with reach scale processes and enhancement objectives, key constraints to successful large wood design installation include access, perception of risk, and presence of bedrock. Access will depend on landowner willingness, which can, in part, reflect the perception of risk by adjacent landowners. Even with the most thorough siting feasibility assessment and design, the possibility still exists that adjacent landowners will fear large wood placement failing and impacting their lands. Consequently, designs would likely need to include a safe-fail aspect. Placements in bedrock-dominated reaches upstream of the FRE facility, including particularly gravel retention structures, may need a highly structural anchoring design that anchors the logs to bedrock.

8.5.6 Timeline

Once identified, riparian/stream buffer enhancement projects could begin immediately to reduce the duration of impacts associated with loss of stream habitat upstream of the FRE facility and temporary reservoir. The proposed timeline for implementation is as follows:

- Landowner engagement/easement: 2022-2024,
- Riparian assessment of prioritized sites: 2022-2023,
- Development of riparian/stream buffer planting plans: 2024-2025,
- Project Implementation: 2025-2028,
- Monitoring: Year 1, 3, 5, 7, 10. After Year 10, 5-year check ins would be sufficient up to Year 30, followed by 10-year check ins to Year 50.

Field investigations to identify aquatic habitat enhancement sites would begin in 2022. Once identified, projects to provide or enhance aquatic habitats could begin immediately to reduce the duration of impacts associated with loss of stream habitat upstream of the FRE facility and temporary reservoir. The proposed timeline for implementation is as follows:

- Field investigations to identify sites: 2022-2023,
- Landowner engagement/easement: 2022-2024,
- Project design and permitting: 2023-2024,
- Pre-mitigation site condition and functional assessment: 2023-2025,
- Project Implementation: 2024-2026,
- Monitoring: Year 1, 3, 5, 7, 10. After Year 10, 5-year check ins would be sufficient up to Year 30, followed by 10-year check ins to Year 50.

8.6 Surface Water Quality

Several types of mitigation have been presented above to address potential water quality impacts from the Proposed Action. Mitigation to increase stream shading and improve summer water temperatures and related dissolved oxygen affects were presented in sections 8.2.2.2 Water Temperature Improvements, 8.3 Riparian/Stream Buffer Expansion Downstream of the FRE, and 8.4 Wildlife Habitat Conservation. Mitigation to address these potential turbidity effects were presented in Section 8.2.2 Aquatic Habitat Enhancements, Section 8.3 Riparian Buffer Expansion and Section 8.6 Wildlife Habitat Conservation.

This mitigation measure consists of the development of a surface water quality monitoring program as part of the M&AMP to document the effectiveness of the aforementioned mitigation measures at offsetting temperature, dissolved oxygen, and turbidity effects resulting from FRE facility operation.

8.6.1 Goals and Objectives

The SEPA/NEPA-DEIS identified the following impacts related to habitat for aquatic species:

- Water temperature increase of up to 5.4ºF (1.8ºC) in the Impact Area downstream of the FRE facility (including the combination of Proposed Action potential effects and potential effects of climate change), related primarily to the loss of shade along the river and tributary streams in the temporary reservoir area.
- Decreased dissolved oxygen downstream about 20 miles from loss of riparian shading in the FRE temporary reservoir.
- Exceedances of turbidity when water is released from the temporary and during subsequent storms.

The goal of several previously described mitigation actions, as noted above, is to mitigate for these potential impacts on water quality from the Proposed Action. The objective of this water quality mitigation measure is to development a Surface Water Quality Monitoring and Management Plan to document the effectiveness of mitigation measures at offsetting temperature, dissolved oxygen and turbidity effects resulting from FRE facility operation.

8.6.2 Site Restoration Potential

Water quality in the upper Chehalis Basin below the FRE facility is impaired as indicated by Clean Water Act Section 303(d) and Water of Concern listings for several parameters including turbidity, nutrients, fecal coliform, dissolved oxygen (DO), and temperature. The water frequently exceeds maximum temperature thresholds in summer for salmon and steelhead including the 7-day consecutive mean daily max temperature (7-DADMax) criterion of 16°C in stream reaches designated as core summer salmonid habitat in WAC 173-201A-602 and the 13°C criteria applied September 15 to July 1 in stream reaches designated with supplemental spawning/incubation criteria (Anchor QEA 2014). Data has also shown acute impairment that exceeds Washington's lethality guidelines (Anchor QEA 2014). Low flow, high water temperature, and low dissolved oxygen were implicated in the 2009 mortality event where approximately 100 spring-run Chinook salmon died in the mainstem Chehalis River near RM 104 and 74 and in the lower Newaukum River (Liedtke et al. 2016).

Consistent with high summer temperatures, sampling by Ecology in 2016, 2017, and 2018 identified summer DO levels upstream of Pe Ell consistently less than the standard for salmon spawning habitat, which at that time was 9.5 milligrams per liter (mg/L) (Anchor QEA 2014). Previous samples from 2013 and 2014 also document DO less than 9.5 mg/L downstream of Pe Ell in summer months (Anchor QEA 2014). In April of 2022, Ecology revised the DO standard for salmon spawning habitat up to 10 mg/L or 95% saturation.

8.6.3 Plan

A surface water quality monitoring would be developed that encompasses all of the mitigation measures that would be implemented to mitigate for potential degradation of water quality from the Proposed Action. The plan would be developed in consultation with the permitting agencies. Key components of the plan would include:

- Identification of metrics and locations for water quality monitoring pre- and post-mitigation implementation,
- Methods and frequency of monitoring,
- Identification of compliance points upstream and downstream of mitigation sites,
- Centralized location for water quality data to be stored over the life of the FRE facility,
- Schedule for reporting and ongoing agency consultation.

A framework for the water quality monitoring is presented with the M&AMP in Section 9.

8.6.4 Expected Functional Lift

Due to existing degraded conditions of the water quality in the upper Chehalis River, any potential reductions in low flow summer water temperatures and increases in dissolved oxygen, even localized effects, would be a benefit to native species. Adult spring Chinook salmon are the most vulnerable salmonid as they are mainstem spawners that spawn in the summer and can hold in the mainstem for months before spawning. While minimizing potential temperature increases to 0.3^{o}C or less would be consistent with current regulations, ecological lift can be obtained by creating localized thermal refuge habitat for these fish to rest and hold during the day as they await cooler nighttime temperatures that will allow them to complete their ascent in the mainstem to cooler spawning habitats. Providing mitigation to facilitate the attainment of these new standards during summer months would provide a needed ecological lift for spring Chinook salmon.

As described in the SEPA DEIS, excessive turbidity in exceedance of the state water quality standard has also been observed in the Chehalis River. Segments of upper Chehalis River have been 303(d) listed for turbidity associated with degraded riparian conditions and storm water run off from forest and agricultural lands (Ecology 2020). Turbidity events, typically occur in winter months when storms and flood flows are more prevalent. Turbidity as high as 610 NTUs have been documented; whereas in summer turbidity is much lower and can be less than 2 NTUs.

The minimization and mitigation proposed in this plan associated with revegetating and expanding riparian buffers in commercial forest and in reaches with heavy agricultural land use, will help to reduce inputs of fine sediments both from localized landslides and from storm runoff. In addition, the distribution of riparian mitigation locations from RM 114 downstream to the confluence with South Fork would allow for capturing runoff and reducing turbidity inputs throughout a 26-mile reach of the mainstem river and well over 20 miles of tributary channels. This extensive distance of mitigation to reduce turbidity input to stream channels will improve aquatic habitat conditions for numerous aquatic species including for salmon and native fish spawning and rearing, for amphibian breeding, and macroinvertebrate production.

8.6.5 Project Constraints

Project constraints for water quality mitigation actions are presented in Sections 8.2.2.2, 8.3.5, and 8.4.5. For implementation of a water quality management plan, constraints include potential access and permitting to install, download and/or maintain equipment at compliance point locations.

8.6.6 Timeline

The timeline for initiating and implementing the various mitigation actions that would mitigate for potential water quality degradation are presented above. A Surface Water Quality Monitoring Plan would be developed as part of the site selection and planning process that outlines the metrics to be measured and locations pre-mitigation and during on-going monitoring to evaluate the effectiveness of the mitigation projects to enhance water quality. Monitoring would occur in Year 1, 3, 5, 7, 10. After Year 10, 5-year check ins would be sufficient up to Year 30, followed by 10-year check ins to Year 50.

9 MONITORING AND ADAPTIVE MANAGEMENT PLAN

9.1 Background

Under the Proposed Action, the Applicant would implement a suite of aquatic, riparian, and upland habitat mitigation, currently under development in this FRE HMP. This mitigation would be required to meet specific performance standards that would be stipulated in environmental permits. As part of the FRE HMP, the Applicant proposes to develop a monitoring and adaptive management plan (M&AMP) to address uncertainties that may affect mitigation function, and to develop criteria that would trigger the implementation of corrective actions or implementation of contingency measures during the performance monitoring period. The M&AMP would cover all mitigation measures implemented under the mitigation categories as described in Section 8, Compensatory Mitigation.

Ecological processes are inherently dynamic, evolving with geophysical processes that range in scale from regional climate patterns to reach-level hydrology and/or channel gradient. As such, predicting future ecological and biological conditions comes with a high level of uncertainty, especially in light of the uncertainty associated with regional climate models and their predictions for future hydrology and temperature in the basin. Additional uncertainty around mitigation implementation success is associated with unpredictable human behaviors, including landowner engagement for mitigation sites and future development and/or landscape scale changes in the upper Chehalis River Basin. The adaptive management portion of the M&AMP provides an ongoing process by which uncertainty can be addressed to ensure successful mitigation.

For the purposes of this draft FRE M&AMP, “adaptive management” refers to actions taken to:

- Reduce or address uncertainties associated with future floods and the potential operational frequency of the FRE facility and resulting impacts on physical processes, fish, wildlife, and terrestrial resources.
- Address uncertainties associated with landowner engagement and future human activities in the floodplain.
- Identify potential problems, possible solutions, and site management adjustments to correct foreseeable challenges based on results of long-term monitoring efforts.
- Provide contingency plans if needed for resource management.
- Serve as a mechanism for communication between resource monitoring and management actions that would result in appropriate adjustments to planned actions.

Key uncertainties associated with the existing baseline and future conditions in the basin would guide further development of the adaptive management framework. These uncertainties could require adjustment to proposed mitigation. Examples of uncertainty are presented below.

1. Will the mitigation function as intend to offset actual impacts once the FRE has been constructed and operated?
2. What are site-specific uncertainties of the planned mitigation actions proposed in the FRE HMP and how might they affect mitigation performance?
3. How will the performance of long-term mitigation be sustained in the context of climate change and associated hydrology and water temperature expectations?
4. What can be learned from early-implementation projects to inform subsequent site-specific actions?

The FRE M&AMP would include a process for management input and for informing and guiding decision making. It is the Applicant's expectation that the FRE M&AMP will be implemented under the direction of a committee of FCZD/County representees, permitting agency representatives (Corps, Ecology, and WDFW and/or others) with jurisdictional authority, and possibly regional experts appointed by the Applicant. As described below, the FRE M&AMP is intended to determine whether the level of effort, specific mitigation actions, and rate of successful implementation are sufficient to achieve the no net loss commitment.

9.2 Monitoring Plan Development Approach

The evaluation questions considered in the development of a monitoring plan would be addressed at both a stream reach and site scale. Standard monitoring protocols developed for salmon-bearing waters of the Pacific Northwest can be applied to address these questions, including Implementation Monitoring, Project Effectiveness Monitoring, Status and Trends Monitoring, and Validation. The final FRE M&AMP would include details of the monitoring approaches described below.

Implementation Monitoring would be designed to determine whether mitigation projects were constructed as designed. Examples include determinations of the number of engineered LWM structures, acres of native riparian trees and shrubs planted, or length of side-channel reconnections were achieved. Implementation monitoring would be planned for all project locations to document project activities, especially those relevant to permit compliance and required reporting. Results from implementation monitoring would be captured in As-Built Design Reports.

Project Effectiveness Monitoring determines whether the physical habitat objectives and intended ecological lift of each mitigation action have been achieved. The types of questions that would need to be asked will be mitigation-type specific. For example, have fish passed upstream where barriers were removed to spawn and rear in reconnected habitat? Did riparian planting result in increased shade cover as determined by measurement of open canopy angle and reduce localized high summer water temperature?

Project effectiveness monitoring would occur at a subset of sites that are representative of the distinct mitigation categories. The number or replicates and location of monitoring sites would be determined after site selection has occurred. Monitoring would combine direct field measurements (e.g., wood counts, plant surveys, water temperature, dissolved oxygen and turbidity measurement, etc.) and remote sensing using drones, LiDAR or other applicable tools that will be useful for providing reach-level attributes (e.g., large wood counts, vegetative species composition). Standardized habitat surveys that characterize physical changes would be implemented for all habitat enhancement mitigation actions. Biological sampling would be included for specific aquatic habitat mitigation to understand aquatic species use of the newly created habitat and how habitat functions may change over time. Biological sampling of the habitat feature would include fish/aquatic species presence and macroinvertebrate sampling (specific to in-channel wood installations). To be an effective tool for adaptive management, monitoring would be completed both prior to construction and for the performance monitory period specified in the environmental permits.

9.3 Data Management

9.3.1 Data Description

To build confidence in the dataset, the collection and recording of field data under the M&AMP will rely upon standardized protocols established and accepted for surveys in Pacific Northwest river and streams. Where appropriate, protocols used will be consistent with those used for ASRP monitoring that is ongoing throughout the Chehalis River Basin. This will help inform some of the ASRP objectives related to watershed health as well as provide some watershed context to mitigation. Use of standardized metrics and procedures for data collection will increase efficiency, save money, and facilitate data compatibility.

It also would be useful if protocols for using remote sensing data protocols were compatible for similar types of monitoring (e.g., LWM counts, vegetation type, etc.). Where objectives maybe specific to mitigation, e.g., measurement of canopy open angle to evaluate increased shade, the data collection protocols would be discussed with permitting agencies to ensure the approach will result in acceptable data for evaluating the objective.

9.3.2 Data Storage and Accessibility

Advanced database tools, data accessibility, and data security are critical for large, complex mitigation programs as multiple user groups require access to evaluate monitoring efforts and implement adaptive management. The M&AMP database will be developed to ensure maximum data quality, integrity, and accessibility with automated features for quality assurance, cloud-based backup, and technical support. To the extent practicable the M&AMP database will be made compatible with ASRP datasets.

9.4 Reporting

Effective monitoring and adaptive management will require consistent and timely reporting. A master schedule will be developed for M&AMP reporting. The reporting schedule will align with the performance monitoring milestones specified in the M&AMP. Report products expected to be developed under the M&AMP include the following:

- As-built Design Reports,
- Annual Performance Monitoring Reports,
- Multi-year Monitoring and Adaptive Management Reports.

9.5 Adaptive Management Plan Development

The Applicant plans to develop an M&AMP that separately addresses each of the six mitigation categories proposed in Section 8 of this FRE HMP. The plan would be developed in consultation with the Adaptive Management Committee, WDFW, Ecology and Corps representatives during the permitting phase of the Proposed Action. The framework for each of the plans is discussed in the following sections.

9.6 Monitoring and Adaptive Management

The Applicant's M&AMP would address the six mitigation categories proposed in Section 8. The plan will include pre-baseline monitoring at mitigation sites as necessary to demonstrate ecological life, implementation monitoring that will document that mitigation was constructed as designed, effectiveness monitoring, and the adaptive management process. The framework for these plans is provided herein.

9.6.1.1 Aquatic Habitat Access

The goal of this mitigation is to increase the mileage of suitable habitat available to salmonids and other native fishes in the upper Chehalis River by removing impediments currently blocking or impeding fish passage.

9.6.1.1.1 Monitoring Framework

- Develop an implementation program that validates as-built versus final design standards/goals. This would include design details for stream restoration post barrier removal.
- Develop a monitoring component that addresses physical habitat resilience and persistence.
- Develop a fish presence survey that includes pre- and post-construction monitoring.

Key Assumptions

- Implementation monitoring would occur at all sites.
- Removal of invasive and noxious vegetation and replacement with natives will result in improved habitat for wildlife species beginning several years post-planting.

- A before/after approach for performance monitoring at a subset of sites would be sufficient to evaluate effectiveness of this mitigation action type.
- Performance metrics and standards may be used to evaluate individual mitigation actions, reach-scale performance, and overall performance of a group of mitigation actions within the same mitigation type.

Monitoring Objectives

1. Document the number of barriers removed and linear distance of habitat reconnected.
2. Document as-built designs.
3. Monitor desired future conditions of increased use of habitat for native fishes.
4. Evaluate ecological lift associated with secondary habitat benefits including composition of native species present, absence of invasive and noxious species in habitat restoration area.

Example metrics could include but would not be limited to:

- Stream gradient,
- Water depths and velocities in restored habitat,
- Fish species presence by season,
- Non-native species presence.

9.6.1.1.2 Adaptive Management:

The adaptive management committee and permitting agencies would consult with the Applicant to refine the habitat access monitoring and discussion of any appropriate adaptations to the implemented Plan. Monitoring data will be used by the Adaptive Management Committee to evaluate project performance over time and to initiate adaptive management action if agreed-upon triggers are identified.

Examples of possible triggers for adaptive management include:

- Landowner access changes after projects are initiated,
- Post-construction channel adjustment at the site of former barrier that could lead to upstream scour.

Adaptive management action examples or aquatic habitat enhancements would be adopted in consultation with the Adaptive Management Committee and could include:

- Site-selection adjustment.

9.6.1.2 Aquatic Habitat Enhancements

The goals of this suite of mitigation actions are to improve the ecological function of aquatic habitat with habitat enhancement features that increase channel and habitat complexity, engage the floodplain, and provide thermal refugia for aquatic species. Mitigation actions considered under this plan include surface water temperature improvements, instream modifications, off-channel modifications, gravel retention jams, and riparian buffer enhancement.

9.6.1.2.1 Monitoring Framework

- Develop an implementation program that validates construction versus design goals. This would include, for example documenting the number of wood pieces installed, the depth and width of alcove habitat created, etc.
- Develop a monitoring component that addresses physical habitat surveys to document resilience and persistence of design features, for example, a scour pool below a log jam or pieces of large wood captured by flood fencing, water temperature within, upstream and downstream of water temperature improvements.

Key Assumptions

- Implementation monitoring would occur at all sites.
- Removal of invasive and noxious vegetation and replacement with natives will result in improved habitat for wildlife species beginning several years post-planting.
- Creation of instream structure and off-channel habitat features will be used by a diversity of aquatic species.
- A before/after approach to a subset of sites would be sufficient to evaluate the effectiveness of this mitigation action type.
- Performance metrics and standards may be used to evaluate individual mitigation actions, reach-scale performance, and overall performance of a group of mitigation actions within the same mitigation type.

Monitoring Objectives

1. Document that the number and, as appropriate, area, of action types and sites installed and sustained at the reach-level meets mitigation objectives.
2. Evaluate project persistence by documenting numeric design goals.
3. Monitor desired future conditions to evaluate the trajectory of the project towards meeting the primary goal of reduced localized summer water temperature.
4. Document improvements to reach-level habitat complexity and diversity.
5. Evaluate ecological lift associated with secondary habitat benefits including composition of native species present, absence of invasive and noxious species.

Example metrics could include but would not be limited to:

- Wood and boulder counts,
- Number and area of cold water refuge sites,
- Water temperature measurements, within, upstream and downstream from temperature improvements,
- Area of spawning gravel accumulated,

- Water depths and velocities in created spawning and rearing habitat,
- Number of macrohabitats by type,
- Area of spawning gravel accumulated,
- Distance of off-channel reconnected,
- Activation flows of off-channel habitats,
- Species presence by season.

9.6.1.2.2 Adaptive Management

The Adaptive Management Committee would consult with the Applicant to refine the habitat enhancement monitoring program, reporting schedule and timeline, data and report sharing, and accessibility. This committee would provide forum for review of monitoring results and discussion of any appropriate adaptations to the implemented Plan. Monitoring data would be used to evaluate project performance over time and to initiate adaptive management action if agreed-upon triggers are identified.

Examples of possible triggers for adaptive management include:

- Failure of a particular type of mitigation,
- Failure to attain a desired primary goal, such as summer water temperature reduction in refuge habitat,
- Shorter than expected life span of wood installations.

Adaptive management action examples or aquatic habitat enhancements would be adopted in consultation with the Adaptive Management Committee and could include:

- Adjustment of site-specific action types,
- Elevation adjustments for wood installations,
- Development of additional installations at new locations.

9.6.1.3 Riparian and Stream Buffer Monitoring and Adaptive Management Plan

The goal of the riparian buffer expansion plan is to mitigate the unavoidable impacts to stream temperature, and expand forested buffers along stream and river margins along 25.5 stream miles of mixed forest downstream of the FRE facility to the confluence with the Newaukum River, including tributary subbasins. This mitigation will provide shade for thermal modulation of air temperatures, interception of surface runoff and reduce erosion, nutrient cycling, enhance vegetative diversity to enhance wildlife and amphibian habitat. Reducing the potential for warm summer water temperatures also reduces the potential for dissolved oxygen concerns.

9.6.1.3.1 Monitoring Framework

- Development of an implementation program that addresses area planted, the elevation of planting sites, species composition, overplanting goals by species, presence and removal/control of invasive and noxious species, plant replacement.
- Development of a monitoring component that addresses but is not limited to, vegetation surveys to document stand survival rates, canopy cover, and downed and dead wood surveys.

Key Assumptions

- Plantings of native riparian trees and shrubs that will survive and grow well in degraded reaches and will provide increased organic input and drift to areas downstream.
- Removal of invasive and noxious species and replacement with natives will result in improved habitat for wildlife species beginning several years post planting.
- Shade benefits will be dependent upon the current condition of the degraded habitat, i.e., benefit to stream reaches with reed canary grass as dominant riparian vegetation would see benefits on the order of several years, where full benefits from expanded riparian forests with species such as red alder, black cottonwood, and Pacific willow would be expected to manifest after 5 to 10 years.
- Implementation monitoring would occur at all sites.
- A before/after approach to a subset of sites would be sufficient to evaluate the effectiveness of this mitigation action type.
- Performance metrics and standards may be used to evaluate individual mitigation actions, reach-scale performance, and overall performance of a group of mitigation actions within the same mitigation type.

Monitoring Objectives

1. Evaluate project persistence by documenting numeric design goals.
2. Monitor desired future conditions to evaluate trajectory of project towards meeting primary goals or increased shade and reduced localized summer water temperature.
3. Evaluate ecological lift associated with secondary habitat benefits including composition of native species, absence of invasive and noxious species, organic stream inputs, wildlife habitat complexity.

Specific metrics to be monitored to provide measures of effectiveness of riparian/stream mitigation would change over time as the forest matures. Example metrics that would address over time include:

- Stem counts of planted native species,
- Stand counts and areas of invasive and/or noxious species,
- Changes in canopy open angle,
- Stream water temperature,
- Stream bank stability,

- Counts of down and dead wood,
- Estimates of leaf litter and organic inputs including drift.

9.6.1.3.2 Adaptive Management

The Adaptive Management Committee would consult with the Applicant to refine the monitoring program objectives and metrics. Monitoring data will be used by the Adaptive Management Committee to evaluate project performance over time and to initiate adaptive management action if agreed-upon triggers are identified.

Possible triggers for adaptive management include:

- Unacceptable levels of plant mortality,
- Severely diminished growth rates as compared to expectations,
- Loss of the plantings due to unanticipated actions, e.g., excessive weather/climate events, human intervention.

Adaptive management action for riparian/stream buffer enhancements would be adopted in consultation with the Adaptive Management Committee and could include:

- Selection of additional riparian enhancement sites,
- Adjusting plant composition goals,
- Adjusting planting elevation.

9.6.1.4 Wildlife Species and Habitats

The goal of wildlife species and habitat mitigation is to expand and conserve 500 acres of forestland upstream of the FRE facility. This would include 100-ft wide buffers on each side of 20.6 stream miles. This mitigation will protect riparian forests beyond current allowable forest practices and allow for forest maturation and successional properties to be drivers of habitat complexity. This would support habitat for wildlife breeding and foraging, resting and overwintering, and specifically, would enhance habitat for marbled murrelet, and Van Dyke's and Dunn's salamanders.

9.6.1.4.1 Monitoring Framework

- Develop implementation monitoring to address: 1) areas of stream reaches purchased for forest conservation, and 2) riparian enhancement within existing forested corridors. It would include validation of design elements such as elevation of planting sites, species composition, overplanting goals, and presence and removal/control of invasive and noxious species.
- Evaluate stand health and assess the need for active management actions, such thinning during stem-exclusion phases, and select harvest and planting to increase native species diversity.
- Develop performance monitoring that includes surveys to document tree species composition, survival rates, canopy cover, and downed and dead wood, and wildlife habitat surveys.

Key Assumptions

- Establishing a 200 ft natural forest buffer on 20.6 miles of stream will provide a protected wildlife corridor as well as additional habitat to support wildlife life functions; as the forest matures these functions will change and increase including increase species diversity.
- Removal of invasive and noxious species and replacement with natives will result in improved habitat for wildlife species beginning several years post-planting.
- Managing for habitat diversity and complexity will support a more diverse array of native species.
- Implementation monitoring would occur at all sites.
- A before/after approach to a subset of sites would be sufficient to evaluate the effectiveness of this mitigation action type.
- Performance metrics and standards may be used to evaluate individual mitigation actions, reach-scale performance, and overall performance of a group of mitigation actions within the same mitigation type.

Monitoring Objectives

1. Evaluate project persistence by documenting numeric design goals.
2. Monitor desired future conditions to evaluate the trajectory of a project towards meeting primary goals of enhanced wildlife habitat, including habitat complexity and species diversity.
3. Documentation of wildlife use of habitat.
4. Evaluate ecological lift associated with secondary habitat benefits including increased nutrient cycling, reduced soil erosion, moderated air temperatures, absence of invasive and noxious species, increased wood recruitment.

Specific metrics to provide measures of effectiveness of wildlife species and habitat riparian mitigation would change over time as the forest matures. Example metrics include:

- Stand density and diversity,
- Wildlife richness diversity,
- Stem counts of planted native species,
- Stand counts and areas of invasive and/or noxious species,
- Changes in canopy open angle,
- Change in air temperature,
- Reduced storm-related stream turbidity,
- Counts of downed and dead wood.

9.6.1.4.2 Adaptive Management

The Adaptive Management Committee would consult with the Applicant to refine the monitoring program objectives and metrics. Monitoring data will be used by the Adaptive Management Committee to evaluate project performance over time and to initiate adaptive management action if agreed-upon triggers are identified.

Possible triggers for adaptive management include:

- Unacceptable levels of tree mortality,
- Poor stand diversity,
- Absence of wildlife species or sign indicative of wildlife use,
- Severely diminished growth rates of planted vegetation as compared to expectations,
- Loss of the plantings due to unanticipated actions, e.g., excessive weather/climate events, human intervention,
- Uncontrollable encroachment of invasive/noxious species.

Adaptive management actions for riparian/stream buffer enhancements would be adopted in consultation with the Adaptive Management Committee and could include:

- Adjustment of planting plan goals – species or numbers,
- Adjustment to active stand management,
- More aggressive control measures for invasive/noxious species.

9.6.1.5 Large Wood Material

The goal of large wood mitigation is to improve the functional value of aquatic habitat, increasing quantities of in-channel LWM. Large wood placements would provide instantaneous increases in habitat complexity and diversity, while wood recruitment associated with riparian/stream buffer expansion will take time as trees grow and die. Restoring natural forest maturation and successional properties will ensure long term wood recruitment into stream channels. This mitigation would provide hydraulic diversity, substrate diversity for macroinvertebrates, in-stream cover, pool formation, and gravel retention.

9.6.1.5.1 Monitoring Framework

- Develop an implementation program that validates construction versus design goals. This would include for example: documenting the number of wood pieces installed, area of riparian buffer planted, species composition and stem counts of native trees, etc.
- Develop a monitoring component that addresses physical habitat surveys to document resilience and persistence of design features. Include areas associate with log jams, wood pieces or root wad placement, counts of large wood captured by flood fencing, and macroinvertebrate richness on wood substrates.
- Develop a monitoring component that addresses but is not limited to, vegetation surveys to document patch survival rates, canopy cover, and downed and dead wood surveys.

Key Assumptions

- Implementation monitoring would occur at all sites.

- Wood installation designs will function as intended in sites selected.
- Creation of instream structure and off-channel habitat features will be used by a diversity of aquatic species.
- Planting of native species in riparian and stream buffer zones will provide for a stable source of wood recruitment throughout the lifecycle of the project.
- A before/after approach to a subset of sites would be sufficient to evaluate the effectiveness of this mitigation action type.
- Performance metrics and standards may be used to evaluate individual mitigation actions, reach-scale performance, and overall performance of a group of mitigation actions within the same mitigation type.

Monitoring Objectives

1. Evaluate project persistence by documenting numeric design goals.
2. Monitor desired future conditions to evaluate trajectory of the project towards meeting the primary goal of increased large wood recruitment.
3. Document improvements to reach-level habitat complexity and diversity.
4. Evaluate ecological lift associated with secondary habitat benefits including the composition of native species present, absence of invasive and noxious species, macroinvertebrate productivity, and fish use of created habitat.

Example metrics could include but would not be limited to:

- Type and count/area of newly created habitat features,
- Wood counts by reach,
- Fish presence/counts in created habitat,
- Macroinvertebrate richness,
- Woody species stem counts,
- Wood species survival rates,
- Counts of downed and dead wood.

9.6.1.5.2 *Adaptive Management*

The Adaptive Management Committee would consult with the Applicant to refine the monitoring program objectives and metrics. Monitoring data will be used by the Adaptive Management Committee to evaluate project performance over time and to initiate adaptive management action if agreed-upon triggers are identified.

Possible triggers for adaptive management include:

- Failure of wood installations,
- Unacceptable levels of tree mortality,
- Severely diminished growth rates as compared to expectations,

- Loss of function due to future flow conditions,
- Loss of the plantings due to unanticipated actions, e.g., excessive weather/climate events, human intervention,
- Uncontrollable encroachment of invasive/noxious species in planting area.

Adaptive management action for large woody material mitigation would be adopted in consultation with the Adaptive Management Committee and could include:

- Adjustment of riparian planting plan goals – species or numbers,
- Additional wood placement installations,
- More aggressive control measures for invasive/noxious species.

9.6.1.6 Surface Water Quality Management Plan

The goal of the Surface Water Quality Management Plan is to evaluate and document the performance of the suite of mitigation actions intended to offset water quality and water temperature impacts throughout the Mitigation Area. Mitigation includes actions that will provide shade to reduce summer water temperatures and subsequently reduce potential for low dissolved oxygen conditions, and expanding or replanting riparian/stream buffers with native vegetation to improve interception of surface runoff and reduce erosion potential upslope.

9.6.1.6.1 Monitoring Framework

- Development of a compliance monitoring program that addresses potential project effects on water temperature, dissolved oxygen and turbidity.
- Development of a monitoring component that addresses performance of specific mitigation actions, such as riparian buffer expansions or creation of water temperature refuge habitats, in providing areas of summer water temperature.
- Development of a monitoring component that addresses performance of riparian and stream buffer expansions and forest conservation if reducing erosion and potential for storm related turbidity pulses.

Key Assumptions

- Compliance monitoring will include water quality sampling upstream and downstream of the proposed FRE location.
- Performance monitoring for water temperature will include monitoring at a subset of riparian/stream buffer enhancement sites and water temperature improvements. Sampling will occur upstream within and downstream of these mitigation sites.
- Performance monitoring for turbidity will coincide with winter storm events and will include monitoring upstream and downstream at a subset of riparian/stream buffer enhancement and forest conservation sites.

- Shade-related temperature and turbidity benefits will be dependent upon the current condition of the degraded habitat, i.e., benefit to stream reaches with reed canary grass as the dominant riparian vegetation would see benefits within the order of several years, where full benefits from expanded riparian forests with species such as red alder, black cottonwood, and Pacific willow would be expected to manifest after 5 to 10 years.
- Performance metrics and standards may be used to evaluate individual mitigation actions, reach-scale performance, and overall performance of a group of mitigation actions within the same mitigation type.

Monitoring Objectives

1. Determine summer temperature and dissolved oxygen differences between upstream and downstream compliance points.
2. Determine summer temperature differential associated with mitigation action types.
3. Compare pre- and post-installation storm-related turbidity at riparian/stream buffer and forest conservation sites.

Specific metrics to be monitored to provide measures of the effectiveness of riparian/stream mitigation would change over time as the forest matures. Example metrics include:

- Water temperature,
- Dissolved oxygen,
- Turbidity in NTUs.

9.6.1.6.2 Adaptive Management

The Adaptive Management Committee and permitting agencies would consult with the Applicant to refine the monitoring program, reporting schedule and timeline, data and report sharing and accessibility, and a forum for review of monitoring results and discussion of any appropriate adaptations to the implemented Plan. Monitoring data will be used by the Adaptive Management Committee and permitting agencies to evaluate project performance over time and to initiate adaptive management action if agreed-upon triggers are identified.

Possible triggers for adaptive management include:

- Unacceptable levels of plant mortality,
- Severely diminished growth rates as compared to expectations,
- Loss of the plantings due to unanticipated actions, e.g., excessive weather/climate events, human intervention.

Adaptive management actions for riparian/stream buffer enhancements would be adopted in consultation with the Adaptive Management Committee and could include:

- Selection of additional riparian enhancement sites,
- Adjustment to plant composition goals,

- Adjustment to planting elevation.

9.7 Monitoring and Adaptive Management Schedule

The schedule for implementation of the M&AMP will be developed and proposed following further development of the FRE HMP and in cooperation with members of the permitting agencies and Adaptive Management Committee. The follow timeline captures current expectations for M&AMP components. The timespans indicated account for continual implementation of individual mitigation actions over a 10-year period.

- Organization of the M&AMP committee 2023-2024,
- Pre- implementation Site Monitoring 2022-2034,
- Mitigation Implementation: 2025-2035,
- Implementation Monitoring: 2025-2035.

Performance Monitoring: Year 1, 3, 5, 7, 10, post-implementation. Followed by 5-year monitoring intervals up to Year 30, followed by 10-year intervals to Year 50.

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Appendix A
FRE-Habitat Mitigation Plan
Technical Appendix

Appendix A1
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ACRONYMS AND ABBREVIATIONS

7-DADMAX	Mean of 7 consecutive measures of daily max temperature.
Applicant	Chehalis River Basin Flood Control Zone District
AR	atmospheric river
ASRP	Aquatic Species Restoration Plan
BDMZ	Black-tailed Deer Management Zone
BMP	best management practice
CBS	Chehalis Basin Strategy
cfs	cubic feet per second
Corps	U.S. Army Corps of Engineers
dbh	diameter at breast height
DEIS	draft environmental impact statement
DO	dissolved oxygen
DPS	distinct population segment
Ecology	Washington Department of Ecology
EDT	Ecosystem Diagnosis and Treatment
EFH	essential fish habitat
EIS	environmental impact statement
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FCZD	Chehalis River Basin Flood Control Zone District
FEIS	final environmental impact statement
Footprint Model	CE-QUAL-W2 Footprint Model
FR	forest road
FRE	Flood Retention Expandable Facility
GMU	game management units
HMP	Habitat Mitigation Plan

IP	intrinsic potential (%)
LWM	large woody material
mg/L	milligrams per liter
MSL	mean sea level
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NTU	nephelometric turbidity unit
OHWM	ordinary high-water mark
RM	river mile
SEPA	State Environmental Policy Act
SGCN	Species of Greatest Conservation Need
SWIFD	Statewide Washington Integrated Fish Distribution
TMDL	total maximum daily load
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WA DNR	Washington Department of Natural Resources
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation

1 INTRODUCTION

The Chehalis River Basin Flood Control Zone District (Applicant) is proposing construction of the Flood Retention Expandable (FRE) facility on the upper Chehalis River (river mile [RM] 108.5), near the Town of Pe Ell, Washington (Proposed Action). This location is well suited for the FRE facility as the channel is naturally constrained by a bedrock canyon and because the Willapa Hills upstream are the primary sources of floodwater during major floods. Also, temporary inundation of the river channel upstream of RM 108.5 would not interfere with residential or commercial development.

The Proposed Action is currently under environmental review. Washington State Department of Ecology (Ecology) published a draft Environmental Impact Statement (DEIS) under the Washington State Environmental Policy Act (SEPA) in February 2020 (Ecology 2020a). The U.S. Army Corps of Engineers (Corps) published a DEIS under the National Environmental Policy Act (NEPA) in September 2020 (Corps 2020a). Both documents (SEPA/NEPA-DEIS) reported findings that the FRE facility would have unavoidable, adverse impacts on aquatic and terrestrial resources. A draft FRE Habitat Mitigation Plan (FRE HMP) was developed to mitigate unavoidable impacts.

This appendix to the FRE HMP describes the existing and potential future conditions of the aquatic and terrestrial species and habitats within the area potentially impacted by construction or operation of the FRE facility as well as the area considered for mitigation. The Impact Area associated with the Proposed Action includes the temporary reservoir upstream of the FRE facility (RM 108.2) and 20 miles of mainstem Chehalis River from the FRE facility downstream to the South Fork Chehalis River confluence at RM 88.1. The Applicant expanded the area under consideration for implementation of mitigation actions (i.e., Mitigation Area) to include headwaters in the Willapa Hills as well as tributary drainages along the mainstem.

Data for the Applicant's technical review of Existing Baseline Conditions was compiled from numerous reports by Washington Department of Fish and Wildlife (WDFW), Ecology, Corps, National Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS), Anchor QEA, Kleinschmidt Associates, and HDR Engineering, as well as peer-reviewed literature and regional white papers. The Existing Baseline Conditions Assessment provides a comprehensive description of the physical environment, current status of aquatic and terrestrial species, and factors currently limiting ecosystem function. Existing conditions are described relative to the species and habitats that have been identified in the SEPA/NEPA-DEIS as likely to be impacted by the Proposed Action.

This section describes the condition and physical processes of the Chehalis River Watershed followed by baseline conditions of aquatic and terrestrial resources within the proposed Mitigation Area. The Mitigation Area consists of the upper Chehalis Basin from its headwaters in the Willapa Hills downstream to the Newaukum River. More detailed information is provided for aquatic and terrestrial habitats and species that may be impacted by the proposed FRE facility and operations as well as potential mitigation actions.

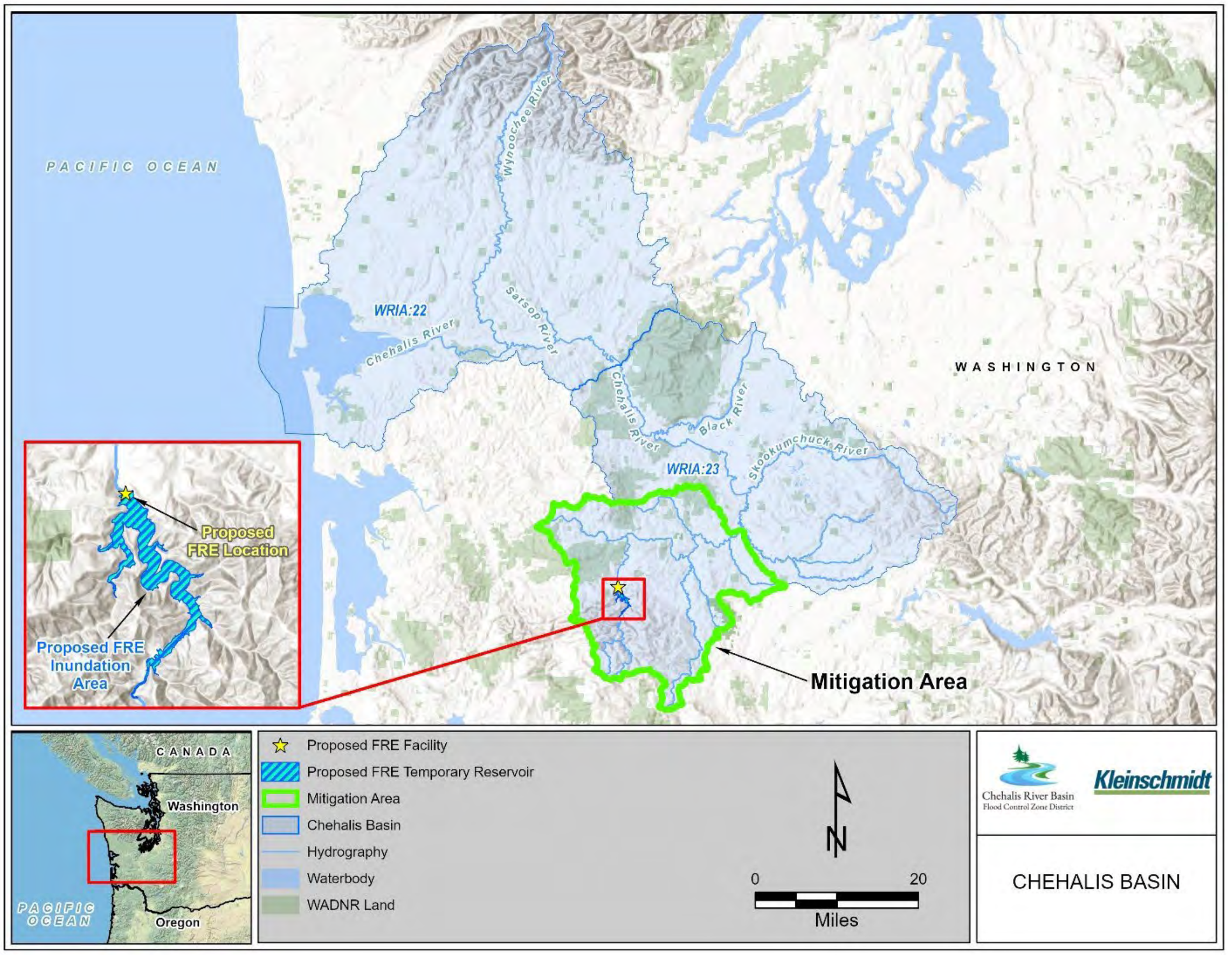
2 CHEHALIS RIVER WATERSHED

The Chehalis River is the second largest river system in Washington with 125 mainstem river miles and a drainage area of 2,700 square miles. It originates at the confluence of the West Fork Chehalis River and East Fork Chehalis River, in southwestern Lewis County, flows east, then north, then west, in a large curve, before emptying into Grays Harbor, an estuary of the Pacific Ocean. The Chehalis Basin includes more than 3,300 miles of rivers and streams that drain the Willapa Hills, and foothills of the Cascade and Olympic Mountains. The Chehalis Basin contains 180 lakes, ponds, and reservoirs providing water for agriculture, fish habitat, and wildlife.

The Chehalis Basin is divided for management objectives into Water Resource Inventory Areas (WRIA) 23 (Upper Chehalis) and 22 (Lower Chehalis) (Figure A1-1). The Upper Chehalis (WRIA 23) drains 1,294 square miles and includes the upper reaches of the Chehalis River and four major tributaries: South Fork Chehalis (RM 88.1), Newaukum (RM 75.2), Skookumchuck (RM 67.0) and Black (RM 47.0) rivers. The Lower Chehalis (WRIA 22) drains approximately 1,472 square miles and includes major tributaries (Satsop [RM 20], and Wynoochee [RM 12]), as well as independent streams that drain into Grays Harbor (e.g., Wishkah, Humptulips, Hoquiam, and Johns rivers).

The Chehalis Basin ranges in elevation from sea level at Grays Harbor to about 3,114 ft at its headwaters in the Willapa Hills. The river downstream of Pe Ell, WA near river mile (RM 101) is low gradient, with only 400 feet of elevation change between Pe Ell and Grays Harbor. Tributary rivers share many of the basin characteristics with the larger Chehalis Basin, having mountainous headwater areas comprised mostly of bedrock, coarse substrates, and confined channels, and lower reaches occupying wider valleys with floodplains and riverbeds consisting of glacial deposits, alluvium, and other unconsolidated deposits of gravel, sand, and fine sediments (Chehalis Basin Strategy [CBS] 2017).

Figure A1-1
Chehalis River Basin in Southwest Washington Including WRIA 22 and WRIA 23. The Location of the Proposed FRE Facility Is Indicated by the Yellow Star on the Mainstem Upper Chehalis River



2.1 Land Use

The Chehalis River has been shaped by human uses including timber harvest, historical log drives and splash damming, agriculture, and development. Timber harvesting dating back to the earliest European settlement reduced shading by riparian vegetation and reduced the availability of large wood log jams in the river that force large pool development, settling of fine sediments, and braiding of the river channel. Historical splash damming and intentional straightening of the river channel around agricultural and residential areas throughout the Chehalis Basin have resulted in a stream channel that is more simplified (predominantly single thread), loss of floodplain complexity and storage capacity, and loss of native riparian vegetation communities compared to historic conditions.

Under current conditions, agriculture, including livestock grazing and farming, dominates land use and occurs within 41% of the total floodplain by area. Timber production and recreational land uses follow closely behind agriculture, occurring in 39% of the floodplain, while 11.5% is in urban development Today, approximately 3% of the Chehalis River floodplain consists of wetlands or off-channel aquatic habitats that exist year-round (Pierce et al. 2017) and nearly two-thirds of the floodplain wetlands occur downstream of the Black River confluence (RM 47.0).

Historic and current land use practices have contributed to existing conditions of channel incision, lack of aquatic habitat complexity, loss of floodplain interaction and floodplain water storage, and loss of riparian habitats and large wood recruitment. The lack of wood and riparian vegetation, make the river's edge susceptible to erosion, and allow the water to be warmed by more direct sunlight, both of which reduce aquatic habitat quality.

In addition to impaired aquatic habitat quality, there are many natural and man-made (e.g., culverts, dams, and fishways) fish passage barriers that limit access to potential spawning and rearing habitat. Barriers in the Chehalis Basin have been assessed and prioritized by WDFW using the Fish Passage Inventory, Assessment, and Prioritization Manual (WDFW 2019d), which includes survey of physical habitat characteristics above and below the barrier, condition of riparian vegetation, potential quantity of fish habitat available for reconnection, water quality metrics, completeness of barrier, and landowner data. Review of both the WDFW Prioritized Chehalis River Barriers database (WDFW 2020) and the WDFW Statewide Fish Passage Barrier Assessment database (WDFW 2022b) identified 252 fish passage barriers to salmonids within the Mitigation Area (Attachment 1) excluding Washington State Department of Transportation (WSDOT) culverts. A complete index of barriers within the Mitigation Area including passability, ownership, available salmonid habitat above the barrier, and priority status is provided in Attachment 1 Table 1 and Table 2; and displayed in Attachment Figure A1-1.

2.2 Terrestrial Habitat

The upper portion of the Chehalis Basin is predominantly forestlands with substantial topographic relief and narrow drainage features, whereas the lower basin opens into broad valleys and floodplains where agriculture and residential development predominate. Approximately 80–84% of the land within the Chehalis Basin is forestland and 54% is managed for timber production, including both private and government-owned lands (Hiss and Knudson 1993; Ruckelshaus Center 2012). The low-lying valley and floodplain provide suitable land for agricultural production that makes up approximately 5-7% of the total land use in the Basin and approximately 41% of land use in the floodplain areas of the Chehalis River (Chehalis Basin Partnership 2004). Major terrestrial wildlife habitat types in the basin include upland forest, forested wetland, scrub-shrub wetland, emergent wetland, riparian scrub-shrub, and riparian forest. Land cover types identified throughout the basin include wetland, open water, scrub-shrub, cultivated crops, hay/pasture, barren, mixed forest, deciduous forest, evergreen forest, developed, and herbaceous (Ecology 2020a).

2.3 Chehalis Basin Hydrology

2.3.1 Precipitation

The Chehalis Basin has a maritime climate characterized by cool, wet winters and warm, dry summers (Gendaszek 2011). Average annual precipitation varies from 46 to 50 inches in the low-lying valleys near Centralia and Chehalis, to 140 inches in the Willapa Hills, and more than 200 inches in the Olympic Mountains (Gendaszek 2011; WSE 2014). Most of the Chehalis Basin, including the Mitigation Area, is rain-dominated (79%), while only limited portions are snow dominated (Perry et al. 2016).

Flooding is associated with winter (November-March) precipitation events known as atmospheric rivers (ARs) that produce high rates of rainfall in the upper Chehalis Basin (Neiman et al. 2011). ARs are defined as relatively long, narrow regions in the atmosphere, characterized by strong atmospheric water vapor transport (Zhu and Newell 1994). In Washington State, ARs transport atmospheric water vapor from the central Pacific Ocean and move over the topographic land features resulting in extreme precipitation and floods (Neiman et al. 2011). In contrast, summer months experience low rainfall or drought.

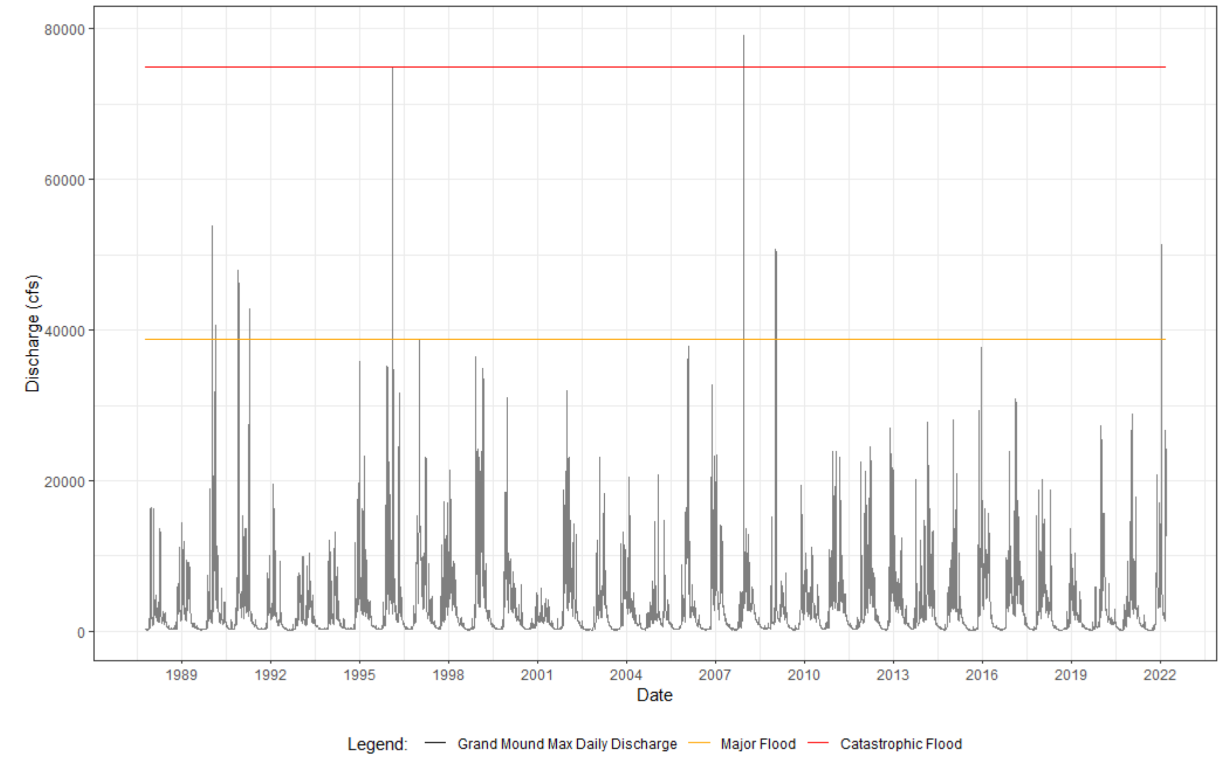
2.3.2 Surface Water and Historic Stream Flow

As noted above, over the past decades the Chehalis Basin has experienced both extreme flooding as well as drought, both of which impact physical characteristics of aquatic habitat and water quality. Periods of low rainfall or drought result in periods of low instream flow, fragmentation of aquatic habitat, and impairment to water quality parameters including temperature and dissolved oxygen.

There are several USGS gages used to estimate and monitor flow in the Chehalis Basin that have been operating for over six decades. The closest USGS stream gage to the FRE facility is near Doty (USGS Gage No. 12020000), located approximately 3.4 miles north of Pe Ell at RM 101.8 (USGS 2022). The drainage area of this location on the Chehalis River encompasses 113 square miles (USGS 2022), including the 76 square miles above the FRE facility. Since 1987, river flows at the Doty gage have ranged from a minimum of 13.9 cubic feet per second (cfs) in August of 2015, to a maximum of 28,900 cfs on February 8, 1996 (USGS 2022).

Major and catastrophic floods within the Basin are defined based on peak flows observed at the USGS Gage No. 12027500 located on the Chehalis River near Grand Mound at RM 59.9. A major flood is categorized by flows that reach 38,800 cubic feet per second (cfs) and a flood is considered catastrophic when river flows exceed 75,000 cfs at Grand Mound. Currently, major floods occur approximately every 7 years, while catastrophic floods occur approximately every 100-years (SEPA DEIS N-5, Ecology 2021). Major flooding has occurred on a total of 26 days over the period of record from 1987-2022, and catastrophic flooding has occurred once, in December of 2007. While atmospheric rivers are the primary contributing factor to extreme flooding, other potential factors may impact frequency and severity of lesser floods that occur on shorter time intervals. Figure A1-2 depicts the maximum daily discharge at the Grand Mound gage from 1987 to 2022.

Figure A1-2
Maximum Daily Discharge (cfs) at USGS Gage No. 12027500 on the Chehalis River (RM 59.9) Near Grand Mound, WA, 1987-2022



2.3.3 Groundwater

Groundwater occurs in both confined and unconfined aquifers, characterized by whether boundary layers are permeable or not, equilibrium with water tables, and atmospheric pressure. There is interaction between surface water and groundwater originating in five major aquifers throughout the Chehalis Basin originating in alluvial and glacial deposits, glacial till, and bedrock (Gendaszek 2011). Drost and other (Drost et al. 1998) estimate that at least 33,000 acre-feet per year of groundwater is discharged from springs throughout the Chehalis Basin, a significant portion of which is withdrawn through wells for domestic supply, agricultural, commercial, industrial, institutional, and livestock uses (Drost et al. 1998).

Much of the groundwater in the Chehalis Basin is connected to surface water, influencing water quality and temperature both of which affect habitat quality for aquatic species (CBS 2017). Pitz et al. (2005) reported that groundwater in the mainstem reaches of the mainstem Chehalis and Newaukum rivers serve as sinks (losing reaches) for the aquifer system. During extensive groundwater modeling efforts in 2004 (Pitz et al. 2005), the highest aquifer water levels were recorded during sample periods in January and the lowest levels were noted in August. The results of the 2005 groundwater exchange study also indicated that groundwater levels in the Chehalis closely followed annual patterns of local precipitation with rising waters in wet periods and falling waters in dry periods, with groundwater response delayed by days to weeks depending on the intensity of rain events (Pitz et al. 2005).

2.4 Riparian Habitat

Riparian habitat, a State of Washington Priority Habitat type affected by the Proposed Action, is defined as the area adjacent to flowing or standing freshwater aquatic systems. Riparian habitat encompasses the area beginning at the ordinary high-water mark (OHWM) and extends to that portion of the terrestrial landscape that is influenced by, or that directly influences, the aquatic ecosystem. In riparian systems, the vegetation, water tables, soils, microclimate, and wildlife inhabitants of terrestrial ecosystems are often influenced by perennial or intermittent water. Simultaneously, adjacent vegetation, nutrient and sediment loading, terrestrial wildlife, as well as organic and inorganic debris influence the biological and physical properties of the aquatic ecosystem. Riparian habitat includes the entire extent of the floodplain and riparian areas of wetlands that are directly connected to stream courses or other fresh water.

Existing conditions associated with the upper Chehalis River riparian areas include intact forested riparian habitat alongside the mainstem of the Chehalis River and along its network of perennial, intermittent, and ephemeral streams. Intact riparian areas are dominated by black cottonwood (*Populus trichocarpa*), Oregon ash (*Fraxinus latifolia*), and red alder (*Alnus rubra*), and oftentimes contain a subcanopy layer consisting of willows (*Salix* spp.) and cascara (*Frangula purshiana*). Other tree species found within this vegetation community include bigleaf maple, Douglas fir, western hemlock, and western red cedar. Understory species found in the riparian community include salal (*Gaultheria shallon*), dull Oregon grape (*Mahonia nervosa*), vine maple (*Acer circinatum*), red huckleberry (*Vaccinium parvifolium*) and other shrub and lower stature tree species. Common herbaceous species include oxalis (*Oxalis oregana*), creeping buttercup (*Ranunculus repens*), stinging nettle (*Urtica dioica*), and invasive reed canarygrass (*Phalaris arundinacea*).

Above the FRE facility, the primary land use is commercial timber production. While historic timber harvest practices have impacted riparian areas, Washington State's 2006 Forest Practices Habitat Conservation Plan (HCP) includes measures intended to protect and restore the riparian buffer zone for shade, reduce summer water temperatures, prevent fine sediment delivery from surface erosion, and provide a source of large woody material. Riparian buffer zones in the mainstem and tributaries upstream of the proposed FRE facility appear consistent with the HCP requirements. While harvest is not allowed within the 50-foot-wide core riparian management zone on each side of the OHWM of the Chehalis River and its tributaries, harvest is allowed within the adjacent inner and outer riparian management zones.

Downstream from the FRE facility riparian areas have been affected by land uses including development, agriculture, and timber harvest resulting in loss of vegetation in the riparian corridor. In these areas, logging and access roads, agricultural crops, and impervious surfaces limit riparian habitat values. These areas attract disturbance-tolerant species like the American crow (*Corvus brachyrhynchos*), house sparrows (*Passer domesticus*), and rock doves (*Columba livia*).

NOAA developed a process-based analysis for quantifying historical, current, and future habitat conditions in the Chehalis Basin (Beechie et al. 2021) that included a model of riparian shade based on Seixas et al. (2018). As described in the FRE HMP Appendix A2, the Applicant conducted a reanalysis of the NOAA data to identify stream reaches where the riparian canopy has undergone considerable change. NOAA data show a that change of canopy opening angle of 30 degrees was associated with stream temperature increases of over 1 degree C. Below the FRE facility within the Mitigation Area, 44% of the 34.77 miles of Chehalis mainstem analyzed by NOAA had riparian canopy openings greater than 30 degrees while 35% of the 375.07 miles analyzed in the tributaries had canopy openings greater than 30 degrees (Appendix A2).

2.5 Sediment Transport

The geomorphology of the Chehalis Basin is heavily influenced by patterns of sediment recruitment and in-basin sediment movement. Generally, alluvium becomes finer along a downstream gradient, transitioning abruptly to fine substrate or sand (Vendetti et al. 2010). In the Chehalis Basin, sediment sources include landslides, bank erosion, and input from tributaries. Tributary basins of the Chehalis with the greatest sediment yields are those with an abundance of material susceptible to erosion, areas with high rates of precipitation and steep slopes, and areas with land-use practices that favor sediment movement (Glancy 1971). Sediment, transported by the river as bedload is coarser (usually sand, gravels, and cobbles) than suspended load and falls out in the river channel, while suspended load (sand, silt, and fines) falls out over bank areas during floods (Watershed GeoDynamics and Anchor QEA 2017).

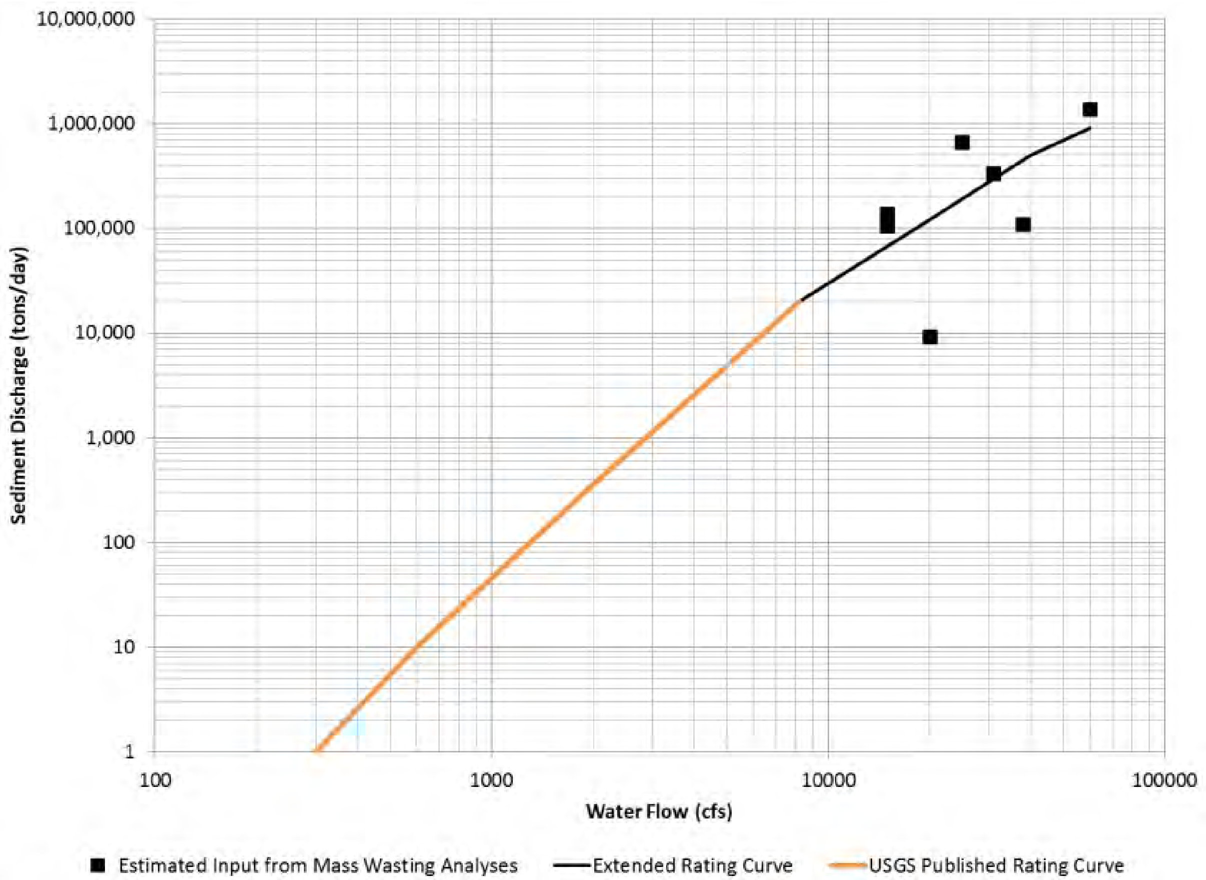
In the upper Chehalis River, large substrate (cobble) input originates in the headwaters and tributaries and is transported as far downstream as approximately RM 80, while gravel from the same source is transported as far downstream as RM 73. Downstream of this the gradient becomes too low for the river to transport any sediment larger than sand which continues to move down to near RM 40 (Watershed GeoDynamics and Anchor QEA 2017).

A USGS desktop study of bedload and suspended load indicated that the largest sediment inputs from the upper watershed occurred during catastrophic floods (Corps 2020b). For example, during the 2007 flood, estimated to be a 500-year flood at the Doty USGS gage and a 100-year flood in the vicinity of Centralia and Chehalis (WSE 2012), numerous landslides and other channel forming events resulted in input of an estimated 5.7 – 8.7 million tons of sediment into the Chehalis River (Sarikhan et al. 2008).

As described in the NEPA DEIS, transport of gravel and cobble substrates in the upper Chehalis River is initiated at flows of approximately 6,000 cfs at the Doty gage (USGS Gage No. 12020000). This flow is lower than the 2-year flood interval (1,200 cfs, Watershed GeoDynamics and Anchor QEA 2017). To evaluate sediment transport at higher flows these authors extended the sediment rating curve for the

Doty gage based on landslide inputs. Interpolation of their extended sediment rating curve at Doty gage suggests that slightly over 100,000 tons/day of sediment would be moved at approximately 20,000 cfs at that gage (Figure A1-3). This would be similar to the 10-year flood interval and slightly higher flow than that estimated to trigger operation of the FRE.

Figure A1-3
Sediment Rating Curve for the Upper Chehalis River Basin



Source: Watershed GeoDynamics and Anchor QEA (2017).

2.6 Large Woody Material Recruitment and Transport

Large Woody Material (LWM) recruited from riparian areas can play an important role in the development and persistence of fisheries habitat as well as fluvial geomorphology of the river. LWM jams recruit additional debris, gravel, fines, and other material that is deposited by flow onto the forming jam. Jams help to maintain pools, divert and maintain side channel, contribute to formation of vegetated islands, and contribute to habitat complexity (Collins et al. 2002). In the Chehalis Basin, LWM is primarily recruited during extreme precipitation events which cause root failure, landslides, and debris torrents in upper portions of the watershed. Less common input of LWM comes from small-scale bank erosion and channel migration, especially in areas without riparian cover. Current levels of LWM in the Chehalis River are low compared to rivers of similar size (Smith and Wenger 2001; Watershed

GeoDynamics and Anchor QEA 2017). Past timber harvest has left a limited supply of LWM in the watershed.

The 2007 flood was the most intense hydrologic event on record for the Chehalis Basin, contributing an estimated 115 acres of new LWM at depth of two feet from large-scale landslides that were deposited throughout the Chehalis floodplain (Watershed GeoDynamics and Anchor QEA 2014). Much of this LWM was removed following the 2007 flood, and recent surveys document LWM numbers in the Chehalis River upstream of the Newaukum River that fall below the criteria for natural and unmanaged watersheds established by Fox and Bolton (Fox and Bolton 2007; Anchor QEA 2016). Watershed GeoDynamics and Anchor QEA (2014) estimated that large inputs of LWM occur during 10 to 25-year floods while smaller flow events (9,000-10,000 cfs measured at Grand Mound) can displace and redistribute LWM already in the system.

2.7 Aquatic Habitat

No Endangered Species Act (ESA) designated Critical Habitat for aquatic resources occurs within the upper Chehalis River Basin (WRIA 23) (Corps 2020a). Essential fish habitat (EFH) has been designated for Chinook salmon (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutch*) in all accessible waterbodies within the Mitigation Area, including the mainstem Chehalis River and its tributaries (Ecology 2019). The State of Washington Priority Habitat types within the Mitigation Area include instream habitat, freshwater wetlands hydraulically connected to the stream, and riparian habitat. Priority habitats are habitat types or elements with unique or significant value to many species. WDFW defines instream habitat as the combination of physical, biological, and chemical processes and conditions that interact to provide functional life-history requirements for instream fish and wildlife resources. Freshwater wetlands are defined as transitional lands between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water at some time during the growing season of each year.

While the aquatic and riparian habitat conditions in the upper basin above the FRE facility, have been degraded by historic and to a lesser degree current timber harvest, this area supports relatively high-quality spawning and rearing habitat for salmonids and other native species. The riparian buffer is fairly intact, providing shade to maintain cooler water temperatures. The mainstem Chehalis River and tributaries above the FRE facility are primarily steep gradient, single-channel streams constrained by the steep valley walls of the Willapa Hills mountain range (Hayslip and Herger 2001). The mainstem channel has limited potential for lateral channel migration (CBS 2017). The area is characterized by low permeability basal bedrock including Tertiary basalt and sedimentary rock. Therefore, this reach has little to no groundwater storage capacity (CBS 2017). The habitat is composed of pools and riffles with gravel, cobble, and fine substrate and some areas of bedrock (Winkowski et al. 2018a).

The upper Chehalis River below the FRE facility has been highly degraded by historic timber harvest, agriculture, and rural development. Channelization of the mainstem has degraded the habitat quality by the lack of braiding and channel complexity, few instream structures, log jams, and limited overhanging vegetation – all features that contribute to quality fish habitat for rearing, foraging, and finding refuge from thermal stress or predators. In addition to the single-channel, disconnected channel morphology and lack of mature riparian vegetation is also considered an impairment in this reach of the Chehalis River (WDFW 2020).

Between the FRE facility and Elk Creek (Reach B), the Chehalis River is a single thread channel confined by a narrow canyon. The habitat is comprised of pools and long riffle habitats with an average gradient of 0.21%. The riverbed in this section consists largely of a thin layer of alluvial substrate over bedrock. Mixed gravel substrate can be found throughout this reach.

Below Rainbow Falls (RM 97), channel straightening and floodplain alteration have increased the river's susceptibility to erosion and direct thermal inputs. The result is a mainstem segment with one predominant incised channel that is disconnected from its floodplain, has more fine-grained sediment, and warmer water temperatures relative to historic conditions.

2.8 Water Quality

The Upper Chehalis River above the FRE facility (Reach A) does not include any water quality impairments for temperature, dissolved oxygen, or other parameters. However, the headwaters of the Chehalis are relatively warmer than other headwater areas due to the relatively lower elevation. Reach A has an intact riparian buffer of large coniferous trees which contributes to the slightly lower summer high temperatures observed by WDFW relative to other unshaded reaches of the mainstem Chehalis River. The tributaries in Reach A also provide cooler water input to the mainstem (Winkowski et al. 2018b).

Consistent with degraded aquatic and riparian habitat, water quality in the upper Chehalis Basin below the FRE facility is impaired as indicated by the federal Clean Water Act Section 303(d) and Water of Concern listings for several parameters including turbidity, nutrients, fecal coliform, dissolved oxygen (DO), and temperature. Section 303(d) mandates that Ecology establish analyses called total maximum daily loads (TMDLs) for surface waters that do not meet standards after application of technology-based pollution controls. TMDL plans are in place in the Upper Chehalis River for DO (Jennings and Pickett 2000), temperature (Ecology 2001), and bacteria (Ahmed and Rountry 2004).

Water quality issues in the Chehalis River downstream of Rainbow Falls (RM 97) are compounded by water rights concerns. Low base flows below Washington State's requirements for minimum instream flow have resulted in curtailment of junior water rights, cessation of recreational fishing, and further concern related to instream temperature which is considered impaired throughout this reach. Summer temperatures frequently exceed the preferred temperature range criteria for salmon and steelhead (Ecology 2020a) (Washington Administrative Code [WAC] 173-201A).

Water temperatures throughout the Chehalis River are relatively warm due to the low elevation and low gradient of the river, which ranges from about 800 feet mean sea level (MSL) in elevation at the confluence of the East and West Forks (RM 118.5) to 22 feet MSL elevation at RM 9. Solar heating is the primary driver of water temperatures, and elevated stream temperatures in the Chehalis River are attributed to a lack of stream shading, with some heating attributed to the loss of shade that was historically provided by mature riparian vegetation (Ecology 2020a). Stream temperatures are also influenced by low flows, channel morphology and sediment loads. Low flows reduce the volume of water that can absorb incoming heat. Increased sediment loads can cause stream channels to become wider and shallower, allowing more thermal radiation to be absorbed by the water surface.

The water frequently exceeds maximum temperature thresholds in summer for salmon and steelhead including the 7-day consecutive mean daily max temperature (7-DADMAX) criterion of 16°C in stream reaches designated as core summer salmonid habitat in Washington Administrative Code (WAC) 173-201A-602 and the 13°C criteria applied September 15 to July 1 in stream reaches designated with supplemental spawning/incubation criteria (Anchor QEA 2014). Data has also shown acute impairment that exceeds Washington's lethality guidelines (Anchor QEA 2014).

Although often lower than 2 nephelometric turbidity units (NTUs) in summer months, turbidity increases from winter storm-induced runoff and has been documented as high as 610 NTUs (Ecology 2020a). The section of the mainstem Chehalis River between Stearns Creek and the Newaukum River is 303(d) listed for turbidity for the designated use of Aquatic Life – Salmonid Spawning, Rearing and Migration.

Water temperature and low flows appear to be drivers of fish distributions in the Chehalis River. During the summer Riverscape study on the Chehalis, fish species assemblage was more consistently associated with stream temperatures in August than physical habitat characteristics (Winkowski et al. 2018a). The authors suggest that warm summer stream temperatures limit the rearing potential, habitat use, and spatial distribution of aquatic species, especially Pacific salmon. More specifically, temperature has been implicated as a limiting factor for spring-run Chinook salmon (Winkowski et al. 2018b).

3 AQUATIC SPECIES

The following section describes the aquatic species, including fish, shellfish, amphibians, and aquatic macroinvertebrates, that occur in the upper Chehalis Basin with an emphasis on species identified in the SEPA/NEPA-DEIS as potentially affected by the Proposed Action including non-native warm-water species which may indirectly affect native species under future conditions of changing water quality. A complete list of species can be found in Attachment 2.

There are no ESA-listed threatened or endangered fish species in the upper Chehalis Basin. Pacific lamprey (*Entosphenus tridentatus*), a federal Species of Concern, is identified as a Species of Greatest Conservation Need (SGCN) under the Washington State Wildlife Action Plan and as a Priority Species under the WDFW Priority Habitat and Species Program (WDFW 2019a). Priority species require protective measures for their survival due to their population status, sensitivity to habitat alteration, and/or recreational, commercial, or tribal importance. In addition, Native American tribes regard Pacific lamprey as a highly valued resource, both for their ecological and cultural importance, and for food and spiritual sustenance. Chinook salmon and steelhead (*O. mykiss*) are Washington State Candidate Species and coho salmon are a State Priority Species. The Olympic mudminnow (*Novumbra hubbsi*), designated as a state-listed Sensitive Species, is the only resident fish with special status in the upper Basin. It is identified also as a SGCN and a WDFW Priority Species (WDFW 2019a).

Although there are no listed salmon populations in the Chehalis River, Essential Fish Habitat (EFH) has been designated for Chinook and coho salmon. Salmon EFH in the Chehalis River covers all accessible waterbodies including the mainstem river and tributaries in the Mitigation Area.

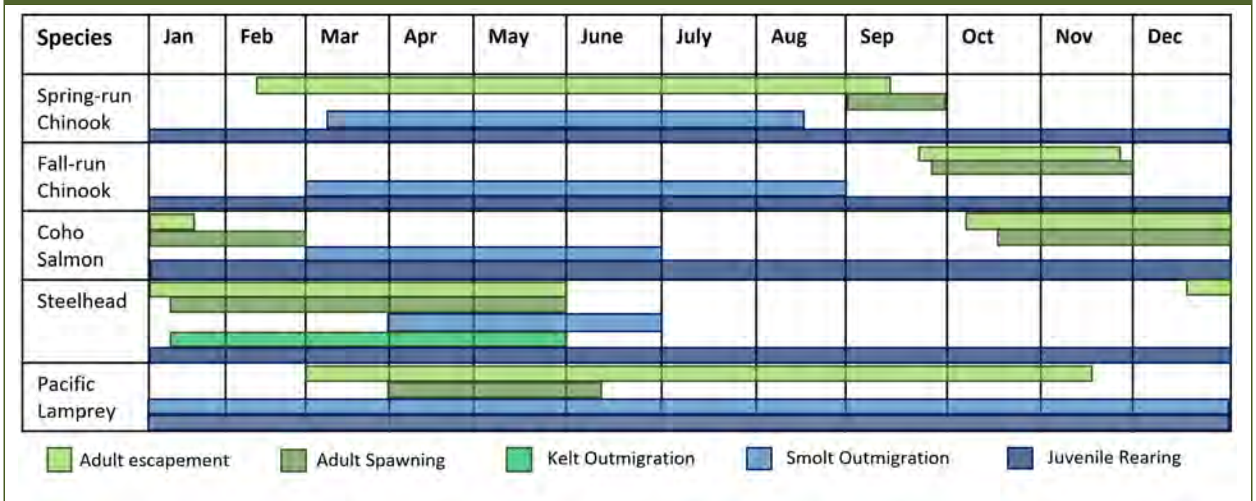
3.1 Anadromous Fish

Anadromous fish in the upper Chehalis Basin within the mitigation area include spring-run and fall-run Chinook salmon, coho salmon, steelhead, and Pacific lamprey. The life history of anadromous fishes is complex, and each life history stage has unique requirements for habitat, water quality, and movement opportunities (passage) depending on whether individual fish are spawning, rearing, migrating, or redistributing in-basin.

All salmonid species need adequate flow and water quality, spawning riffles and pools, a functional riparian zone, and upland conditions that favor stability, but some of these specific needs vary by species, such as preferred spawning areas and gravel. Although some overlap occurs, different salmon species within a river are often staggered in their use of a particular type of habitat. Some are staggered in time, and others are separated by location.

In the Chehalis Basin, Chinook salmon, coho salmon, steelhead, and Pacific lamprey movement for spawning occurs throughout the year, with the most intense periods of spawning occurring between fall and early spring. Figure A1-4 illustrates the timing of movement patterns of anadromous species within the Chehalis Basin. Life history, population status, distribution, and habitat requirements for each species are discussed in the sections that follow.

Figure A1-4
Movement Patterns by Life History Stage for Anadromous and Resident Fish Species Present in the Chehalis Basin



Source: CBS 2018.

3.1.1 Spring-Run Chinook Salmon

Spring-run Chinook salmon in the Chehalis River generally have a sub-yearling freshwater life history, migrating to the sea within the first year. Adults return to spawn between 3-6 years of age with most returning at age 4. Spring-run Chinook salmon return to freshwater in a sexually immature state and spend considerably longer holding in freshwater prior to spawning than other salmonid species, typically entering the Chehalis River during the later winter and spring, spawning in the fall. During summer months, spring-run Chinook salmon can be observed holding in cool-water refugia, including major tributaries such as the Skookumchuck and Newaukum rivers and areas where tributaries converge with the mainstem Chehalis River such as downstream of the Newaukum River, and to a lesser extent in the South Fork Chehalis River. Spring-run Chinook salmon spawning in the upper Chehalis River occurs between September and mid-October, peaking in early October.

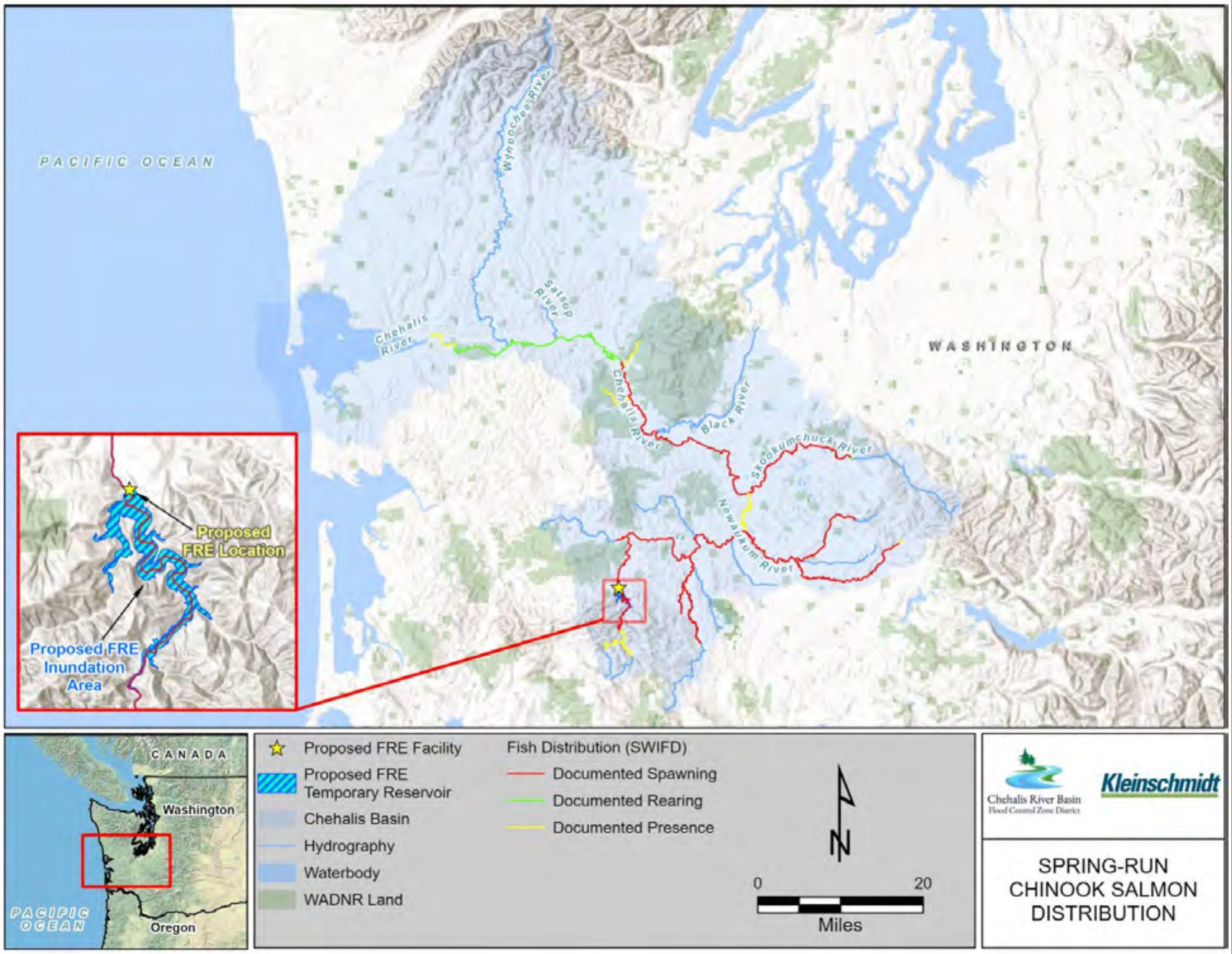
In the mainstem Chehalis River, spring-run Chinook salmon spawning occurs between Porter Creek (RM 33.3) and the Skookumchuck River (RM 67.0) and from near Adna (RM 81.3) to the upper Chehalis River (RM 113.4). Spring-run Chinook salmon also spawn in the Skookumchuck and Newaukum rivers and to a lesser extent in the South Fork Chehalis River (Figure A1-5). Between 1991 and 2018, the estimated average Chehalis Basin run size of spring-run Chinook salmon upstream of RM 9 was 2,095 fish and ranged from a high of 5,034 (2004) to a low of just 496 adults in 2018 (Ronne et al. 2020).

Key local spring-run Chinook salmon populations exist in the Skookumchuck and Newaukum rivers while the South Fork Chehalis River and upper Chehalis River provide smaller production areas. During October 2018, a peak supplemental survey for spring Chinook salmon redds was conducted from above the proposed FRE facility downstream on the mainstem Chehalis to the Newaukum River; a total of 39 redds were observed in the mainstem between the proposed FRE facility and the Newaukum River while zero redds were observed above the proposed FRE facility (Ronne et al. 2020). The documented redds were evenly distributed from the proposed FRE facility downstream to RM 78.5 below the town of Adna and no redds were observed between RM 78.5 and the confluence with the Newaukum River (RM 75.2) (Ronne et al. 2020).

During intensive weekly surveys conducted annually upstream of the proposed FRE facility from 2013 through 2018, annual estimates of spring-run Chinook salmon spawner abundance ranged from 34 to 65 fish in 2013 and 2014 when the October 15 date was used to differentiate between spring and fall runs (Ronne et al. 2020). Starting in 2015, the methodology to distinguish the fall and spring runs was modified to consider the condition of the redd; phenotypic characteristics, behavior, and condition of associated live fish observed in the vicinity of the redd; prior observations of spring or fall Chinook salmon activity during the survey period; current and previous flow levels; and spawning activity within the basin. When the modified method was applied, annual estimates of spring-run spawner abundance above the FRE facility was as few as 3 fish in 2015 and 2018 and as high as 8 fish in 2017 (Ronne et al. 2020). Ronne and others (Ronne et al. 2020) estimated the contribution of spring-run Chinook salmon above the FRE facility to be 1.25% of the entire Chehalis Basin spawner abundance. Of the 7 spring-run Chinook salmon redds observed above the FRE facility from 2015 through 2019, 5 (71%) were found within the temporary reservoir in the mainstem (4 redds) and Crim Creek (1 redd), and 2 redds (29%) were found in the mainstem Chehalis River upstream of the upper extent of the maximum pool elevation of the temporary reservoir (Ronne et al. 2020).

Limiting factors for spring-run Chinook salmon in the Chehalis Basin include temperature, lack of key habitats, and lack of habitat diversity. Temperature is the primary limiting factor for spring-run Chinook salmon during holding, spawning, and rearing, likely due to riparian loss, increased sedimentation resulting in channel changes, and decreased summer flows in the mainstem and tributaries (Smith and Wenger 2001). Lack of habitat complexity and low stream flows have decreased the availability of coldwater holding and staging refugia and further elevate spring-run Chinook salmon vulnerability to increased stream temperature. Winkowski et al. (2018) determined that fish species assemblage and habitat use was more consistently associated with stream temperature than any physical habitat characteristic including flow conditions or habitat complexity. A combination of competition with native cyprinids tolerant of warmer stream temperatures and spring-run Chinook salmon physiological intolerance to stream temperatures over 20°C results in limited ability to make use of available habitat.

Figure A1-5
Map of Spring-Run Chinook Salmon Distribution in the Chehalis Basin



Source: Statewide Washington Integrated Fish Distribution (SWIFD).

Throughout the Chehalis Basin, the abundance of spring-run Chinook salmon has been declining in recent years (Lestelle et al. 2019) and there is much concern over the future of spring-run Chinook salmon in the upper Chehalis Basin. The distribution of the species in the upper Chehalis Basin is limited to key local populations in the Skookumchuck and Newaukum rivers along with small production areas in the South Fork and upper Chehalis River.

Genetic studies have been conducted to understand the Chinook salmon population structure in the basin. This upper Basin subpopulation has been shown to have some genetic distinction from others in the Chehalis Basin, but it is not known what is driving that distinction, and whether it is reflective of very low spawner numbers due to a population bottleneck (Thompson et al. 2018, 2019).

A genetic study performed by Brown et al. (2017) evaluated samples collected from carcasses throughout the basin to examine the relatedness of Chinook salmon across the Chehalis Basin and to determine whether any discernable distinction between the spring- and fall-run stocks. These authors reported a population structure that included two clusters that grouped downstream mainstem and tributary spawners separate from upstream mainstem and tributary (Skookumchuck, Newaukum, and South Fork Chehalis rivers) and indicated that this pattern is commonly observed among salmonid populations related to spawning over large distances. In addition, no genetic differentiation was evident for spring- and fall-run Chinook salmon, a pattern that was evident for other salmon populations in Washington (Brown et al. 2017). More recent studies by Thompson et al. (Thompson et al. 2019) and Gilberston et al. (Gilberston et al. 2021) had provided additional supporting information of both genetic distinction among geographically distinct spawning groups and relatedness of spring- and fall-run Chinook salmon in the basin.

In rivers where multiple run-types exist, some amount of spatial and temporal separation is required to preserve the population structure and life history variation expressed as run-types (Gilbertson et al. 2021). Overlap in timing and distribution normally result in breeding across run types within a salmon species, but some geneticists believe that human activities and climate change have resulted in a noticeable increase in this type of interbreeding in places where Chinook salmon runs are still distinct (Ford et al. 2020). Where population sizes are low or disparate and interbreeding is high, this could result in one life history time dominating the other and an overall reduction in life history variation within the population. Chinook salmon spawning studies on the Chehalis River indicate that peak spawning of spring-run fish now largely overlaps in both space and time with fall-run Chinook salmon spawning (Zimmerman 2017). That overlap combined with the dramatically low recent spawner counts in the upper Basin has elevated concern about the potential for loss of this life history variant within the basin.

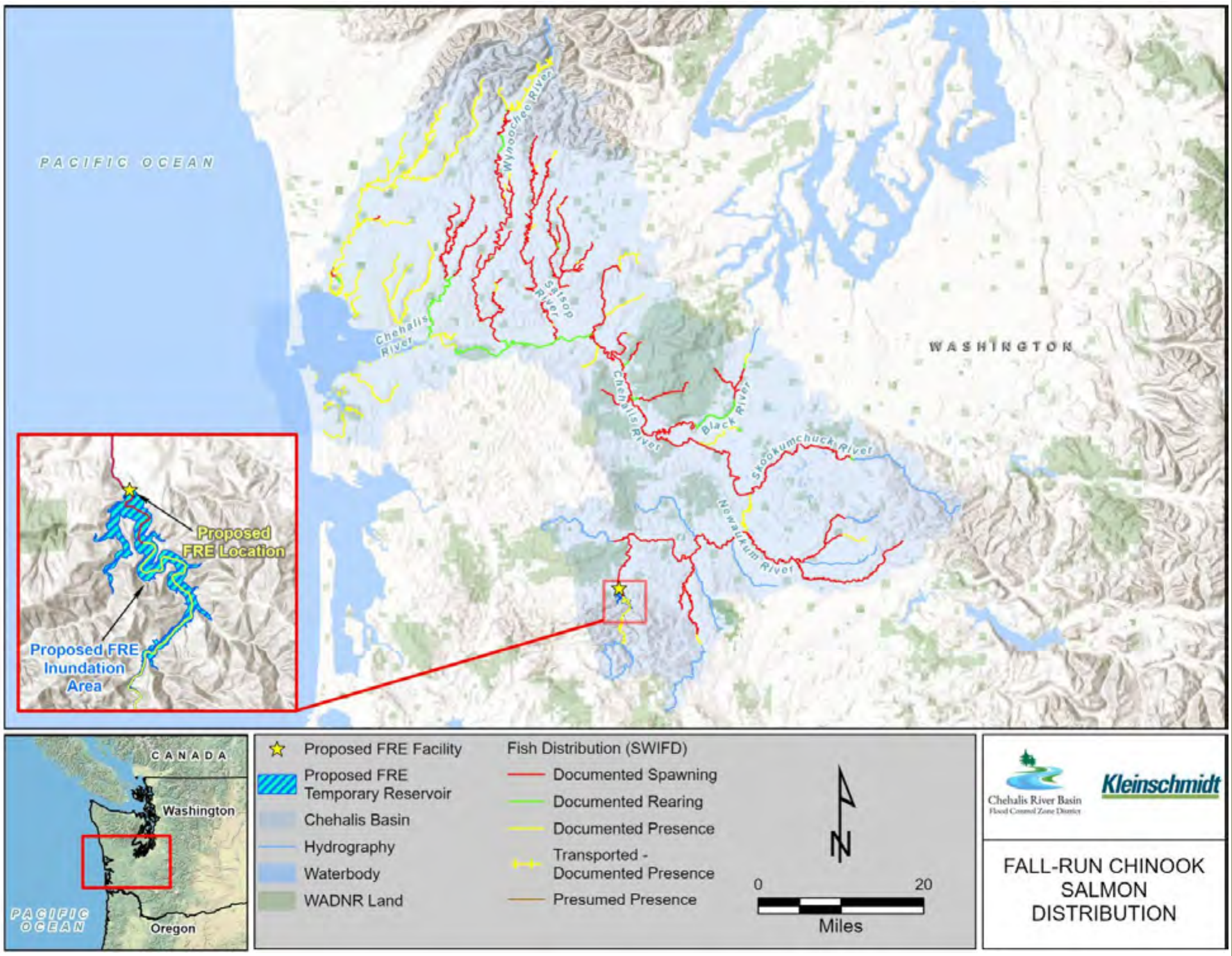
3.1.2 Fall-Run Chinook Salmon

Chehalis River fall-run Chinook salmon have a sub yearling freshwater life history and typically out-migrate to marine habitats in their first spring. Adults typically return to spawn at 4 to 6 years of age, with most returning at age 5. Fall-run Chinook salmon differ from spring-run Chinook salmon in that they enter the river fully mature just weeks prior to spawning, which occurs in the lower Chehalis Basin from August through November with peak numbers in September and in the upper Chehalis River October through early December peaking in late October. October 15 is an assigned threshold date used by fisheries managers to differentiate spring- from fall-run Chinook salmon in the Chehalis River (Ashcraft et al. 2017).

Fall-run Chinook salmon spawn throughout the mainstem Chehalis River between the Satsop River near Elma (RM 28.0) and the Skookumchuck River (RM 67.0), and from the South Fork Chehalis River (RM 88.1) to upstream of the proposed FRE facility (Figure A1-6). In the upper Basin, fall-run Chinook salmon spawning also occurs in the Skookumchuck, Newaukum, and South Fork Chehalis rivers and in lower Elk Creek. From 1971 through 2018, the average annual fall-run Chinook salmon escapement to the Chehalis River upstream of RM 9 was 5,352 fish and ranged from 9,951 (2018) to 2,862 (1994) adults (Ecology 2020a).

During October 2018, a peak supplemental survey for fall-run Chinook salmon redds was conducted from above the proposed FRE facility downstream the mainstem Chehalis to the Newaukum River; a total of 480 redds were observed in the mainstem between the proposed FRE facility and the Newaukum River while 139 redds were observed above the proposed FRE facility (Ronne et al. 2020). The documented redds below the proposed FRE facility had the highest density in the upper portion of the survey reach near the town of Pe Ell and were observed downstream to RM 76.2; no redds were observed between RM 76.2 and Newaukum River (RM 75.2) (Ronne et al. 2020).

Figure A1-6
Map of Fall-Run Chinook Salmon Distribution in the Chehalis Basin



Source: SWIFD.

During intensive weekly surveys conducted annually upstream of the proposed FRE facility from 2013 through 2018, annual estimates of fall-run Chinook salmon spawner abundance ranged from 297 to 302 fish in 2013 and 2014 when the October 15 date was used to differentiate between spring and fall runs (Ronne et al. 2020). Starting in 2015, the methodology to distinguish the fall and spring runs was modified to consider the condition of the redd; phenotypic characteristics, behavior, and condition of associated live fish observed in the vicinity of the redd; prior observations of spring or fall Chinook salmon activity during the survey period; current and previous flow levels; and spawning activity within the basin. When the modified method was applied, annual estimates of fall-run spawner abundance above the FRE facility ranged from 239 fish in 2017 to 578 fish in 2018 (Ronne et al. 2020). Ronne and others (Ronne et al. 2020) estimated the contribution of fall-run Chinook salmon above the FRE facility to be 3.37% of the entire Chehalis Basin production. Of the fall-run Chinook salmon redds observed above the FRE facility from 2015 through 2019, 92% were found within the temporary reservoir in the mainstem Chehalis River, Crim Creek, Lester Creek and Big Creek, and 8% were found upstream of the upper extent of the maximum pool elevation of the temporary reservoir in the mainstem Chehalis River, Crim Creek, Big Creek, Thrash Creek and the West Fork Chehalis River (Ronne et al. 2020).

This species is heavily harvested in ocean fisheries. Hatchery production contributes to annual returns to the Grays Harbor and lower Chehalis River tributaries (Humptulips, Wishkah, Satsop, and Wynoochee rivers; WDFW 2019c). The closest release location for hatchery fall Chinook salmon is in the Satsop River sub-basin located near RM 20. Surveys conducted from 2013 through 2019 found fish originating from hatcheries to be rare or absent (<1% of carcasses) (Ronne et al. 2020).

Limiting factors for fall-run Chinook salmon are similar to spring-run Chinook salmon, though because fall-run fish arrive later and do not hold in the river for an extended period prior to spawning, they have less exposure to elevated temperatures as adults, and juveniles out-migrate as sub yearlings in the spring. Nonetheless, habitat with suitable thermal conditions (<20°C summer temperatures) is the primary limiting factor for fall-run Chinook salmon.

3.1.3 Coho Salmon

Coho salmon are widely distributed throughout the Chehalis Basin, including the major tributaries in the upper Chehalis River. Two broad populations of coho salmon are recognized in the Chehalis Basin based on their spawn timing: early and late return. Early coho salmon return and spawn from August to late November, and late coho salmon are recognized as those returning and spawning in early December through January. The fourth week of November is used as a threshold date for differentiating early coho salmon from late coho salmon (Ashcraft et al. 2017).

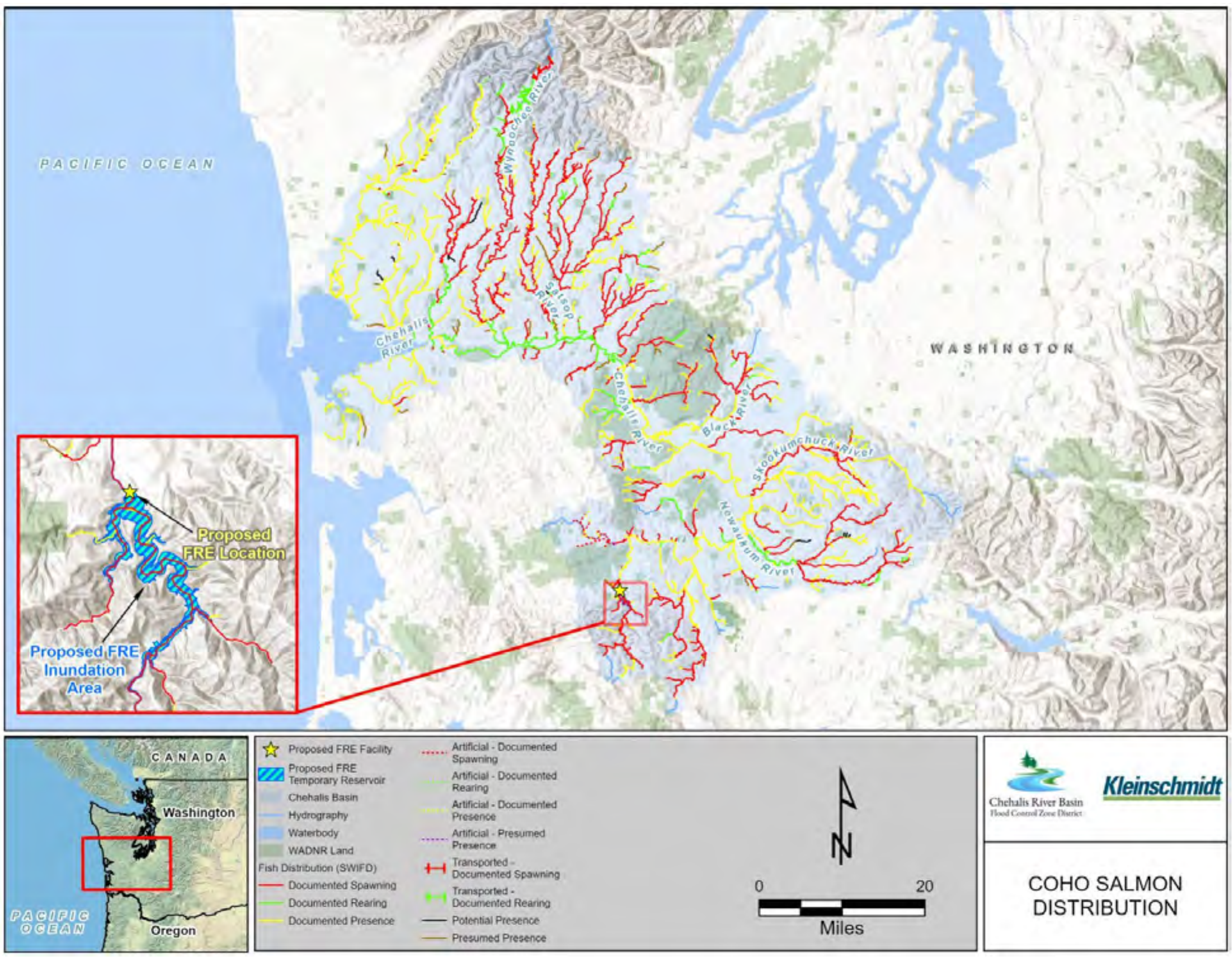
Out-migrating coho salmon at the WDFW smolt trap in 2018 included both yearlings and subyearlings in both smolt and transitional phenotypes. The out-migration period for these fish began in mid-March and extended to mid-July (the entire period of trap operation) (Winkowski et al. 2018a)

Coho salmon are harvested in both sport and commercial fisheries, and returns to the Grays Harbor tributaries, lower Chehalis Basin tributaries, Skookumchuck River, Newaukum River, and Elk Creek are extensively supplemented by hatchery production (WDFW 2019c).

Coho salmon spawn in headwaters and tributaries throughout the Chehalis Basin (Figure A1-7). From 1987 through 2017, the average annual coho salmon escapement to the Chehalis River upstream of RM 9 was 24,190 and ranged from 46,398 (2010) to 8,966 (2007) (Ecology 2020a).

During December 2018, a peak supplemental survey for coho salmon redds was conducted in the mainstem Chehalis River and the tributaries above the proposed FRE facility downstream the mainstem Chehalis River to Rainbow Falls (RM 97); a total of 5 redds were observed in the mainstem between the proposed FRE facility and approximately RM 103 (about 2.7 miles above the Elk Creek confluence) while 533 redds were observed in the mainstem and tributaries both within and above the proposed temporary reservoir(Ronne et al. 2020). Of the 5 documented redds in the mainstem Chehalis River below the proposed FRE facility, 4 were located near the town of Pe Ell downstream of Stowe Creek and one was located near the Shields Creek confluence.

Figure A1-7
Map of Coho Salmon Distribution in the Chehalis Basin.



Source: SWIFD.

During intensive weekly surveys conducted annually upstream of the proposed FRE facility from 2013 through 2018, annual estimates of coho salmon spawner abundance ranged from 174 fish in 2013 to 2,128 in 2018 (Ronne et al. 2020). Ronne and others (Ronne et al. 2020) estimated the contribution of coho salmon above the FRE facility to be 2.72% of the entire Chehalis Basin coho salmon abundance. Of the coho salmon redds observed above the FRE facility from 2013 through 2019, 1,032 (32%) were found within the mainstem and tributaries of the temporary reservoir, and 2,179 (68%) were found upstream of the upper extent of the maximum pool elevation of the temporary reservoir in the mainstem Chehalis River, Crim, Lester, Browns, Big, Roger, Alder, Thrash, Mack, Cinnabar, and George creeks and the East Fork and West Fork Chehalis rivers (Ronne et al. 2020).

Chehalis River coho salmon subpopulations show genetic differentiation including demes found upstream of the proposed FRE facility, in the South Fork Chehalis and Newaukum rivers (Seamons et al. 2019). Elk Creek supports late run coho salmon derived from Skookumchuck Hatchery stock. Few hatchery-produced coho salmon are found upstream of Elk Creek and there was no genetic signal from Skookumchuck late-run coho salmon observed in fish collected from the upper Chehalis or South Fork Chehalis rivers.

In general, streams with more complex habitat including instream structure (logs, undercut banks, etc.) support more rearing coho salmon (Hartman et al. 1982), not only because they provide more available habitat but also because they provide more food and cover. Overhanging vegetation is also correlated with increased gut fullness and growth of coho salmon juveniles from input of insects and other food items that fall into the stream from riparian vegetation (Smith and Wenger 2001).

Limiting factors for coho salmon in the Chehalis Basin include temperature, lack of off-channel habitats, and lack of habitat diversity. Temperature is the primary limiting factor for coho salmon during holding, spawning, and rearing (Smith and Wenger 2001). Coho salmon seek cold water habitats in upper tributary reaches when barriers such as culverts are not present. A combination of competition with native cyprinids more tolerant of warmer water and physiological intolerance to stream temperatures over 20°C results in limited ability for coho salmon to make use of mainstem habitats (Winkowski et al. 2018a).

3.1.4 Steelhead

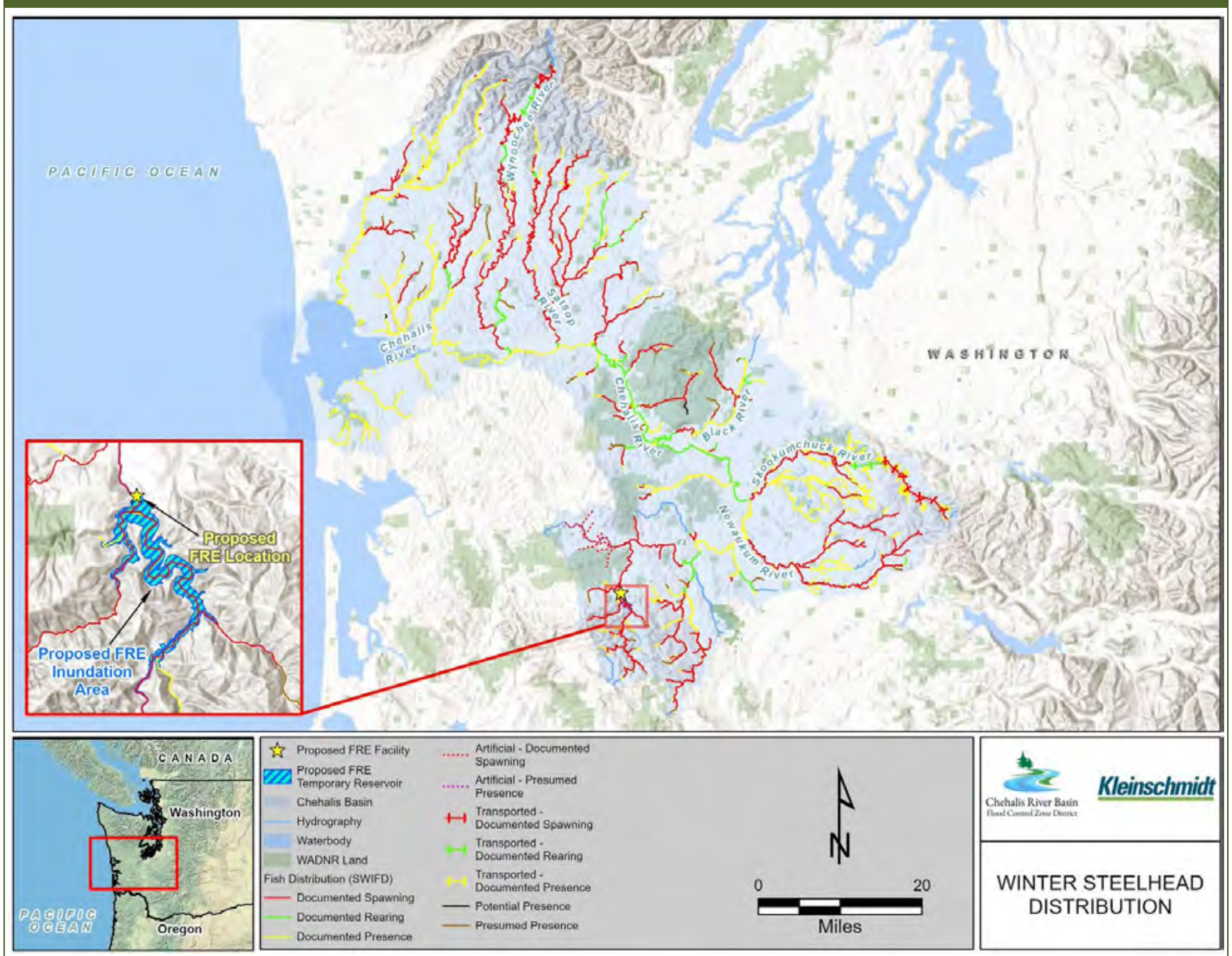
Steelhead present in the Chehalis River Basin include winter- and summer-run fish. Winter-run steelhead are present throughout the basin while summer-run fish are only present in the lower basin up to and including the Wynoochee River. Hatchery production has contributed significantly to winter-run steelhead returns to the Grays Harbor tributaries, lower Chehalis Basin tributaries, and the Newaukum River, Skookumchuck River, and Elk Creek (WDFW 2019c). Hatchery winter-run steelhead are regularly harvested in sport fisheries, and hatchery and wild steelhead are harvested by both Quinault Indian Nation and Chehalis Tribe commercial fisheries but are not targeted in state-managed commercial fisheries.

Compared to salmon species in the upper Chehalis, steelhead exhibit the most protracted spawning period, extending from December through June. Juvenile winter-run steelhead generally migrate to the ocean following 2 to 3 years rearing in freshwater, with most adult fish returning at 4 to 5 years of age. In 2018, out-migration of steelhead smolts at the WDFW smolt trap operated at RM 42 was first observed the week of March 26th, peaking in late April. Out-migrants included one-year olds (157.4 mm +/- 11.6), two-year olds (174.0 mm +/- 23.1), and three-year olds (194.8 mm +/- 23.1) (Winkowski and

Zimmerman 2019). WDFW estimated that wild steelhead out migrants in 2018 numbered approximately 32,058 fish (+/- 15,864 SD) for the basin.

In the upper Chehalis River, most documented winter steelhead spawning occurs in the mainstem Chehalis above the South Fork Chehalis River confluence and in the Skookumchuck, Newaukum, and South Fork Chehalis rivers as well as other medium and small tributaries (Figure A1-8). At its most inclusive level, the genetic structure of winter-run steelhead can be spatially organized into three groups corresponding with headwater geography: tributaries draining the Olympic Mountain Range, tributaries draining the Cascade Mountain Range, and tributaries draining the Willapa Hills (Seamons et al. 2017). The Willapa Hills group includes steelhead spawning upstream of the proposed FRE facility and in the South Fork Chehalis River. Steelhead in the Skookumchuck River were found to be genetically distinct and had low diversity, likely due to hatchery program activities. The collection of samples taken in the Newaukum River did not appear to be from a single spawning population and were composed of individuals from the lower, middle and upper Chehalis River.

Figure A1-8
Map of Winter-run Steelhead Distribution in the Chehalis Basin



Source: SWIFD.

March 15 is a threshold date that is used by fisheries managers to differentiate redds made by the earlier spawning hatchery-origin winter steelhead from later spawning wild winter steelhead. However, there is evidence that this assumption is not applicable to steelhead of the upper Chehalis Basin. Skookumchuck Hatchery steelhead, which spawn earlier than natural-origin steelhead, are released annually in Elk Creek. Adult winter-run steelhead have been observed spawning in the upper Basin above the Elk Creek confluence (RM 100.2) prior to March 15, but snorkel surveys conducted each winter since 2014 indicate minimal to no observations of hatchery-origin steelhead in the upper Chehalis Basin. However, 2019 carcass surveys found 1 out of 6 carcasses to be of hatchery-origin, but the sample size was too small to be conclusive (Ronne et al. 2020).

Between 1983 and 2018 estimated average winter-run steelhead escapement for the Chehalis Basin upstream of RM 9 was 2,650 and ranged from 4,604 (2004) to 1,164 (2011) (Ecology 2020a). During April 2019, a peak supplemental survey for winter steelhead redds was conducted in the mainstem Chehalis River and the tributaries above the proposed FRE facility and in the mainstem Chehalis River from the Pe Ell bridge downstream to the Newaukum River confluence (RM 75.2); a total of 53 redds were observed in the mainstem between the Pe Ell bridge and the Newaukum River while 399 redds were observed in the mainstem and tributaries both within and above the proposed temporary reservoir area (Ronne et al. 2020). Of the 53 documented redds within the area of the mainstem Chehalis River surveyed, all but two were located upstream of the Elk Creek confluence with a higher density occurring near Pe Ell. No winter-run steelhead redds were observed below RM 97.

During intensive weekly surveys conducted annually upstream of the proposed FRE facility from 2013 through 2018/2019, annual estimates of late winter-run steelhead spawner abundance ranged from 860 fish in 2017 to 1,550 in 2014, while early winter-run steelhead spawner abundance ranged from 8 to 300 fish over the same period (Ronne et al. 2020). Ronne and others (2020) estimated the contribution of combined winter-run steelhead above the FRE facility to be 15.43% of the entire Chehalis Basin steelhead spawner abundance.

Of the steelhead redds observed above the FRE facility from 2013 through 2018/2019, 1,391 (31%) were found within the mainstem and tributaries of the temporary reservoir, while 3,139 (69%) were found upstream of the upper extent of the maximum pool elevation of the temporary reservoir in the mainstem Chehalis River, Crim, Lester, Browns, Big, Roger, Alder, Thrash, Mack, Cinnabar, George, and Sage creeks and the East Fork and West Fork Chehalis rivers (Ronne et al. 2020).

As with other salmonids, limiting factors for Chehalis Basin steelhead include temperature, habitat complexity, and habitat diversity. Displacement by warm-water tolerant species (cyprinids) may also limit juvenile steelhead use of otherwise suitable summer rearing habitat (Winkowski et al. 2018a) and may expose juveniles to elevated risk of predation. Passage barriers such as culverts that impede access to colder tributary refugia may also limit success of steelhead spawning and rearing in the upper basin.

3.1.5 Pacific Lamprey

Pacific lamprey appear to be broadly distributed in the mainstem Chehalis River and major tributaries. They have been documented in the mainstem upstream of and downstream of the proposed FRE facility site (U.S. Fish and Wildlife Service [USFWS] 2011) and were observed in every sub-basin sampled including the Newaukum and Skookumchuck rivers and the Black River (outside of the Mitigation Area) (Jolley et al. 2016). Spawning population size and run timing of Pacific lamprey have not been documented in the Chehalis Basin, though spawning distribution was surveyed by WDFW from 2013 through 2018. Spawning was concentrated in the mainstem Chehalis River between the Stearns Creek and the South Fork Chehalis River and from Pe Ell upstream to the FRE facility, and within the area upstream of the FRE facility.

Pacific lamprey spawn in low-gradient streams in the basins of large rivers and spend more than half of their 6- to 10-year life span as filter-feeding larvae burrowing in fine sediments of streams (Torgersen and Close 2004). After an extended time (4 to 6 years), larvae (ammocoetes) go through a metamorphosis that includes major morphological and physiological changes in preparation for their downstream migration and life in marine environments. Juveniles (macropthalmia) migrate downstream during spring freshets and feed in the ocean for 1 to 3 years before returning as adults for reproduction (Close et al. 2002). Pacific lamprey likely do not return to natal streams (Hatch and Whiteaker 2009) but are thought to be guided to spawning locations by other cues, such as odors emanating from ammocoetes (Yun et al. 2011). Levels of genetic differentiation among Pacific lamprey from different areas are low, likely due to a lack of population differentiation that would occur with natal homing (Docker 2010).

Spawning and rearing Pacific lamprey occupy different habitats, with spawning fish preferring riffles and pool tail-outs not more than 1.0 ft deep and not more than 5.9 fps, while juveniles require loose fine substrate in slack water habitats more than 2.2 ft (Winkowski and Kendall 2018). Limiting factors for Pacific lamprey include predation, access to suitable habitat due to barriers such as culverts, degradation of floodplain and stream habitat, water quality, and human lack of understanding baseline abundance and distribution from which trends can be evaluated.

3.2 Resident Fishes

Summer stream temperatures in headwaters and the upper mainstem Chehalis River are cooler than downstream areas and support a cold-water fish assemblage dominated by salmonids compared to downstream reaches that are dominated by native cyprinids (minnows) (Winkowski et al. 2018a).

Both rainbow trout and cutthroat trout are widely distributed throughout the upper mainstem Chehalis River and the larger tributaries. Within the FRE facility temporary reservoir area, rainbow trout occurred in both the mainstem and tributaries while cutthroat trout were found in Lester, Hull, Browns, Big and Roger creeks and mainly upstream of presumed anadromous barriers such as gradient, water depth, and/or cascades (Winkowski et al. 2016). Like anadromous salmonids, resident trout also prefer clean, cold-water habitat with habitat features including riffles and pools, especially key for spawning.

A range of non-game and non-priority species are present throughout the Chehalis Basin and within the proposed Mitigation Area including mountain whitefish (*Prosopium williamsoni*), largescale sucker (*Catostomus macrocheilus*), longnose dace (*Rhinichthys cataractae*), speckled dace (*R. osculus*), redside shiner (*Richardsonius balteatus*), northern pikeminnow (*Ptychocheilus oregonensis*), western brook lamprey (*Lampetra richardsoni*), and various cottids (Winkowski et al. 2016; Zimmerman and Winkowski 2016).

Mountain Whitefish (*Prosopium williamsoni*) have been documented throughout the mainstem Chehalis River within several miles both downstream of and upstream of the FRE facility, at the confluence with Crim Creek, and upstream of the confluence of Browns Creek (Winkowski et al. 2016). Whitefish prefer clear, cold water and large deep pools. They are predominantly bottom feeders. Whitefish spawn from September through January to December when water temperatures are 2-6^{o}C, seeking out areas of coarse gravel or gravel (Wydoski and Whitney 2003). Eggs overwinter, emerging as fry in early spring. Little is known about juvenile spatial distribution of whitefish within the Chehalis Basin. While adult distribution is not thoroughly documented, movement pattern studies in tributaries of the Chehalis River suggest that primary movement occurs prior to spawning and may be associated with increased variability in the hydrograph during the early fall period (Winkowski et al. 2018a).

Olympic mudminnow, a state-listed Sensitive Species, is highly unique to the coastal lowlands of Western Washington, occurring nowhere else in the world, and most of the population occurs within the Chehalis Basin with few sightings in other drainages (Mongillo and Hallock 1999). Olympic mudminnow only occur in streams with little or no flow, wetlands, and ponds. The species is wholly dependent on temporarily flooded wetland habitats and is sensitive to changes in hydrology, including changes in flow. They are known to occur in low densities in off-channel habitat adjacent to the Chehalis River between the confluences of the Black River and the South Fork Chehalis River (RM 47.0 to 88.1; Hayes et al. 2017; Hayes 2019b).

3.3 Non-Native Fishes

Non-native fish species believed to be present in the Chehalis Basin are a relatively warmwater assemblage that includes American shad (*Alosa sapidissima*), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), brown bullhead (*Ameiurus nebulosus*), common carp (*Cyprinus carpio*), largemouth bass (*Micropterus salmoides*), pumpkinseed (*Lepomis gibbosus*), rock bass (*Ambloplites rupestris*), smallmouth bass (*Micropterus dolomieu*), yellow perch (*Perca flavescens*), and catfish (*Ictalurid spp*.) (Hayes et al. 2019; Winkowski and Zimmerman 2019). Most of these fish are found in off-channel wetlands rather than in the mainstem. In surveys completed in 2014, non-native centrarchid species such as bass, sunfish, and bluegill, were not observed upstream of the confluence of the mainstem Chehalis River with the South Fork Chehalis River at RM 88.1 (Winkowski et al. 2018a).

Largemouth bass and smallmouth bass present the greatest threat to native fish in the study area. Bass are opportunistic predators and large individuals can prey heavily on juvenile salmon where their distributions overlap (Wydoski and Whitney 2003). The presence of invasive predators, including bass, is named as a potential limiting factor for the sustainability of some salmon populations in the Chehalis Basin (Grays Harbor County Lead Entity Habitat Work Group [GHLE] 2011). Bass thrive in the warmer reaches and slow-moving off-channel habitats of the mainstem. The upstream extents of bass invasion into salmonid-dominated river habitats are associated with warm water temperatures above 50°F and is projected to increase under future climate scenarios (Wydoski and Whitney 2003; Rubenson and Olden 2019). Largemouth bass are distributed in the Chehalis River from near RM 9 to at least as far upriver as the confluence with the South Fork Chehalis River (Hayes et al. 2016, J. Winkowski et al. 2018a).

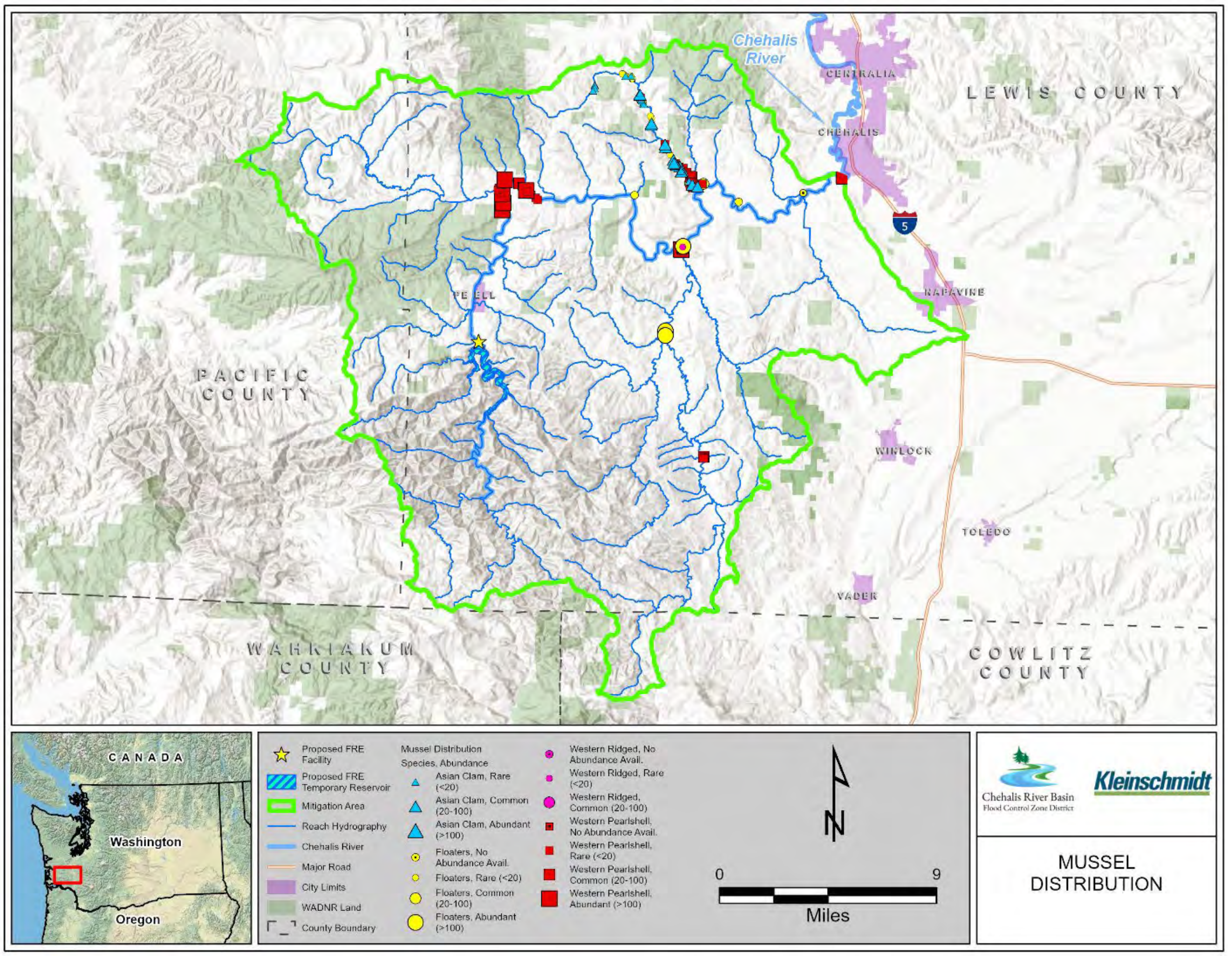
3.4 Freshwater Mussels

Three species of native freshwater mussels have been documented in the Chehalis River: western floater (*Anodonta spp.*), western pearlshell (*Margaritifera falcata*), and western ridged mussel (*Gonidea angulata*; Waterstrat 2013). In addition to the native mussels, Asian clams, a non-native species has been documented in Bunker Creek. The western ridged mussel is currently proposed for federal listing under the ESA (Blevins et al. 2020).

Native freshwater mussels have been observed throughout the upper Chehalis River; however, little is known about their distribution and habitat use. During WDFW surveys conducted in 2020 and 2021, freshwater mussels were found to be numerous in the mainstem Chehalis River from about RM 101 just upstream of the confluence with Elk Creek near the community of Doty downstream to the Newaukum River confluence (RM 75.2) (Figure A1-9). They appear to be more common between Rainbow Falls (RM 97.0) and the confluence with the Newaukum River than reaches upstream of Rainbow Falls. Mussel densities in some reaches were so high that they were the major substrate (Winkowski et al. 2018b). No mussel beds were observed within the vicinity of the proposed FRE facility or temporary reservoir during freshwater mussel surveys conducted by WDFW in 2020 (Douville et al. 2021).

The health and diversity of macroinvertebrates such as freshwater mussels and clams is considered a metric of habitat quality and rearing potential for a stream system. Freshwater mussels provide a vital function in an aquatic ecosystem by providing and enhancing habitat, filtering and cleaning water, and providing food for species vital to the foodweb. Mussels are filter feeders that siphon algae, bacteria, and detritus out of the water column. Filtering mussels can reduce turbidity and control nutrient loads in the water column, improving overall water quality (Nedeau et al. 2009). A dense mussel bed can filter nearly 35% of the total daily discharge from a large river (Mazzacano and Blackburn 2015). Decaying shells become a source of calcium, phosphorus, and nitrogen (Mazzacano and Blackburn 2015).

Figure A1-9
Map of Freshwater Mussel Abundance found during WDFW 2020 and 2021 Surveys



Source: Douville et al. 2021.

3.5 Aquatic invertebrates

At the time of this writing, no data were publicly available on the species assemblage or abundance of aquatic invertebrates in habitats within the Mitigation Area that may be used to assess quality of existing food sources for aquatic species.

3.6 Amphibians

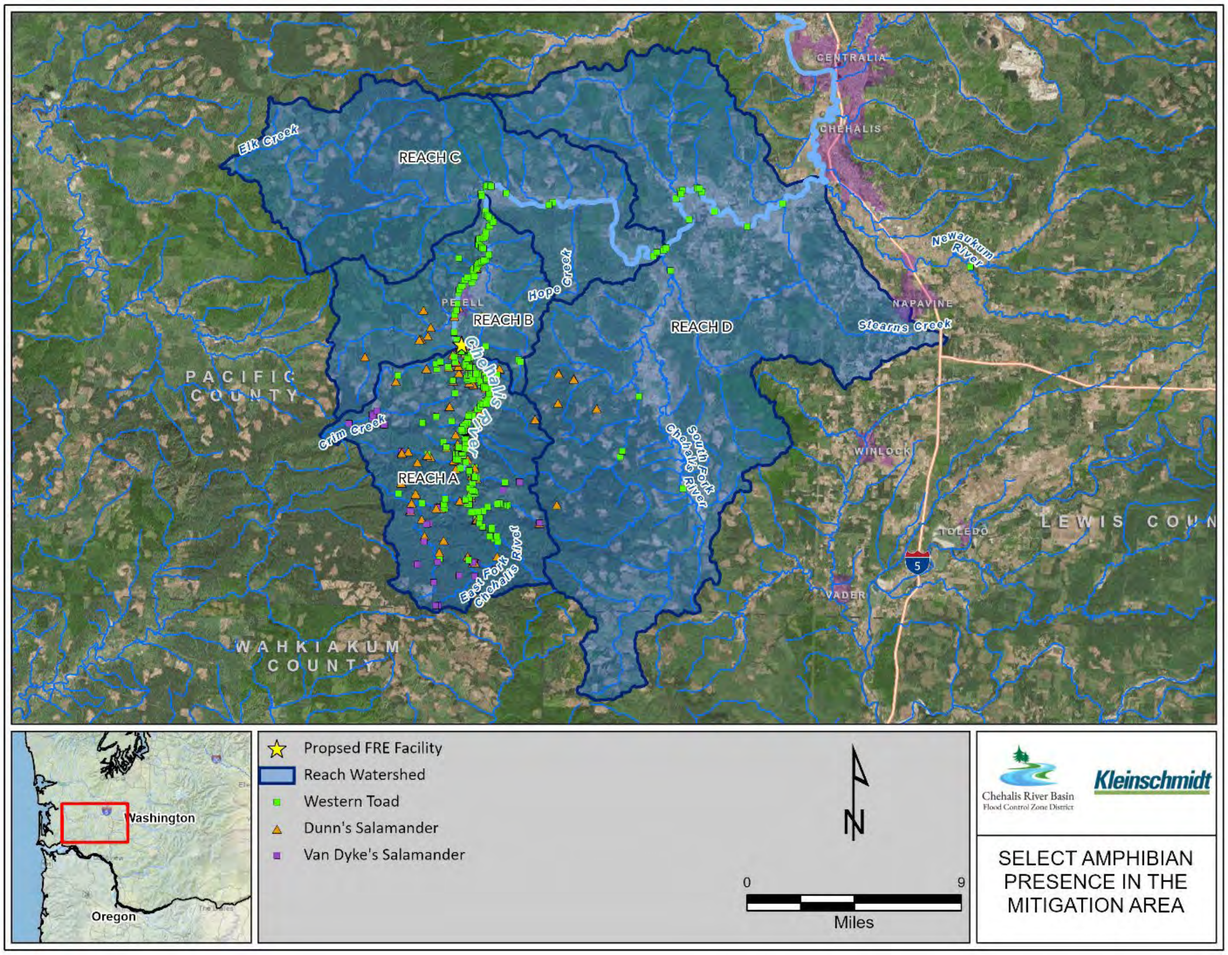
Amphibian species can be grouped into categories according to their breeding habitat: still-water breeding, stream breeding, and terrestrial breeding. Still-water breeding amphibians in the Mitigation Area are often associated with off-channel floodplain habitats including oxbows and ponds. Stream breeding amphibians utilize flowing water in rivers and streams, while terrestrial breeding amphibians are often associated with riparian habitats and moist cool forests. Terrestrial-breeding amphibians are discussed below in Section 4.1.

Amphibian surveys were conducted by WDFW in the vicinity of the FRE facility and temporary reservoir between 2014 and 2017. Priority aquatic amphibian species found within the Mitigation Area include the western toad (*Anaxyrus boreas*), a candidate for state listing (Figure A1-10). The western toad is a still-water breeding species that is known to breed in the mainstem Chehalis River and larger tributaries within the proposed temporary reservoir footprint (Hayes et al. 2017). Western toad spawning and incubation occurs in standing water, including ponds, lakes, slow-moving reaches of streams, springs, reservoirs, canals, and roadside ditches. Adults have been observed as far as 1.6 miles from breeding sites. Hibernation occurs in terrestrial locations, but little else is known about their hibernation (Washington Department of Natural Resources [WA DNR] 2013). In addition to being documented in the temporary reservoir area, western toad has also been documented in areas both upstream and downstream (Hayes et al. 2017).

Still-water breeding amphibians detected during WDFW surveys include Pacific treefrog (*Pseudacris regilla*), northern red-legged frog (*Rana aurora*), northwestern salamander (*Ambystoma gracile*), rough-skinned newt (*Taricha granulosa*), and western toad (Figure A1-11). Stream breeding amphibians detected during the surveys include giant salamander (*Dicamptodon* sp.), coastal giant salamander (*Dicamptodon tenebrosus*), coast tailed frog (*Ascaphus truei*), and Columbia torrent salamander (*Rhyacotriton kezeri*) (Hayes et al. 2017).

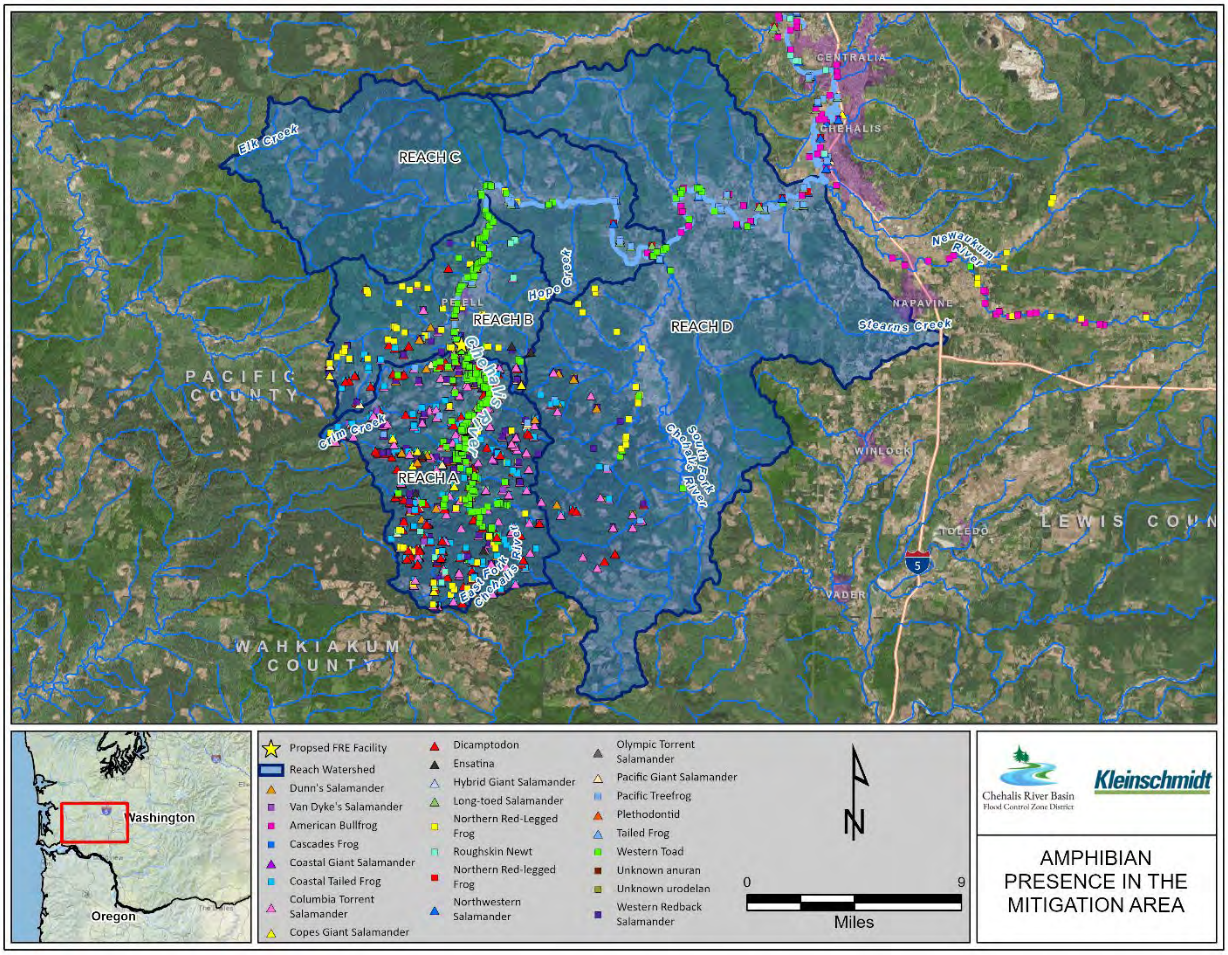
Other aquatic amphibian species that were not documented during WDFW surveys in the vicinity of the FRE facility and temporary reservoir but may potentially occur in the Mitigation Area include the long-toed salamander (*Ambystoma macrodactylum*) and Cope's giant salamander (*Dicamptodon copei*) (Ecology 2020a).

Figure A1-10
Occurrence of Priority Amphibian Species documented during WDFW 2014-2017 Surveys



Source: Hayes et al. 2018

Figure A1-11
Occurrence of Amphibian Species documented during WDFW 2014-2017 Surveys



Source: Hayes et al. 2018

4 TERRESTRIAL SPECIES

The upper Chehalis Basin provides habitat for a wide array of wildlife species. The following sections address priority terrestrial-breeding amphibians, birds, and mammals that may occur in the Mitigation Area or are indirectly affected by potential impacts associated with the Proposed Action. Attributes of native species that are described here include their federal and state special status and ecological role in the Chehalis Basin. A list of terrestrial species likely to occur in the Mitigation Area are presented in Attachment 2.

4.1 Amphibians

Still-water breeding and stream breeding amphibians are discussed above in Section 3.6 under aquatic species. Terrestrial breeding amphibians are often associated with forested riparian habitats and moist cool forests. Amphibian surveys were conducted by WDFW in the vicinity of the FRE facility and temporary reservoir between 2014 and 2017. Priority terrestrial-breeding amphibian species in the Mitigation Area include the Dunn's salamander (*Plethodon dunni*) and Van Dyke's salamander (*Plethodon vehiculum*) which are both candidates for state listing (Figure A1-10). Terrestrial-breeding amphibians detected include ensatina (*Ensatina eschscholtzii*), western red-backed salamander (*Plethodon vehiculum*), Dunn's salamander, and Van Dyke's salamander (Hayes et al. 2017) (Figure A1-11).

Dunn's and Van Dyke's salamanders inhabit cool, moist microclimates in forested habitats (Larsen 1997). The Willapa Hills region is one of three disjunct distributional centers for Van Dyke's salamander, which is endemic to western Washington (Olson and Crisafulli 2014). Dunn's salamanders range extends from northeastern California to western Oregon and the Willapa Hills in southwestern Washington. Both species occupy wet, rocky substrates or woody debris with several inches of duff. Occupied sites are heavily shaded and can include seeps and stream banks. Both species are often found in riparian zones, but have been documented further upslope in appropriate, stable microclimates (Larsen 1997).

4.2 Birds

A number of avian species with a special status potentially utilize the Mitigation Area. Birds that are federally or state listed that potentially occur include marbled murrelet (*Brachyramphus marmoratus*), northern spotted owl (*Strix occidentalis caurina*), streaked horned lark (*Eremophila alpestris strigata*), and yellow-billed cuckoo (*Coccyzus americanus*) (Ecology 2020a). In addition to priority species, other avian species likely to occur in the basin include those common to western Washington such as American robin (*Turdus migratorius*), spotted towhee (*Pipilo maculatus*), black-capped chickadee (*Parus atricapillus*), Bewick's wren (*Thryomanes bewickii*), and Swainson's thrush (*Catharus ustulatus*).

The marbled murrelet (*Brachyramphus marmoratus*) is a federally and state-listed species that occurs above the FRE facility and Critical Habitat under the ESA has been designated both upstream and downstream of the proposed FRE facility (WSDOT 2020). The marbled murrelet is a small seabird native to the Pacific Coast that breeds from central California to the Aleutian Islands of Alaska. Though primarily an ocean-dwelling species that spends more than 90 percent of life at sea, marbled murrelets nest inland in old-growth conifer-dominant stands. Nest sites are typically located within approximately 37 miles (60 km) of the ocean but potentially can be up to 70 miles (113 km) inland (Hammer and Nelson 1995). They forage at sea, carry single prey items to their young in the nest, and make multiple trips back and forth each day.

Suitable nesting habitat for marbled murrelets consists of mature conifers (>15 inches diameter at breast height [dbh]) situated in contiguous conifer-dominant (>60 percent) stands with at least one suitable nesting platform at least 33 ft (10 m) off the ground (Hamer and Nelson 1995). Nesting platforms are at least four inches wide and are typically composed of a wide branch covered with moss, lichen, mistletoe, witches' brooms (a dwarf mistletoe infected tree limb), or other deformities (Hamer and Nelson 1995).

As coastal forests undergo clear-cutting and development, marbled murrelets are forced to search further inland for suitable nesting habitat. Timber harvest, development, and an overall increase in wildfires also increase habitat fragmentation and the creation of edge habitat that can lead to an increase in nest predation by predators like corvids (Hamer and Nelson 1995). These and other threats like changes in oceanic conditions have caused a rapid decline in the species' population thus resulting in marbled murrelets being listed as state-endangered in Washington, Oregon, and California and threatened under the federal ESA.

Within the Mitigation Area, pockets of suitable marbled murrelet nesting habitat with potential nesting platforms are present within patches of mature coniferous forest in the headwater areas of the Upper Chehalis Basin and may be present within the vicinity of the proposed FRE temporary reservoir. While much of the area is in timber production and no old-growth forest is present, mature forest is present in linear patches along the stream corridors which may provide nesting habitat for marbled murrelets. Marbled murrelet activity has been documented in the upstream portions of the maximum temporary reservoir area WDFW 2020a. Additionally, circling marbled murrelets, which is indicative of nesting activity, were documented within a mile of the temporary reservoir area within the subcanopy of forest habitat (Stambaugh-Bowey-WDFW pers comm. 2019).

Northern spotted owl is strongly associated with old growth forest and requires large patches of suitable habitat for nesting. Based on the results of a number of surveys conducted during the last 17 years, the presence of the northern spotted owl in the study area is extremely low and limited to dispersing and foraging individuals (WSDOT 2020). Streaked horned lark is associated with a wide variety of habitats that all have bare ground or sparse vegetation and an open landscape. There is no suitable habitat for streaked horned lark in the vicinity of the FRE facility and temporary reservoir. Yellow billed cuckoo is associated with riparian forest habitat. However, there are no records of the species breeding in the Pacific Northwest since the 1940s and data indicates there to be only a remote chance of non-breeding visitation to the area (Wiles and Kalasz 2017).

A golden eagle (*Aquila chrysaetos*) nesting area was identified in the vicinity of the FRE facility in 2013 (WDFW 2019b). Golden eagles are a priority species and are protected under the federal Bald and Golden Eagle Protection Act.

4.3 Mammals

Mammals with federal or state threatened, endangered, or proposed status are not likely to occur in the Mitigation Area. Priority species that are not state or federally listed that may potentially occur in the area include Columbia black-tailed deer (*Odocoileus hemionus columbianus*), Roosevelt elk (*Cervus canadensis roosevelti*), Keen's myotis (*Myotis evotis keenii*), Townsend's big-eared bat (*Corynorhinus townsendii*), and roosting concentrations of big-brown bat (*Eptesicus fuscus*), and myotis bats (*Myotis spp.*) (Ecology 2020a).

Columbia black-tailed deer and Roosevelt elk are traditionally important food sources for Indigenous people. The upper Chehalis Basin offers habitat preferred by deer and elk including productive grasslands, meadows, and clearcuts, interspersed with closed-canopy forests (WDFW 2022a).

The Willapa Hills elk herd is distributed throughout its historic range, although its distribution is not uniform. There is not a formal population estimate for the Willapa Hills Roosevelt elk herd, but WDFW estimates the herd size to be between 8,000 and 10,000 elk (WDFW 2016). One of the game management units (GMU) with the highest density of elk is located on the west side of the temporary reservoir (GMU 506); however, elk numbers are managed in portions of that GMU to minimize agricultural damage from foraging elk (WDFW 2014b). WDFW conducted survey flights during March of 2020 that covered the southern portion of the herd area. A total of 1,524 elk were observed, and the total elk abundance for the southern portion of the herd area was estimated to be 2,984. The calf-to-cow ratio measured 34 calves per 100 cows, which indicates good recruitment (WDFW 2021). Willapa Hills elk reportedly move down from Bawfaw Peak and other high elevation areas into winter range areas that include the flats of the West and East Forks of the Chehalis River, in the vicinity that includes the temporary reservoir site (PHS 2022).

Population trends of black-tailed deer in Washington are difficult to ascertain because of the habitat they occupy and changes in hunting regulations and intensity (WDFW 2014a). However, estimates derived from harvest reports for black-tailed deer in the Willapa Hills Black-tailed Deer Management Zone (BDMZ) indicate that the population was stable between 2005 and 2015 (WDFW 2016). Black-tailed deer habitat has been reduced over time in western Washington because of human encroachment, reduced timber harvest, and natural forest succession (WDFW 2014a). Data is being analyzed from research to determine black-tailed deer fawn production and survival and additional research is ongoing (WDFW 2021).

Keen's myotis is associated with mature coastal conifer forests but may move to mid-elevations during winter. Townsend's big-eared bat occur at low densities throughout their range, which includes the Mitigation Area. Big-brown bat and myotis bats' ranges also include the Mitigation Area (WDFW 2022a).

In addition to priority species, other mammal species likely to occur throughout the basin include those common to western Washington such as Douglas squirrel (*Tamiasciurus douglasii*), racoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), beaver (*Castor canadensis*), coyote (*Canis latrans*), and various bat species.

4.4 Reptiles

According to Priority Habitats and Species mapping, no priority reptile species are documented within the Mitigation Area (PHS 2022). Other reptile species documented in the vicinity include northern alligator lizard (*Elgaria coerulea*), common garter snake (*Thamnophis sirtalis*), northwestern garter snake (*Thamnophis ordinoides*), and rubber boa (*Charina bottae*) (WDFW 2017).

5 PROPOSED ACTION MITIGATION AREA

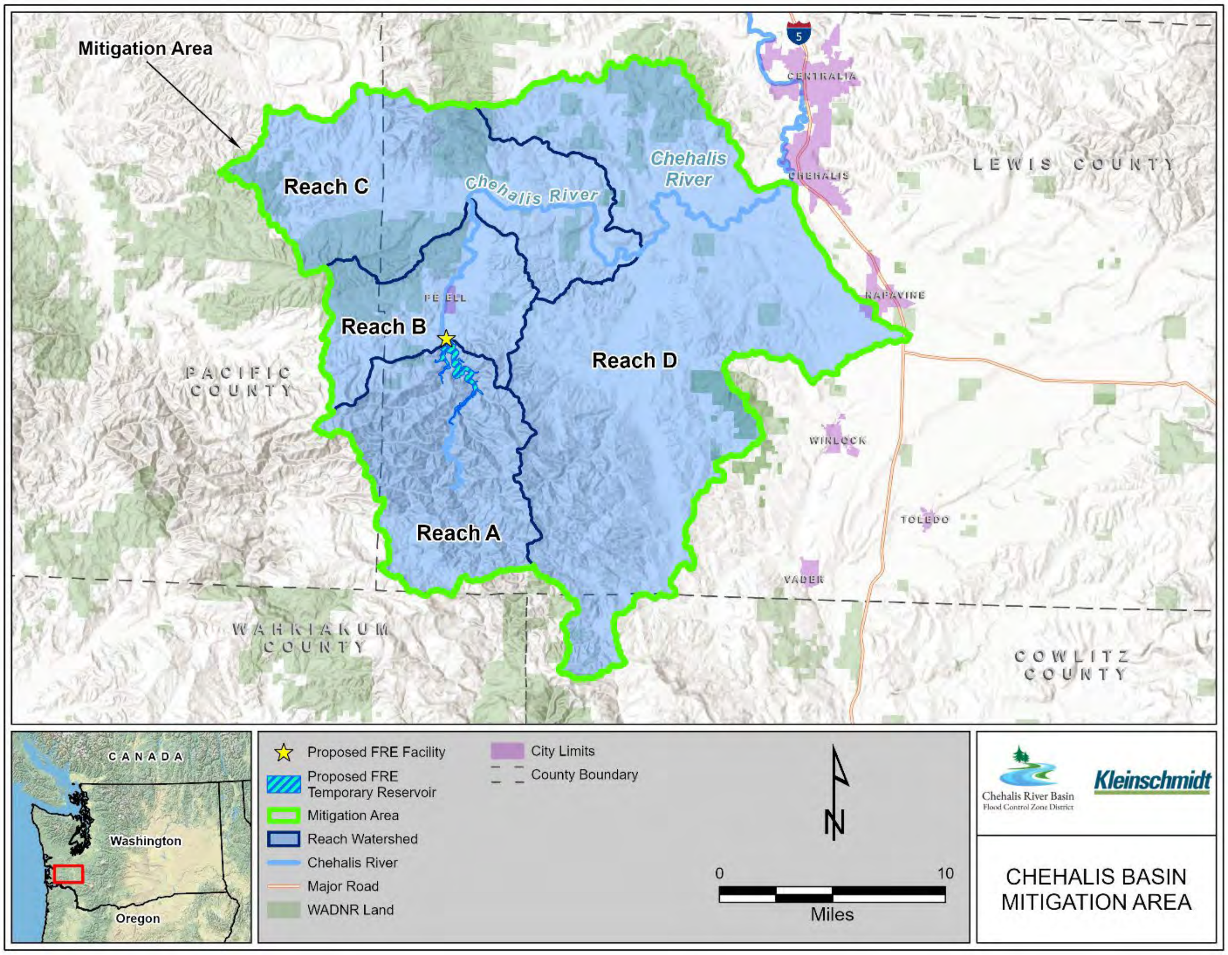
As previously defined, the proposed mitigation area includes the upper Chehalis River Basin from its headwaters downstream to the Newaukum River confluence at RM 75.2. To structure an approach to mitigation, four sub-watersheds or reaches were designated within the Mitigation Area based on the extent of potential impacts of the FRE facility both upstream and downstream of the FRE, river geomorphology, and the location and extent of mitigation opportunities. The Mitigation Reaches are described in Table A1-1 and displayed in Figure A1-12. The following sections describe the existing conditions of the aquatic and terrestrial species and habitats in the Mitigation Reaches.

Table A1-1

Description of Chehalis Mitigation Area Reaches A through D

REACH	REACH DESIGNATION	PERENNIAL STREAM LENGTH (RM)	CATCHMENT SIZE (MI^2)	INFLOWING TRIBUTARIES
A	Mainstem Chehalis River and Tributaries upstream of the FRE Structure (RM 108.5)	11.5 mainstem 157.5 tributary	76.2	Lester, Crim, Hull, Browns, Big, Roger, Smith, Alder, Thrash, Mack, Cinnabar, George, Sage, East and West Fork Chehalis
B	Tributaries and mainstem Chehalis River from the FRE facility (RM 108.5) to Elk Creek confluence (RM 100.2)	8.7 mainstem 98.6 tributary	57.1	Mahaffey, Rock, Stowe, Cannonball, Shields, Jones, Fronia, Robinson
C	Tributaries and mainstem Chehalis River from Elk Creek (RM 100.2) to South Fork Chehalis River (RM 88.1)	12.6 mainstem 223.2 tributary	100.5	Elk, Capps, Absher, Dunn, Marcuson, Dell, Hope, Garret, Nicholson
D	Tributaries and mainstem Chehalis River from South Fork Chehalis River (RM 88.1) to the Newaukum River (RM 75.2)	13.5 mainstem 517.5 tributary	215.8	South Fork Chehalis River, Bunker, Van Ornum, Stearns, Mill

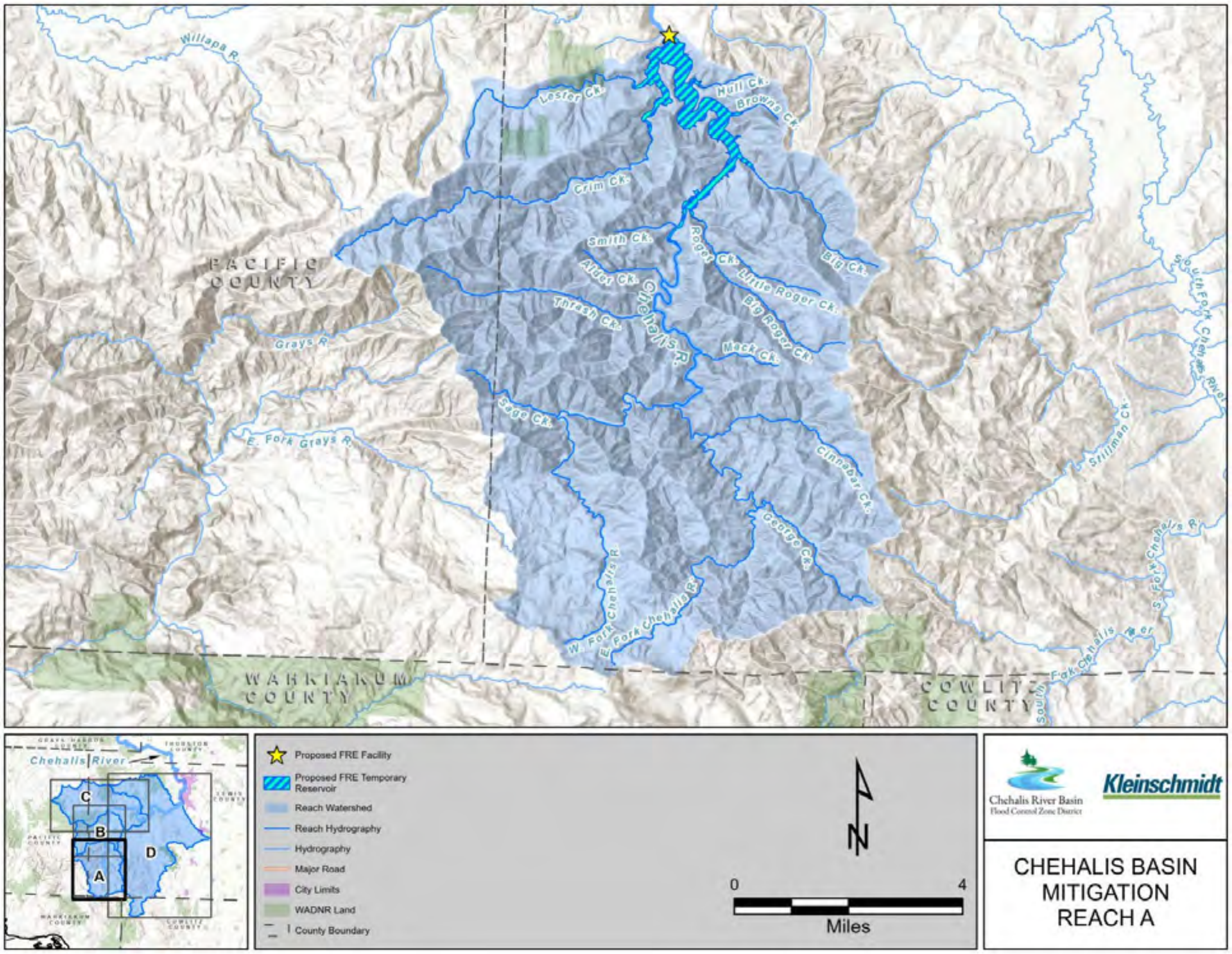
Figure A1-12
Area Considered for Mitigation including Mitigation Reaches A, B, C, and D



5.1 Reach A: Upper Chehalis River Basin Upstream of the FRE

Mitigation Area Reach A consists of the headwaters of the Chehalis River and its tributaries, originating in the Willapa Hills and extending downstream to the proposed FRE facility site (RM 108.5). About 11.5 miles of the mainstem Chehalis River and 157.5 miles of perennial tributaries drain the 76.2 square mile headwaters (Figure A1-13). Tributaries include the East and West forks of the Chehalis River, and George, Cinnabar, Mack, Thrash, Alder, Roger, Big, Browns, Hull, Crim, and Lester creeks. This reach encompasses the entire temporary reservoir area and the FRE facility. The primary water source for the Town of Pe Ell is Lester Creek, which flows into Crim Creek just upstream of its confluence with the Chehalis River, and just upstream of the proposed FRE facility (Ecology 2020b).

Figure A1-13
Mitigation Reach A



5.1.1 Upland Habitat

The upper watershed is managed for timber harvest, with Mitigation Reach A lying almost entirely within a 56,000-acre forested parcel owned by the Weyerhaeuser Company. Various access roads, exist along the streams, including Forest Road (FR) 1000 that runs along the right bank of the mainstem, and on the hillslopes, with bridges spanning inflowing tributaries.

Existing conditions in Reach A have been impacted by timber practices resulting in even-aged stands that are dominated by Douglas fir in various stages of growth and density. The commercially managed forests are even-aged stands of trees, typically ranging from less than 10 years old to more than 60 years old. Based on analysis of satellite imagery from 2018, approximately 12% of the upland area within 0.25 miles of the mainstem Chehalis River between the proposed FRE facility and upper inundation extent of the temporary reservoir was clearcut/ bare of vegetation, 5% was in early regrowth period, and 83% was mature upland forest. A similar analysis based on imagery from 1998 included 33%

clearcuts/ bare of vegetation, 16% early regrowth period, and 51% of the same spatial area (GoogleEarth/Quickbird 2022).

Land cover types identified in Reach A include wetland, open water, scrub-shrub, hay/pasture, mixed forest, deciduous forest, evergreen forest, developed, and herbaceous (Ecology 2020a). Table A1-2 provides the land cover types within the footprint of the proposed temporary reservoir.

Upland forests provide numerous benefits for wildlife such as food sources, cover, nesting, and denning opportunities, as well as migrating habitat. Priority mammal species documented in Reach A include Roosevelt elk and black-tailed deer, which are documented in all Mitigation Reaches.

Designated critical habitat for the state and federally listed marbled murrelet is present within Reach A (USFWS 2022). Marbled murrelet activity indicative of nesting behavior has been documented and suitable nesting habitat is present. No critical habitat is designated within the Proposed Action area and WDFW has indicated that no known nesting platforms are present. Suitable nesting habitat is dependent on the presence of nesting platforms in large trees that typically occur old growth forests. However, suitable nesting habitat can occur in younger, managed forests with large trees. Stream corridors within Reach A may provide such large trees in areas not harvested per WA DNR Forest Practices requirements. Marbled murrelet nesting occurs April 1 through September 23) (WSDOT 2020).

Reach A supports habitat for other special status avian species as well. The northern spotted owl is a state and federally listed species. While the likelihood of resident, territorial northern spotted owls in the upper Chehalis River is low, Reach A does contain potential foraging and dispersal habitat for transient northern spotted owls (Smith and Wenger 2001).

The northern goshawk, a candidate species for state listing, was documented in Reach A in 1996 (PHS 2022). The golden eagle, also is a candidate species for state listing and protected by the Bald and Golden Eagle Protection Act, was documented nesting in Reach A in 2013 (PHS 2022). The sandhill crane is state listed as an endangered species. Elochoman Pass, within Reach A, is identified as a migratory stop for the sandhill cranes (PHS 2022).

Snags in upland forests are a priority habitat feature (Ecology 2020a) that provide nesting habitat for cavity-nesting birds like great horned owl (*Bubo virginianus*) and woodpeckers including the downy woodpecker (*Picoides pubescens*). Snags also provide perch sites for raptors like northern harriers (*Circus cyaneus*) and golden eagles (*Aquila chrysaetos*).

Table A1-2
Land Cover Classifications, Typical Vegetation Cover by Classification, and Distinct Characteristics of Land Cover Types Within the Temporary Reservoir

LAND COVER CLASSIFICATION	COVER IN FRE/TEMPORARY RESERVOIR (%)	TYPICAL VEGETATION	DISTINCT CHARACTERISTICS
Wetlands	1%	See Anchor QEA (Anchor QEA 2018)	Wetlands delineated by Anchor QEA (Anchor QEA 2018).
Open Water/Sand Bar	10%	Unvegetated	Mapped aquatic features
Terrestrial Bare Ground/Roads	4%	Unvegetated	Lack of vegetation over multiple growing seasons; often associated with wide logging roads and equipment staging areas.
Herbaceous/Grass	1%	Reed canarygrass (*Phalaris arundinacea*), colonial bentgrass (*Agrostis capillaris*), sword fern (*Polystichum munitum*), western lady fern (*Athyrium angustum*), piggyback plant (*Tolmiea menziesii*), creeping buttercup (*Ranunculus repens*)	Grasses and forbs present during growing season; often found adjacent to wetlands, riparian corridors, and recently disturbed areas.
Deciduous Riparian Shrubland	<1%	Various willows (*Salix* spp.), young red alder (*Alnus rubra*), red-osier dogwood (*Cornus alba*), vine maple (*Acer circinatum*), Indian plum (*Oemleria cerasiformis*), thimbleberry (*Rubus parviflorus*), salmonberry (*Rubus spectabilis*)	Dominated by deciduous shrub/saplings less than 6 meters (20 feet) tall (>75% cover).
Deciduous Riparian Forest with Some Conifers	17%	Red alder, Western red cedar (*Thuja plicata*), Western hemlock (*Tsuga heterophylla*), black cottonwood (Populus balsamifera), cascara (*Frangula purshiana*), willows, big leaf maple (*Acer macrophyllum*), red elderberry (*Sambucus racemosa*), snowberry (*Symphoricarpos albus*)	Dominated by deciduous tree species 6 meters (20 feet) tall or taller (>75% cover).
Mixed Coniferous/Deciduous Transitional Forest	29%	Douglas fir (*Pseudotsuga menziesii*), red alder, big leaf maple	Approximately equal distribution of deciduous and coniferous species (not clearly dominated by one or the other).
Coniferous Forest	28%	Douglas fir	Dominated by coniferous species (>75% cover).

Both Dunn's salamander and VanDyke's salamander are terrestrial salamanders that are candidates for state listing and were identified within Reach A during surveys conducted by WDFW each year from 2014 through 2017. Van Dyke's salamander was detected at lower frequency throughout the survey areas, but generally tended to favor higher elevation sites (above 1,500 feet). That contrasted with Dunn's salamander distribution which dropped off above 1500 feet.

5.1.2 Riparian Habitat

In developing the draft Vegetation Management Plan (Chehalis River Basin Flood Control Zone District [FCZD] 2021a), the Applicant mapped riparian vegetation within the temporary reservoir area as either deciduous riparian shrubland or deciduous riparian forest with some conifers. Other streamside vegetation is mapped as coniferous forest or mixed coniferous/deciduous transitional forest. The species composition of these plant communities is provided above in Table A1-2.

Current Forest Practices Rules are in place to protect riparian areas and promote the development of the riparian forest and processes for recruitment of LWM. Riparian protection provided by these rules are site specific, with some flexibility to allow harvest outside the core buffer zone of 50 feet, but generally consist of 50- to 200-foot wide buffers. While not all riparian tree stands are fully functioning, they are on a trajectory to mature and become a source of LWM in the future.

5.1.3 Sediment Transport

Soil units in Reach A include loose to very dense Holocene colluvium, loose to dense Holocene landslide deposits, and loose to very dense weathered bedrock, with a weak surface soil layer on top (Shannon and Wilson, Inc. 2019). Overall, Reach A is considered a transport reach, meaning that instream sediment is mobile and is transported downstream depending on intensity of flow events (CBS 2017). Large substrate (cobble) input originating in the headwaters and upper tributaries and is transported as far downstream as approximately RM 80, while gravel from the same source is transported as far downstream as RM 73.

Sediment sources include landslides, bank erosion, and inflow from tributaries during high flow events. The frequency of landslides has Increased since the beginning of timber harvest in the upper Chehalis Basin. A USGS desktop study of bedload and suspended load indicated that inputs from the upper watershed occurred mostly during catastrophic floods (CBS 2020).

5.1.4 Large Woody Material

In the upper Chehalis Basin, LWM is primarily recruited during extreme precipitation events which cause root failure, landslides, and debris torrents in upper portions of the watershed. The 2007 flood resulted in significant input of LWM to the basin because of landslides, hillslopes failure, and bank erosion (CBS 2017). Consistent with tree harvest and an increased frequency of landslides since the beginning of timber harvest in the upper Chehalis Basin, large wood recruitment into the channel has been reduced. Current Forest Practices Rules are in place to protect riparian areas and promote the development of the riparian forest and processes for recruitment of LWM. While not all riparian tree stands are fully functioning, they are on a trajectory to mature and become a source of LWM in the future. Wood load estimates for Reach A ranged from 2.8 to 17.9 m^3/100 meters (Watershed GeoDynamics and Anchor QEA 2017).

5.1.5 Aquatic Habitat

The upper Chehalis River supports salmon, steelhead, lamprey, and other native fishes. Summer stream temperatures in headwaters and the upper mainstem Chehalis River are cooler than downstream areas and support a cold-water fish assemblage dominated more by salmonids than cyprinids, catostomids, and other species. Non salmonids documented in Reach A by WDFW include largescale sucker, longnose dace, speckled dace, redside shiners, reticulate sculpin, torrent sculpin, and Pacific lamprey.

The mainstem Chehalis River and tributaries in Reach A are primarily single-channel streams constrained by the steep valley walls of the Willapa Hills mountain range (Hayslip and Herger 2001). The mainstem channel has limited potential for lateral channel migration (CBS 2017). The area is characterized by low permeability basal bedrock including Tertiary basalt and sedimentary rock. Therefore, this reach has little to no groundwater storage capacity (CBS 2017).

The gradient in Reach A is steeper than elsewhere in the Basin and the habitat in much of the reach is typically composed of pools and riffles (Winkowski et al. 2018a). The channel ranges in width from a bedrock-constrained 50-60 feet at the upper extent of the proposed temporary reservoir, to more unconfined channel 140-180 feet wide with meandering channel and gravel bars in the middle portion of the temporary reservoir, becoming constrained again by bedrock features to 50-80 feet in width near the proposed FRE facility. Gravel, cobble, and fine substrate characterize the sediment with some areas of bedrock (Winkowski et al. 2018a).

A recent assessment of lateral habitats throughout the Chehalis River basin (Beechie et al. 2021) showed them to be rare in Reach A. Based on a spatial analysis of the Beechie et al. data, the total area of lateral habitat was approximately 3.95 acres. Three habitat types were represented: 3.45 acres of backwater pools representing 1.5% of the area within the reach; 0.25 acres of side channel representing 0.6%; and a 1.48-acre pond representing less than 0.1% of the reach by area. No sloughs were evident in Reach A.

Intrinsic Potential (IP) models provide a means to identify the proportion of available stream miles that can provide habitat for various fish species or specific life stages. IP models rely on the assumption that the relative value of aquatic habitat to specific fish species is heavily influenced by the persistent geomorphic structure of a watershed. In the absence of comprehensive, detailed empirical data, IP analysis can offer useful comparisons of habitat suitability based on available datasets. IP is often used in restoration, conservation, or mitigation efforts to determine sites with high potential for ecological lift. IP values range from zero to one (0-1), with one (1) indicating that 100% of available habitat is suitable for the modeled species, and zero (0) indicating that none of the available habitat is suitable. Table A1-3 presents the IP estimated by WDFW for Reach A. Along with the IP analysis, Table A1-3 presents the documented miles of stream use by species reported under the Statewide Washington

Integrated Fish Distribution (SWIFD) program (WDFW 2018). Reach A includes a total of 11.48 miles of mainstem, and 46.3 miles of tributary with documented used by salmonids for rearing, spawning, or general presence (Table A1-3).

Table A1-3
Modeled Intrinsic Potential (IP) for Salmonid Habitat Suitability and Miles of Stream Used by Anadromous Fish in Mitigation Reach A. No Available Date Is Indicated by–-

		CHINOOK SALMON		COHO SALMON		STEELHEAD	
STREAM IDENTIFIER	TRIBUTARY TO	IP	SWIFD (MILES)	IP	SWIFD (MILES)	IP	SWIFD (MILES)
Mainstem Chehalis River Reach A		*0.61*	11.2	*0.66*	11.48	*0.75*	11.47
East Fork Chehalis River	Chehalis Reach A	*0.56*	3.7	*0.62*	8.91	*0.79*	8.91
George Creek	East Fork Chehalis River		--		1.97		2.63
Cinnabar Creek	East Fork Chehalis River	*0.15*	--	*0*	0.55	*0.16*	1.92
West Fork Chehalis River	Chehalis Reach A	*0.52*	4.3	*0.57*	4.58	*0.81*	4.29
Sage Creek	West Fork Chehalis River		--		0.82		0.08
Mack Creek	Chehalis Reach A		--		0.26		1.25
Thrash Creek	Chehalis Reach A	*0.37*	--	*0.44*	2.86	*0.97*	2.86
Thrash Creek	Chehalis Reach A		--		1.12		1.12
Roger Creek	Chehalis Reach A	*0.42*	--		1.19	*0.71*	1.19
Big Roger Creek	Roger Creek		--		1.2		1.1
Big Creek	Chehalis Reach A	*0.24*	--	*0.5*	1.94	*0.73*	3.31
Browns Creek	Chehalis Reach A		--		0.44		0.49
Hull Creek	Chehalis Reach A	*0.02*	--	*0.19*	0.25	*0.44*	0.24
Crim Creek	Chehalis Reach A		--	*0.39*	7.49	*0.83*	7.47
Lester Creek	Crim Creek		--		1.23		0.07

Source: Statewide Washington Integrated Fish Distribution (SWIFD) Portal, Updated 4/2018.

Fish passage is partially blocked for some resident fish to the uppermost reaches of the headwaters by Fisk Falls, a natural barrier between RM 113 and 113.6 at the confluence of the mainstem and Roger Creek. However, modification of the falls in 1970 improved fish passage for Chinook and coho salmon, steelhead, and resident trout compared to historical conditions (WDF 1975; WDFW 2019e). Based on the Chehalis Fish Passage Barrier Prioritization (WDFW 2022b), this fishway is considered 33% passable, affecting approximately 2.5 miles of coho salmon and cutthroat habitat and 2.4 miles of steelhead habitat upstream (Table A1-4). A blockage on the West Fork Chehalis River has developed more recently at RM 4.2 and the culvert at FR 1000 may create a partial barrier for coho salmon, steelhead, or resident trout (Ecology 2020a).

Table A1-4
Summary of Prioritized Fish Barriers Within Reach A, Linear Habitat Affected, and Species Present

BARRIER TYPE	VALUE	COHO SALMON	STEELHEAD	CUTTHROAT
Complete Barrier Count	0			
Partial Barrer Count	1	1	1	1
Potential Linear Habitat Affected (mi)	-	2.51	2.39	2.51

Source: WDFW 2022b.

Western toad is a candidate for state listing. Various life stages of western toad were documented by WDFW in Reach A including adults, juveniles, tadpoles, and egg masses during summer surveys in 2013-2017 from May-July, predominantly in portions of the mainstem upstream of the proposed inundation area. Breeding sites ranged from 5.9 -14.6 per RM from 2014 to 2016 within the reservoir footprint. No life stages were documented in lower reaches of Big Creek, Thrash, or Crim Creek (Hayes et al. 2018) that would be inundated during flood water retention at the FRE facility. Within the upper Chehalis River, western toad abundance and diversity of life history stages was greatest in Reach A relative to Reach B where predominantly tadpoles were observed and Reach C where egg masses and tadpoles were present in 2016 (Hayes et al. 2018).

Other amphibian species documented in Reach A include Pacific treefrog, northern red-legged frog, roughskin newt, giant salamanders, coastal tailed frog, and Columbia torrent salamander (Hayes et al. 2017). Pacific treefrogs tadpoles were observed in mainstem portions of Reach A within and upstream of the proposed temporary reservoir with distribution extending approximately one mile upstream of the mainstem Chehalis confluence with Thrash Creek (Hayes et al. 2018). Amphibian species documented within the temporary reservoir footprint during 2014 instream surveys include western red-backed salamander, northern red-legged frog, rough skin newt, coastal tailed frog, and Columbia torrent salamander (Hayes et al. 2018).

No mussel beds were observed within the vicinity of the proposed FRE facility or temporary reservoir during freshwater mussel surveys conducted by WDFW in 2020 (Douville et al. 2021).

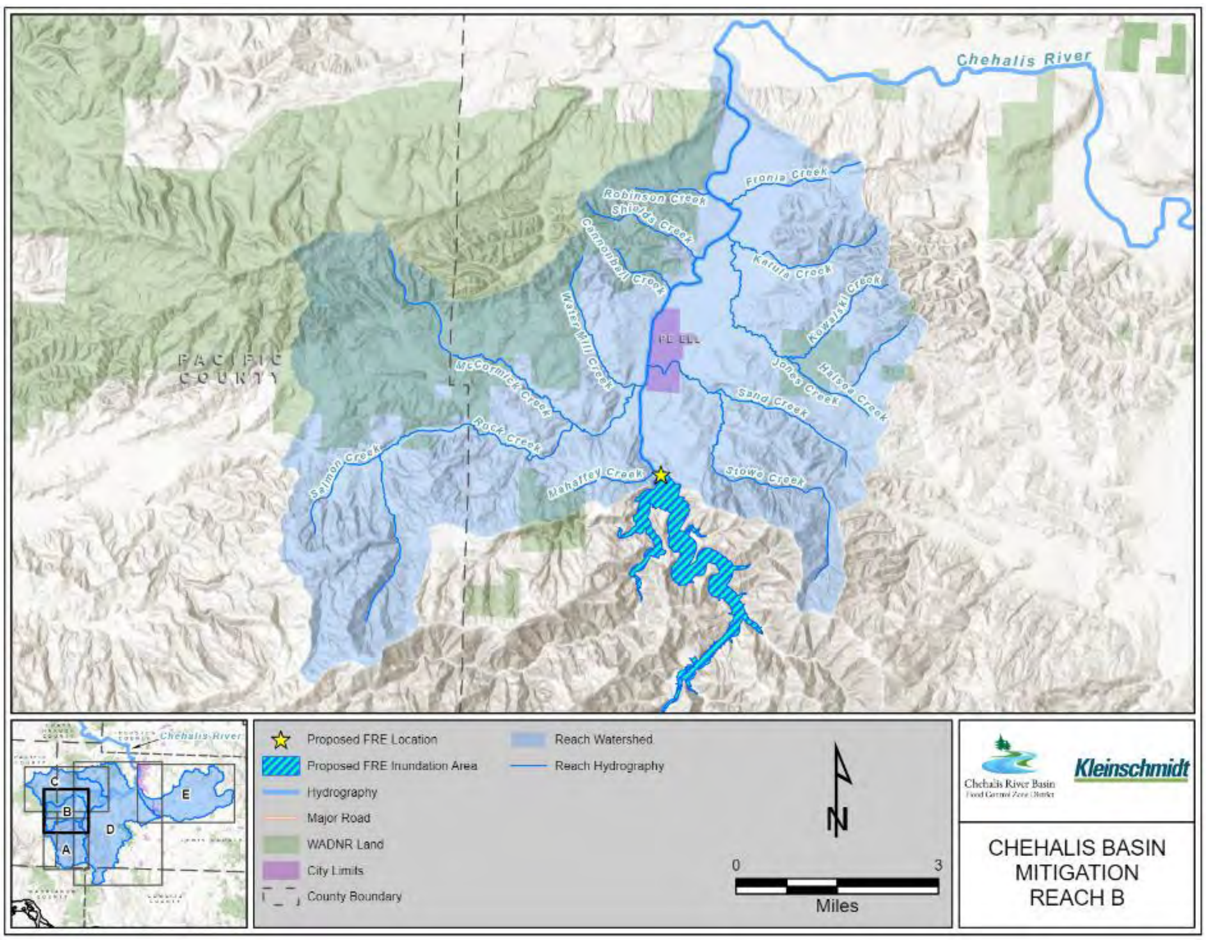
5.1.6 Water Quality

Reach A does not include any water quality impairments for temperature, dissolved oxygen, or other parameters. Reach A has a fairly intact riparian buffer of large coniferous trees which contributes to the slightly lower summer high temperatures observed by WDFW relative to other unshaded reaches of the mainstem Chehalis River. The tributaries in Reach A also provide cooler water input to the mainstem (Winkowski et al. 2018a). However, the headwaters of the Chehalis are relatively warmer than other headwater areas due to the relatively lower elevation. In August of survey years 2014 through 2016, maximum daily temperature recorded by multiple fixed-location temperature loggers exceeded 18^{o}C at all elevations within Reach A (Ecology 2001).

5.2 Reach B: Chehalis River from the FRE facility downstream to Elk Creek

Reach B extends from the FRE facility (RM 108.5) downstream to the Elk Creek confluence (RM 100.2) at approximately 290 ft MSL elevation. Reach B includes 8.7 miles of mainstem Chehalis River and 98.6 miles of inflowing perennial tributaries. Tributaries that inflow to Reach B include Rock, Stowe, Cannonball, Shields, Jones, Fronia, and Robinson creeks (Figure A1-14). Land use within the immediate floodplain is primarily irrigated agriculture, residential and rural development associated with the communities of Pe Ell and Doty. Land use in the tributary drainages is mostly managed upland forest.

Figure A1-14
Mitigation Reach B Extends from the Proposed FRE Facility (RM 108.5) Downstream to the Confluence with Elk Creek (RM 100.2) Downstream of Pe Ell, WA



5.2.1 Upland Habitat

Land use within the immediate floodplain is primarily irrigated agriculture, residential and rural development associated with the communities of Pe Ell and Doty. Land use in the tributary drainages is mostly managed upland forest. Land cover types identified along the mainstem of the Chehalis River of Reach B include wetland, open water, scrub-shrub, hay/pasture, barren, mixed forest, deciduous forest, evergreen forest, developed, and herbaceous (Ecology 2020a).

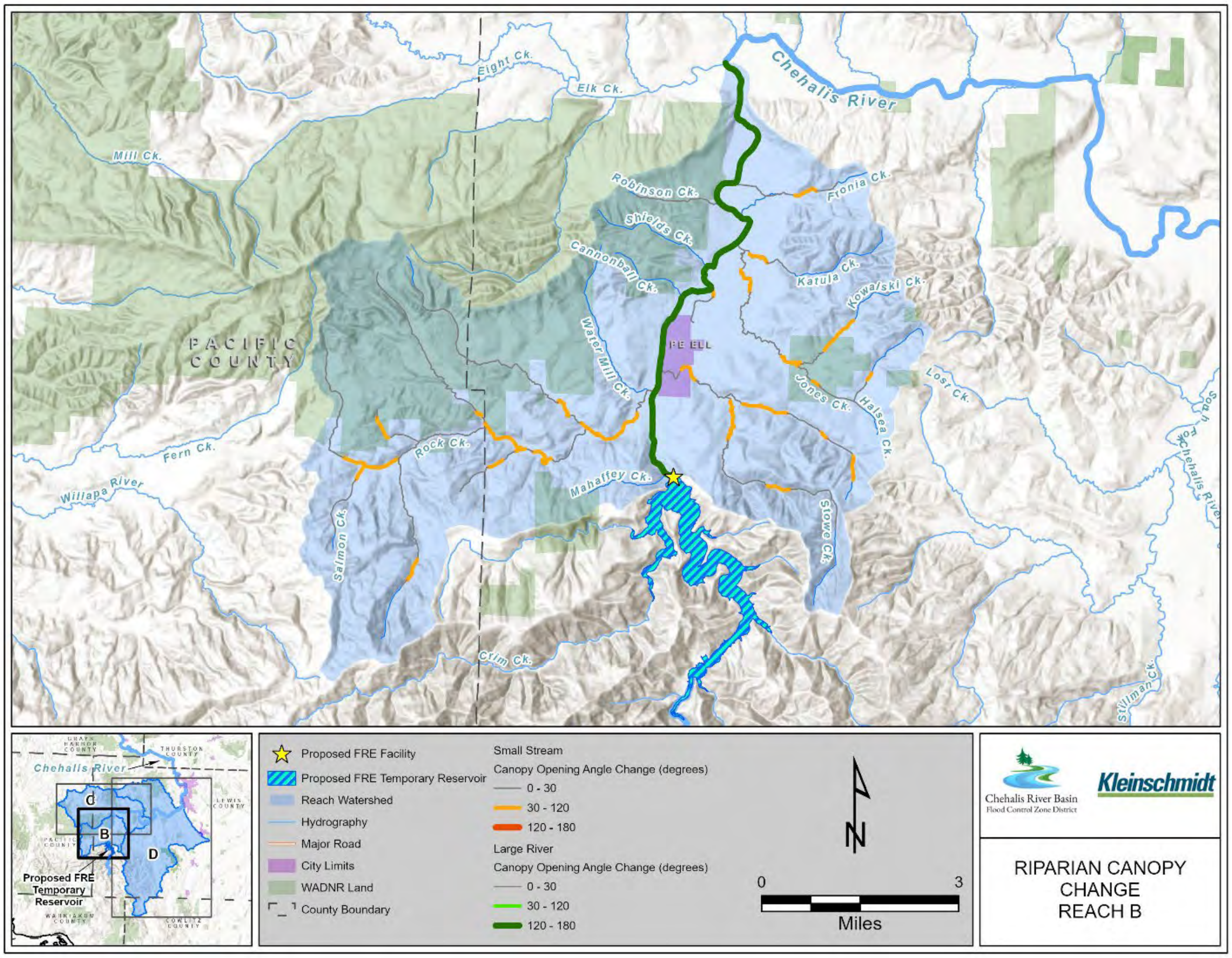
Priority mammal species documented in Reach B include Roosevelt elk and black-tailed deer, which are documented for all Mitigation Reaches. The Willapa Hills Roosevelt elk herd and black-tailed deer occur throughout the watershed. Habitat within Reach B (WDFW 2014a) is also part of the Willapa Hills BDMZ.

Several special status avian species are present or have supporting habitat within Reach B. Priority Habitats and Species mapping shows no records of marbled murrelet (PHS 2022). However, critical habitat for this ESA listed species is present in Reach B (USFWS 2022). Priority Habitats and Species mapping shows records of both golden eagle and northern spotted owl species or habitat occurrences within Reach B (PHS 2022), but the data does not indicate whether the northern spotted owl occurrences correspond to nesting territories. Similar to the upper Chehalis Reach A, the likelihood of resident, territorial northern spotted owls is low. Potential foraging and dispersal habitat for transient northern spotted owls is present in the Western Washington Lowlands province, including Reach B (Smith and Wenger 2001). The wild turkey is a designated priority species with regular concentrations of the species documented within Reach B.

5.2.2 Riparian Habitat

Based on available mapping and aerial imagery, much of the riparian area along the Chehalis River in Reach B has been impacted by agriculture. However, narrow bands of cottonwood/willow riparian habitat remain as mapped in a Cottonwood Habitat Study (Hough-Snee et al. 2019). Most of the mainstem Chehalis downstream of Pe Ell has a wide channel with shallow water depths, and little to no shade-providing riparian vegetation which exposes surface water to direct solar heating and results in elevated water temperatures. Based on the Applicant's review of the NOAA modeling data (Beechie et al. 2021), 14.17 miles of the 49.79 miles of Reach B mainstem and tributaries analyzed had changes in riparian canopy opening angles of 30 degrees or greater from historic conditions (Figure A1-15; FRE HMP Appendix A2).

Figure A1-15
Change in Riparian Canopy Opening Angle in Reach B from Historic to Current. (Seixas et al. 2018)



Priority amphibian species documented in Reach B include western toad and Dunn's salamander (PHS 2022). Other amphibian species documented in Reach B include western redbacked salamander, ensatina salamander, Columbia torrent salamander, northwestern salamander, giant salamander, roughskin newt, coastal tailed frog, red-legged frog, and Pacific treefrogs (Hayes et al. 2017). The 2014 instream and off-channel surveys of western toad by WDFW identified sparse distribution of tadpoles within Reach B. Pacific treefrogs were also documented in Reach B between Pe Ell and the confluence with Elk Creek (Hayes et al. 2018).

5.2.3 Sediment Transport

Sediment sources include landslides, bank erosion, and inflow from the upper watershed and tributaries during high flow events. Large substrate (cobble) and gravel input originate in the upper tributaries and are transported downstream into and through Reach B. A USGS desktop study of bedload and suspended load indicated that inputs from the upper watershed occurred mostly during catastrophic flooding events and that most transported sediment originating from within Reach B came from bank erosion and channel migration within Reach B (CBS 2020).

5.2.4 Large Woody Material

Wood load estimates for Reach B were 4.2 to 13.7 m^3/100 meters (Watershed GeoDynamics and Anchor QEA 2017). Large Woody Material is transported into Reach B from the headwaters during major flood events and any recruitment from within Reach B is from small-scale bank erosion more than major floods (Collins et al. 2002). Much of the riparian area in this reach lacks mature vegetation, decreasing the potential for LWM recruitment.

5.2.5 Aquatic Habitat

Channelization of the mainstem has degraded the habitat quality by the lack of braiding and channel complexity, few instream structures, log jams, and limited overhanging vegetation – all features that contribute to quality fish habitat for rearing, foraging, and finding refuge from thermal stress or predators. In addition to the single-channel, disconnected channel morphology and lack of mature riparian vegetation is also considered an impairment in this reach of the Chehalis River (WDFW 2020).

The mainstem Chehalis River in Reach B is a confined single channel comprised of pools and long riffle habitats. The average gradient of 0.21% (CBS 2017) is lower than that of Reach A. Pool density averaged 0.8 pools per 325 ft with higher concentration of pools in upstream reaches of the mainstem compared to downstream reaches within Reach B. The dominant channel type observed during surveys was pool-riffle (88.4%) with forced pool-riffle and bedrock areas present in upstream reaches (Winkowski et al. 2018a). Most of the mainstem Chehalis downstream of Pe Ell is wide with shallow water depths.

The dominant substrate has a coarseness ranking of 3.1 (SD 0.6) with an observed variation in coarseness from upstream near the FRE facility (coarser) to downstream (finer) reach segments (Winkowski et al. 2018a). Recent observations indicate the predominance of bedrock substrate in pools with gravels and cobbles in riffle areas.

Historic intentional straightening of the Chehalis River to improve agricultural opportunities and develop and protect residential settlements has resulted in incision and channelization. As a result, much of the channel has been unable to interact with or migrate across the floodplain since the 1940s (WDFW 2019a). A recent assessment of lateral habitats throughout the Chehalis River basin (Beechie et al. 2021) showed them to be rare in Reach B. Based on a spatial analysis of the Beechie et al. data, the area of lateral habitat totaled was approximately 10.8 acres. Two habitat types were represented, with 2.7 acres of backwater pools representing 1.3% by area and 3.3 ha pond representing less than 0.3% by area. No side channels or sloughs were evident in Reach B.

The upper Chehalis River Reach B supports salmon and steelhead, lamprey, and other native fishes. Intrinsic Potential (IP) for salmonid species in aquatic habitats in Reach B is presented in Table A1-5. Actual salmonid fish use in mainstem Reach B and inflowing tributaries reported under SWIFD includes a total of 8.7 miles of mainstem and 27.2 miles of tributary used by salmonids for rearing, spawning, or general presence (Table A1-5).

Table A1-5
Modeled Intrinsic Potential (IP) for Salmonid Habitat Suitability and Miles of Stream Used by Anadromous Fish in Mitigation Reach A. No Available Date Is Indicated by–-

		CHINOOK SALMON		COHO SALMON		STEELHEAD	
STREAM IDENTIFIER	TRIBUTARY TO	IP	SWIFD (MILES)	IP	SWIFD (MILES)	IP	SWIFD (MILES)
Mainstem Chehalis River Reach B		*0.68*	8.7	*0.87*	8.05	*0.57*	8.05
Rock Creek	Chehalis Reach B		--	*0.75*	6.99	*0.66*	--
Salmon Creek	Rock Creek		--		1.68		3.36
McCormick Creek	Rock Creek	*0.29*	--	*0.77*	2.08	*0.63*	2.25
Water Mill Creek	Rock Creek		--		0.6		0.6
Stowe Creek	Chehalis Reach B	*0.34*	--	*0.91*	3.87	*0.54*	7.08
Sand Creek	Stowe Creek		--	*0.96*	2.04	*0.52*	2.04
Cannonball Creek	Chehalis Reach B		--		0.18		--
Jones Creek	Chehalis Reach B	*0.17*	--	*0.93*	4.54	*0.5*	8.86
Halsea Creek	Jones Creek		--		0.18		0.04
Kowalski Creek	Jones Creek		--		1.01		2.6
Katula Creek	Jones Creek	*0.2*	--	*0.98*	1.7	*0.5*	1.88
Fronia Creek	Chehalis Reach B		--		2.29		2.1

Source: SWIFD Portal, Updated 4/2018.

Based on the Chehalis Fish Passage Barrier Prioritization, Reach B contains 32 culverts and other barriers to fish movement, 11 of which are complete barriers and 21 are partial barriers (33 to 67% passable). In total, approximately 18.3 miles of potential fish habitat for coho salmon and cutthroat trout and 14.9 miles of steelhead habitat exists upstream of these barriers located in Stowe, Jones, Rock, Salmon, and McCormick creeks as well as unnamed tributaries (Table A1-6) (WDFW 2022b).

Table A1-6
Summary of Fish Barrier Culverts Within Reach B and Potential Linear Habitat Affected Upstream

BARRIER TYPE	VALUE	COHO SALMON	STEELHEAD	CUTTHROAT TROUT
Complete Barrier Count	11	11	11	11
Partial Barrier Count	21	21	21	21
Unknown Barrier Status	0	0	0	0
Potential Linear Habitat Affected (mi)	-	18.32	14.93	18.32

Source: WDFW 2022b.

WDFW conducted mussel surveys within Reach B in 2020 that focused on the Chehalis River mainstem. Another survey was conducted in 2021 and included a survey near confluence of Elk Creek. A total of five mussel beds, each comprised of Western Pearlshell Mussels (*Margaritifera falcata*), were observed within the Chehalis River around River Mile 101, near the town of Doty (Douville et al. 2021). Three of the five beds had abundant mussels (over 100 live mussels observed). The two beds documented closest to the confluence of Elk Creek contained less than 20 live mussels (Douville et al. 2021).

5.2.6 Water Quality

Water quality is impaired primarily with respect to temperature for cool-water-associated species such as salmonids, but also due to low dissolved oxygen (DO) as a result of high water temperature and bacteria that affect all aquatic species. Summer temperatures frequently exceed the preferred temperature range criteria of 13°C for salmon and steelhead spawning and incubation from September through July 1 (Ecology 2020a). In August of survey years 2014 through 2016, maximum daily and mean daily temperature recorded by multiple fixed-location temperature loggers exceeded 18°C (Ecology 2020a). Based on WDFW thermal monitoring, summer temperatures in the upper Chehalis River including Mitigation Reaches A-C ranged from 16.9 – 21.4°C, with the proportion of time water temperatures were over 18°C estimated at 60% (+/- 20%) (Winkowski et al. 2018a). Warm summer stream temperatures are assumed to limit the rearing potential, habitat use, and spatial distribution of aquatic species, especially Pacific salmon (Winkowski et al. 2018a).

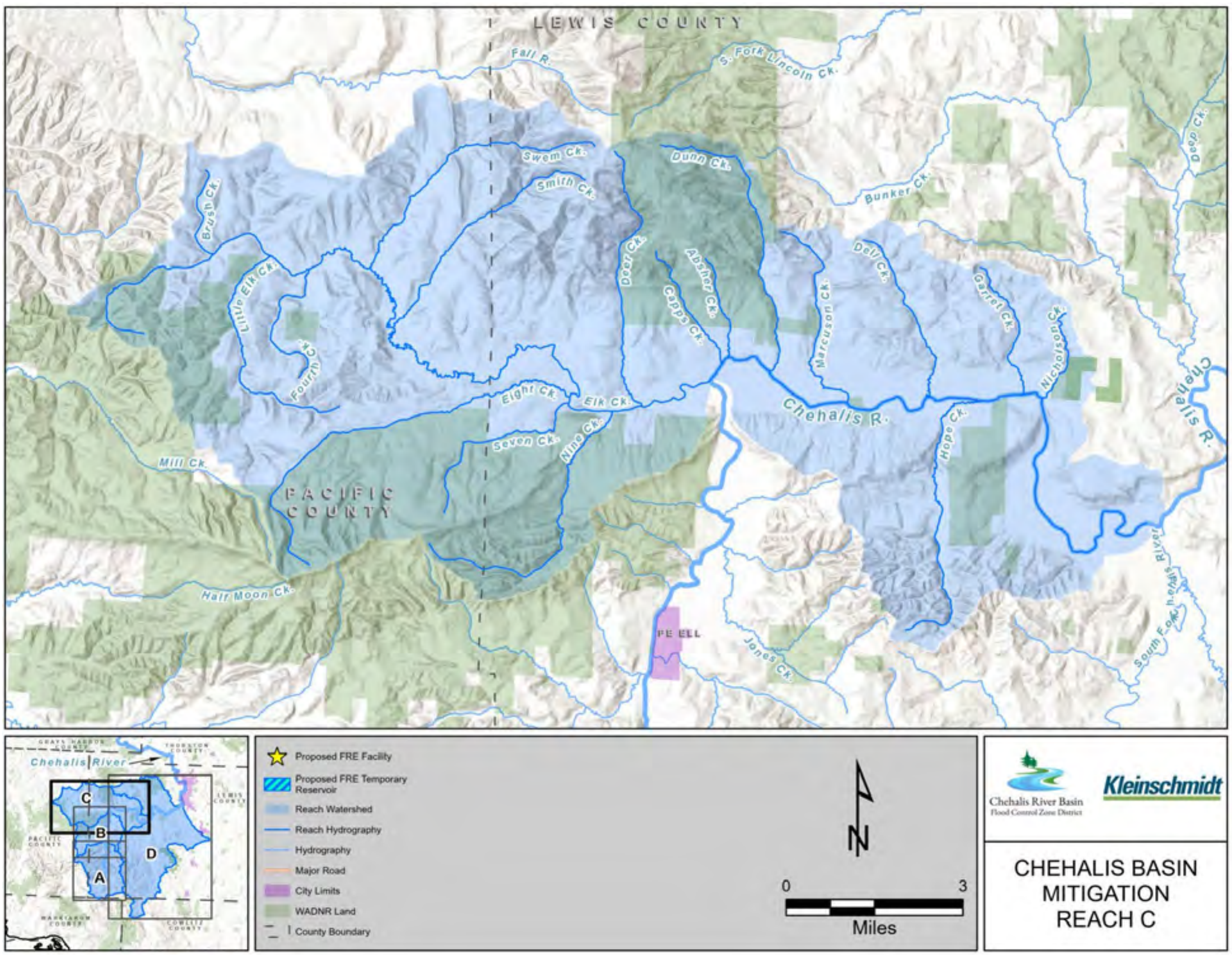
Monthly sampling by Ecology in 2016, 2017, and 2018 identified DO levels in samples from the Chehalis River upstream of Pe Ell to be less than or below the 9.5 milligrams per liter (mg/L) criteria on August 31, 2016 (8.9 mg/L), and August 15, 2018 (8.9 mg/L). Monitoring data collected by Anchor QEA showed DO less than 9.5 mg/L downstream of Pe Ell in August and September 2013 and in July 2014 (Anchor QEA 2014).

TMDLs have been developed for the Upper Chehalis Basin, including this area, for temperature, DO, and fecal coliform bacteria. The Chehalis River and Stowe Creek are waters of concern for pH where there have been exceedances of the 6.5-8.5 pH criteria for core summer salmonid habitat, but not enough excursions to consider the waterbodies impaired (Ecology 2016).

5.3 Reach C: Chehalis River from Elk Creek to the South Fork Chehalis River

Mitigation Reach C includes the mainstem Chehalis River from Elk Creek (RM 100.2) at elevation of approximately 290 feet MSL downstream to its confluence with the South Fork Chehalis River (RM 88.1) at elevation of approximately 200 feet MSL. Reach C consists of 12.6 miles of the mainstem Chehalis River and 223.2 miles of perennial tributaries with a total catchment size of 100.5 square miles (Figure A1-16). Inflowing tributaries to Reach C include Elk, Capps, Absher, Dunn, Marcuson, Dell, Hope, Garret and Nicholson creeks. Land use within the immediate floodplain of Reach C is primarily irrigated agriculture, residential and rural development of Doty and Dryad. Land use in the drainages of inflowing tributaries is mostly managed upland forest, though the larger Elk Creek tributary mainstem is similar to the mainstem Chehalis.

Figure A1-16
Mitigation Reach C Including Mainstem Chehalis River from the Elk Creek Confluence Downstream to the South Fork Chehalis River



5.3.1 Upland Habitat

Land cover types identified along the mainstem of the Chehalis River within Reach C include wetland, open water, scrub-shrub, cultivated crops, hay/pasture, barren, mixed forest, deciduous forest, evergreen forest, developed, and herbaceous (Ecology 2020a). Open areas downstream of Rainbow Falls that are near developed areas are mostly vegetated with mowed non-native grasses, Canada thistle (*Cirsium arvense*), prickly lettuce (*Lactuca serriola*), teasel (*Dipsacus fullonum*), white clover (*Trifolium repens*), field horsetail (*Equisetum arvense*), and Himalayan blackberry (*Rubus armeniacus*).

Priority mammal species documented in Reach C include Roosevelt elk and black-tailed deer, which are documented in all Mitigation Reaches.

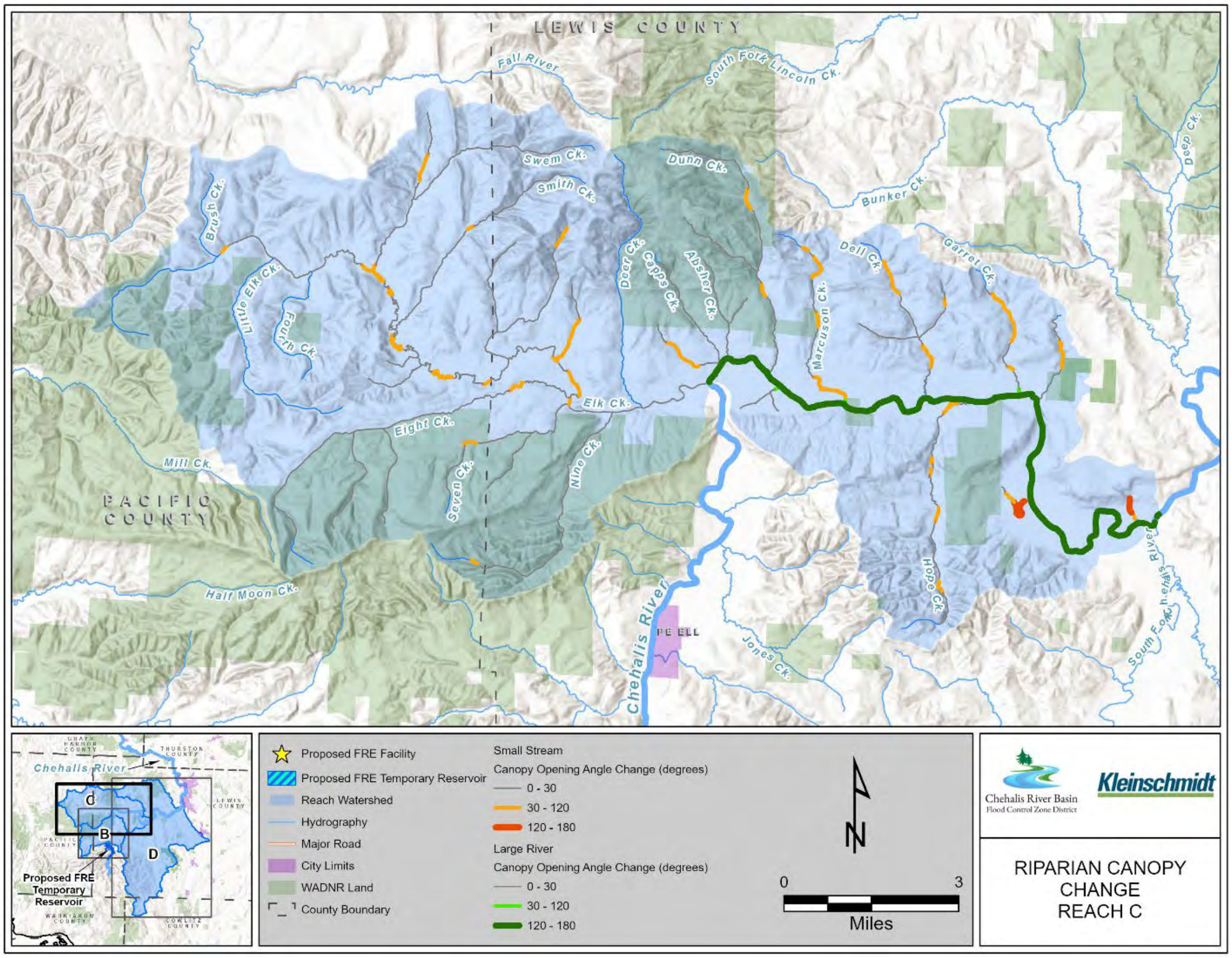
Similar to the Upper Chehalis mitigation reaches, several special status avian species are present or have supporting habitat within Reach C. Priority Habitats and Species mapping shows records of both golden eagle and northern spotted owl species or habitat occurrences within Reach C (PHS 2022), but the data does not indicate whether the northern spotted owl occurrences correspond to nesting territories. The likelihood of resident, territorial northern spotted owls is low. Potential foraging and dispersal habitat for transient northern spotted owls is present in the Western Washington Lowlands province, including Reach C (Smith and Wenger 2001). Regular concentrations of wild turkeys have been documented within Reach C. Cavity-nesting ducks are designed as priority species and breeding areas for cavity-nesting ducks are documented within Reach C (PHS 2022).

Priority amphibian species documented in Reach C include Dunn's salamander (PHS 2020). Other amphibians documented in small numbers in mainstem Chehalis Mitigation Reach C include northern red-legged frog, roughskin newt, and Pacific treefrogs. American bullfrogs were more common in mainstem reaches. Surveys in tributaries and off-channel habitat documented rare occurrences of northern red-legged frogs, roughskin newts and American bullfrogs (Hayes et al. 2018).

5.3.2 Riparian Habitat

Based on available mapping and aerial imagery, large areas of riparian habitat have been impacted by agriculture. Patches and narrow strips of cottonwood/willow habitat exist along the mainstem Chehalis River in Reach C (Hough-Snee et al. 2019). Based on the Applicant's review of the NOAA modeling data (Beechie et al. 2021), 19.4 miles of the 101.98 miles of mainstem Chehalis and tributaries in Reach C had changes in riparian canopy opening angles of 30 degrees or greater from historic conditions (Figure A1-17; FRE HMP Appendix A-2).

Figure A1-17
Change in Riparian Canopy Opening Angle in Reach C from Historic to Current. (Seixas et al. 2018)



5.3.3 Sediment Transport

Substrate in this section of the mainstem Chehalis is mostly silty fine sand, gravelly sand, and sandy gravel (Hayslip and Herger 2001). This type of sediment is recruited from the low-elevation alluvial valley that shapes this portion of the river along with the rain-driven hydrology. Sediment mobility in this reach is low, making it an area of sediment deposition (CBS 2017). Cobble and gravel found within this reach has been transported down to Reach C from the headwaters during extreme flood events.

5.3.4 Large Woody Material

Large Woody Material recruitment in Reach C typically comes from small-scale bank erosion more than major floods. LWM has been transported into Reach C from landslides in the headwaters caused by catastrophic floods, such as occurred in 2007. However, much of the wood from that event was subsequently removed from the area. Riparian vegetation varies from rare to dense along Reach C, reducing LWM recruitment. Wood loading was estimated at 2.8 and 11 m^3/100 meters (Watershed GeoDynamics and Anchor QEA 2017).

5.3.5 Aquatic Habitat

In Reach C, the Chehalis River is low gradient (0.08% average), slow moving, and unconfined. Historically, channel migration due to frequent flooding resulted in aquatic habitat with an extensive off-channel network characterized by oxbows, sloughs, beaver ponds, and side channels with diversity in water velocity, substrate, and cover. However, human uses have included intentional straightening of the channel and filling in depressional wetlands to improve agricultural opportunities and develop and protect residential settlements, resulting in incision and channelization. Much of the channel within Reach C has been unable to interact with or migrate across the floodplain since the 1940s (WDFW 2019a).

The historic floodplain habitat has been significantly reduced across the entire Chehalis Basin; it is estimated that approximately 80% of off-channel floodplain rearing habitat for coho salmon has been lost compared to historic conditions recorded at the turn of the 20th century (CBS 2017). Most of the mainstem Chehalis within Reach C has a wide channel with shallow water depths and a high amount of fine sediments. Remnants of several meanders still exist in the mainstem. Some reaches and tributary confluence areas (where the channel conditions permit) are also connected to nearby floodplain areas that experience seasonal flooding in the winter through spring to create emergent wetlands. These ephemeral habitats gradually warm in temperature as spring and summer progress, contracting or becoming completely desiccated by late summer. This ephemeral habitat in the floodplain has been identified as important overwintering habitat for fish (Henning et al. 2007).

A recent assessment of lateral habitats throughout the Chehalis River basin (Beechie et al. 2021) showed them to be rare in Reach C. Based on a spatial analysis of the Beechie et al. data, the total area of lateral habitat calculated less was approximately 59.1 acres. Three habitat types were represented, with 4.9 acres of backwater pools representing 2.3% of the area within the reach, 0.25 acres side channel representing 0.4% and 53.9 acres pond representing 1.7% by area. No sloughs were evident in Reach C.

The upper Chehalis River Reach C supports salmon and steelhead, lamprey, and other native fishes. The fish community found in Reach C reflects the physical conditions of the mainstem river. Warm summer stream temperatures are assumed to limit the rearing potential, habitat use, and spatial distribution of aquatic species, especially Pacific salmon (Winkowski et al. 2018a). The river becomes dominated downstream by native cyprinid species and non-native species (e.g., sunfishes, basses) that have a higher tolerance for warm water temperatures and fine sediments compared to cold-water species such as salmonids (Winkowski et al. 2018a). Exotic species make up half of the vertebrate species in extensive surveys of floodplain off-channel habitats and commonly include species that prefer slow-moving water (e.g., basses, bullhead catfish, yellow perch, and common carp). The mainstem is used by juvenile salmonids for rearing during all stages of development and as a migration corridor for adult salmon accessing spawning habitat in the upper reaches or tributaries.

Intrinsic Potential (IP) for salmonid species in aquatic habitats in Reach C is presented in Table A1-7. Actual salmonid fish use in mainstem Reach C and inflowing tributaries reported under SWIFD includes a total l of 14.6 miles of mainstem and 51.84 miles of tributary used by salmonids for rearing, spawning, or general presence (Table A1-7).

Table A1-7

Modeled Intrinsic Potential (IP) for Salmonid Habitat Suitability and Miles of Stream Used by Anadromous Fish in Mitigation Reach A. No Available Date Is Indicated by–-

		CHINOOK SALMON		COHO SALMON		STEELHEAD	
STREAM IDENTIFIER	TRIBUTARY TO	IP	SWIFD (MILES)	IP	SWIFD (MILES)	IP	SWIFD (MILES)
Mainstem Chehalis River Reach C		0.73	14.6	0.87	13	0.57	13
Elk Creek	Chehalis Reach C		1.7	0.78	13.41	0.64	15.22
Swem Creek	Elk Creek		--		2.08		2.84
Smith Creek	Elk Creek		--		1.84		2.3
Eight Creek	Elk Creek	0.65	--		4.45		2.45
Seven Creek	Elk Creek		--		1.06		2.13
Nine Creek	Elk Creek	0.31	--	1	1.25	0.47	3.23
Capps Creek	Chehalis Reach C	0.17	--	0.68	0.75	0.57	0.95
Absher Creek	Chehalis Reach C	0.09	--	0.19	0.76	0.44	--
Dunn Creek	Chehalis Reach C	0.28	--	0.66	3.45	0.62	3.3
Marcuson Creek	Chehalis Reach C		--		0.09		6.32
Dell Creek	Chehalis Reach C	0.34	--	0.91	2.24	0.58	2.46
Hope Creek	Chehalis Reach C		--		4.9		4.91
Garret Creek	Chehalis Reach C	0.27	--	0.89	0.67	0.59	3
Nicholson Creek	Chehalis Reach C		--		1.89		2.19

Source: Statewide Washington Integrated Fish Distribution (SWIFD) Portal, Updated 4/2018.

Rainbow Falls is a bedrock cascade on the mainstem located at RM 97, approximately 3.2 RM downstream of the Elk Creek confluence that does not represent a passage barrier to anadromous salmonids or lamprey. Whether it may exclude fish such as centrarchids from accessing upstream habitat is unknown. Based on the Chehalis Fish Passage Barrier Prioritization of the Reach C tributaries, there are 44 culverts and other barriers to fish movement present, 17 of which are complete barriers and 27 are partial barriers (33 to 67% passable). In total, approximately 27.9 miles of potential habitat for coho salmon and cutthroat trout and 24.7 miles of steelhead habitat, exists in tributaries upstream of these barriers located in Absher, Miller, Davis, Nicolson, Marcuson, Garret, and Dell creeks as well as unnamed tributaries (Table A1-8) (WDFW 2022b). One culvert located on Nicholson Creek has been associated with Chinook salmon habitat.

Table A1-8
Summary of Prioritized Fish Barriers Within Reach C, Linear Habitat Affected, and Species Present

BARRIER TYPE	VALUE	CHINOOK SALMON	COHO SALMON	STEELHEAD	CUTTHROAT TROUT
Complete Barrier Count	17	17	17	17	17
Partial Barrier Count	27	27	27	27	27
Unknown Barrier Status	0		0	0	0
Potential Linear Habitat Gain (mi)	-	unknown	27.91	24.69	27.91

Source: WDFW 2022b.

Priority amphibian species documented in Reach C include the western toad (PHS 2020). Western toad spawning areas were identified in Reach C at the confluence of the mainstem Chehalis River and South Fork Chehalis by the presence of egg masses observed during 2016 instream surveys by WDFW. Toadlets were also observed in the South Fork Chehalis immediately upstream of the confluence with the mainstem (Hayes et al. 2018).

The Chehalis River within Reach C were surveyed for mussels by the WDFW in 2020 and 2021. Five mussel beds were observed near Doty in 2020. An additional 5 beds were observed downstream of Doty in 2021. All mussel beds were comprised of western pearlshell ranging from less than 20 to around 100 mussels per bed (Douville et al. 2021). Five mussel beds were observed in the Chehalis River upstream of the confluence of the South Fork Chehalis River. One mussel bed was of floater mussels (*Anodonta* spp.) and four beds contained western pearlshell (Douville et al. 2021).

5.3.6 Water Quality

Precipitation in this portion of the Basin ranges from 50-75 inches per year (Weatherbase 2021). During summer low-flow periods, the Chehalis River is recharged by groundwater from aquifers. Reach C is connected to the upper basin aquifer composed of alluvial and glaciofluvial deposits of Vashon age (CBS 2017). Summer months of low rainfall or drought result in periods of low instream flow, fragmentation of aquatic habitat, and impairment to water quality parameters including temperature and dissolved oxygen.

Water quality issues in this portion of the Chehalis River are compounded by water rights concerns. Low base flows below Washington State's requirements for minimum instream flow have resulted in curtailment of junior water rights, cessation of recreational fishing, and further concern related to instream temperature which is considered impaired throughout this reach. The presence of little to no shade-providing riparian vegetation exposes surface water to direct solar heating resulting in elevated water temperatures. Summer temperatures frequently exceed the preferred WAC 173-201A temperature range criteria for salmon and steelhead (Ecology 2020a).

DO monitoring by Ecology from 2004 through 2009 documented DO exceedances that fell below the criteria of 9.5 mg/L at Ecology's Dryad station at RM 98, near Rainbow Falls (Ecology 2016). Between 2010 and 2016, the lowest monthly DO sampling result from Dryad was 8.5 mg/L (Ecology 2016).

A fecal coliform bacteria total maximum daily load (TMDL) for the Chehalis River in WRIA 23 was completed in 2004 based on standard exceedances, and instream levels have generally been decreasing over time after implementing and improving best management practices (BMPs) for non-point-source pollutants and replacing failing on-site sewage treatment systems. Monitoring data from Ecology's long-term monitoring station at Dryad show only one monthly sample exceedance of the fecal coliform standard since 2004.

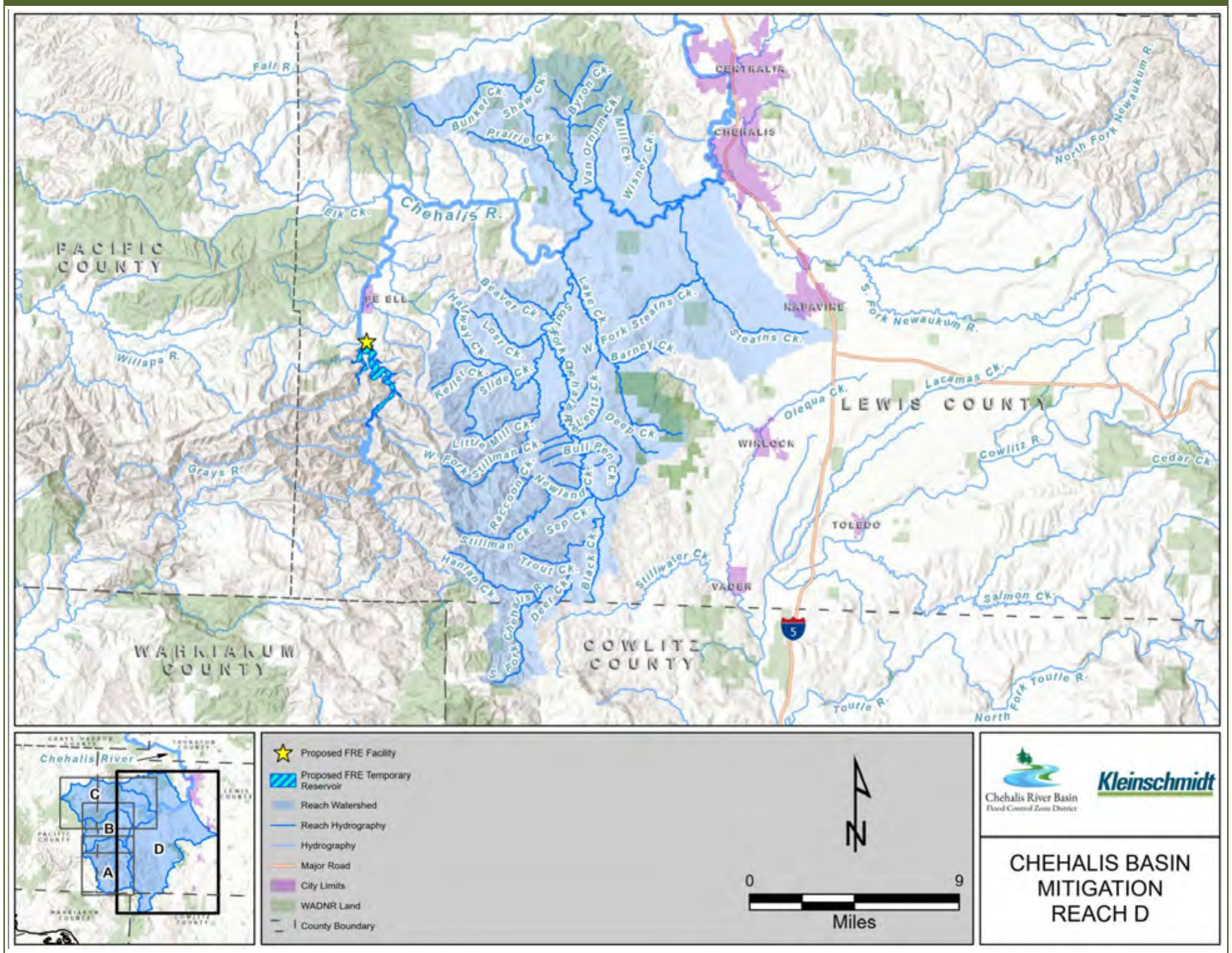
5.4 Reach D: Chehalis River from the South Fork Chehalis River to the Newaukum River Confluence

Reach D includes 13.5 miles of mainstem Chehalis River from the South Fork Chehalis River confluence (RM 88.1) at 201 feet in elevation downstream to the to Newaukum River (RM 75.2) at an elevation of 159 feet. The only major tributary included in this reach is the South Fork Chehalis River (33.4 stream miles) which ranges in elevation from over 1500' in the headwaters to 219' at the confluence with the mainstem at RM 88.1. Other tributaries include Bunker (15.0 stream miles), Van Ornum, Stearns, and Mill creeks as well as various smaller inflowing tributaries which (including the South Fork Chehalis River), containing over 517 miles of stream. The total catchment area of Reach D is 215.8 square miles (Figure A1-18).

Reach D receives significant inflow from the South Fork Chehalis which enters the mainstem at RM 88.1 and includes major salmonid-producing tributaries including Lake and Stillman Creek, and smaller salmon-supporting tributaries including Lentz, Beaver, Hanlan, Black, and Cedar Creeks (Phinney and Bucknell 1975). The South Fork Chehalis River has a drainage area of 48 square miles with headwaters in the Willapa Hills and continues for 27 miles prior to joining the Chehalis River at RM 88.1. The South Fork Chehalis River has one active USGS gage (No 12020800 near Wildwood) that has collected seasonal flow data since 1999. A second Ecology gage (No 23K060) at RM 0.1 installed in 2015 collects both stream flow data and water quality parameters including temperature, DO, pH, and conductivity (CBS 2017). receives inflow from several small to medium sized streams that provide valuable habitat and potential habitat for coho salmon including Stearns, Mill, Bunker, and Van Ornum creeks. Precipitation patterns are consistent with Reach B and C.

Land use within the immediate floodplain of Reach D is primarily irrigated agriculture, residential and rural development outside of Chehalis and Centralia. Land use in the valley portions of the South Fork Chehalis is similar to the mainstem while the upper portions of the watershed are higher gradient and predominantly managed forest land. Land use in the Bunker Creek sub-basin is entirely within farmland and rural development, the Stearns Creek sub-basin includes both farmland and small amounts of managed forestlands. Tributary sub-basins inflowing into Reach D have high road density, average 4.9 roads/ mi^2, and an associated high level of bank erosion and sedimentation (Ecology 2020a).

Figure A1-18
Mitigation Reach D Including Mainstem Chehalis River from the Confluence with the South Fork Chehalis River Downstream to the Newaukum River



The mainstem Chehalis River in Reach D has a mixture of confined, moderately confined, and unconfined areas of active channel migration and an average gradient of 0.12%. Like Reach C, historic channel straightening has resulted in incision and channelization. Further, increased sediment loads from the South Fork Chehalis combined with lack of LWM contribute to channel erosion and incision in this reach (Smith and Wenger 2001). As a result, much of the channel has been unable to interact with or migrate across the floodplain since the 1940s (WDFW 2019b).

5.4.1 Upland Habitat

Land cover types identified along the mainstem of the Chehalis River within Reach D include wetland, open water, scrub-shrub, cultivated crops, hay/pasture, barren, mixed forest, deciduous forest, evergreen forest, developed, and herbaceous (Ecology 2020a). Land use within the immediate floodplain of Reach D is primarily irrigated agriculture, residential and rural development outside of Chehalis and Centralia. Land use in the valley portions of the South Fork Chehalis is similar to the mainstem while the upper portions of the watershed are higher gradient and predominantly managed forest land. Land use in the Bunker Creek sub-basin is entirely within farmland and rural development, while the Stearns Creek sub-basin includes both farmland and small amounts of managed forestlands. Tributary sub-basins inflowing into Reach D have high road density, average 4.9 roads/ sq. mile and an associated high level of bank erosion and sedimentation (Wampler et al. 1993).

Big brown bat is a priority species that is documented within Reach D (PHS 2022). The current online data is not specific but based on an earlier Priority Habitats and Species data search, it appears as though a breeding area was documented in 2018 (PHS 2022).

Northern spotted owl is a state and federally listed species. Priority Habitats and Species mapping shows records of northern spotted owl species or habitat occurrences within Reach D (PHS 2022). The data does not show whether the occurrences correspond to northern spotted owl nesting territories. The likelihood of resident, territorial northern spotted owls is low throughout the region. Potential foraging and dispersal habitat for transient northern spotted owls is present in the Western Washington Lowlands province, including Reach D (Smith and Wenger 2001).

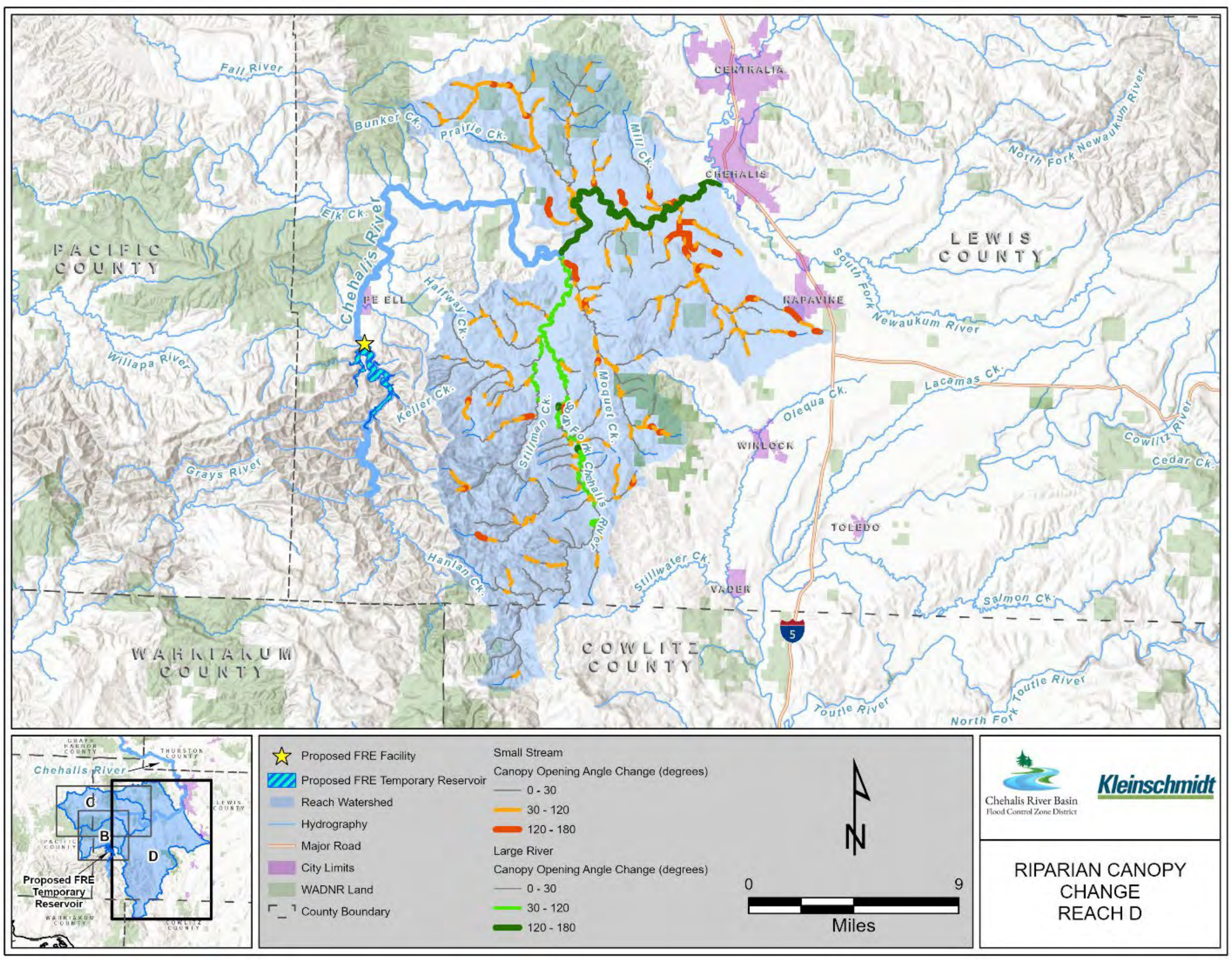
Golden eagle is a candidate for state listing and is protected by the Bald and Golden Eagle Protection Act. Priority Habitats and Species mapping shows records of golden eagle species or habitat occurrences within Reach D (PHS 2022).Trumpeter swan is designated as a priority species. Priority Habitats and Species mapping shows records of two winter foraging sites for the species. The numbers of swans that visit the sites are variable at times (PHS 2022). Wild turkey is designated as a priority species. Regular concentrations of the species are documented within Reach D (PHS 2022). Cavity-nesting ducks are designed as priority species. Breeding areas for cavity-nesting ducks are documented within Reach D (PHS 2022). Waterfowl concentrations are listed under the Priority Habitats and Species Program. Priority Habitats and Species mapping shows records of two sites with large concentrations of wintering waterfowl within Reach D. High numbers of pintail (*Anas acuta*), wigeon (*Mareca* sp.), and green-winged teal (*Anas carolinensis*) were noted at one site (PHS 2022).

Priority amphibian species documented in Reach D include Dunn’s salamander (PHS 2022). Other amphibians documented in mainstem reaches downstream of the FRE facility including Reach D were small numbers (4-31 individuals) of northern red-legged frog, roughskin newt, and pacific treefrogs. American bullfrogs were more common in mainstem reaches (100 individuals). Surveys in tributaries and off-channel habitat documented rare occurrences of northern red-legged frogs, roughskin newts and American bullfrogs (Hayes et al. 2018).

5.4.2 Riparian Habitat

Lack of mature riparian vegetation is considered an impairment in this reach of the Chehalis River (WDFW 2020). Large areas of riparian habitat have been impacted by agriculture. Patches and narrow strips of cottonwood/willow habitat exist along the mainstem Chehalis River in Reach D (Hough-Snee et al. 2019). The lack of shade-providing riparian vegetation exposes surface water to direct solar heating resulting in elevated water temperatures. Based on the Applicant's review of the NOAA modeling data (Beechie et al. 2021), 112.1 miles of the 258.07 miles of the mainstem Chehalis and tributaries analyzed in Reach D had changes in riparian canopy opening angles of 30 degrees or greater from historic conditions (Figure A1-19; FRE HMP Appendix A2).

Figure A1-19
Change in Riparian Canopy Opening Angle in Reach D from Historic to Current. (Seixas et al. 2018)



5.4.3 Sediment Transport

The mainstem Chehalis River in Reach D has a mixture of confined, moderately confined, and unconfined areas of active channel migration. and an average gradient of 0.12%. Historic intentional straightening of the channel in this portion of the Chehalis River has resulted in incision and channelization. Further, increased sediment loads from the South Fork Chehalis combined with lack of LWM contribute to channel erosion and incision in this reach (Smith and Wenger 2001). As a result, much of the channel has been unable to interact with or migrate across the floodplain since the 1940s (WDFW 2019b). This channelization creates habitat impairment in the lack of braiding and channel complexity, deep pool, log jams, and over hanging vegetation - all features that contribute to fish habitat quality for rearing, foraging, and finding refuge from thermal stress or predators. In addition to the single-channel, disconnected channel morphology, lack of mature riparian vegetation is also considered an impairment in this reach of the Chehalis River (WDFW 2020).

Substrate in the mainstem Chehalis is mostly silty fine sand, gravelly sand, and sandy gravel (Hayslip and Herger 2001). This type of sediment is recruited from the low-elevation alluvial valley that shapes this portion of the river along with the rain-driven hydrology. Bank erosion is common along the mainstem in this reach, exacerbated by loss of riparian vegetation due to agriculture and urbanization, and conversion of conifer to hardwoods (Smith and Wenger 2001).

Excess sediment delivery from Bunker Creek sub-basin is associated with a high density of roads (>3 mi/square mi. coupled with moderate to steep slopes. High sedimentation and low standing volume of LWM results in high sediment transport rates, increased scour, channel incision, decreased width to depth ratios, and reduced habitat complexity. Sediment input from the South Fork Chehalis also contributes to this reach. For example, heavy winter storms in 2007 resulted in numerous landslides and other channel forming events within the Basin which resulted in input of an estimated 5.7 – 8.7 million tons of sediment into the Chehalis basin-wide with over 934,000 tons delivered into the South Fork Chehalis Watershed (Sarikhan et al. 2008).

5.4.4 Large Woody Material

Large Woody Material recruitment within Reach D comes from small-scale bank erosion more than major floods. Lack of mature riparian vegetation is considered an impairment in this reach of the Chehalis River (WDFW 2020) which limits local LWM recruitment. In-river occurrence of LWM in this reach is also limited. Wood loading was estimated as 10 m^3/100 m within the confluence of the South Fork Chehalis River (Watershed GeoDynamics and Anchor QEA 2014).

5.4.5 Aquatic Habitat

The mainstem Chehalis River in Reach D has an incised channel and aquatic habitat degradation is extensive throughout South Fork Chehalis and Bunker Creek sub-basins as well. The lack of channel and habitat complexity as well as little in-channel habitat contribute to reduced quality of this reach for fish rearing and foraging. Lack of mature riparian vegetation is also considered an impairment in this reach of the Chehalis River (WDFW 2020). Most of the mainstem Chehalis in this area has a wide channel and with little to no shade-providing riparian vegetation direct solar heating resulting in elevated water temperatures.

A recent assessment of lateral habitats throughout the Chehalis River basin (Beechie et al. 2021) showed them to be uncommon in Reach D. Based on a spatial analysis of the Beechie et al. data, the total area of lateral habitat calculated less was approximately 103.3 acres. Four habitat types were represented, with 12.6 acres of backwater pools representing 5.7% of the area within the reach, 4.2 acres of side channel representing 7.4% by area, 0.24 acres of slough representing 0.2% area, and 86.2 acres of pond representing 2.7% by area.

The South Fork Chehalis River has a low gradient from its confluence with the mainstem Chehalis River upstream to the Black Creek confluence (South Fork RM 16.8); above Black Creek the gradient increases and the average stream width narrows to 15 - 40 ft (Phinney and Bucknell 1975). Black Creek itself is low gradient, but most South Fork tributaries are steep, providing limited available habitat for salmonids.

The fish community found in Reach D reflects the physical habitat conditions of the mainstem river. The river is dominated downstream by native cyprinid species and non-native species (e.g., sunfishes, basses) that have a higher tolerance for warm water temperatures and fine sediments compared to cold-water species such as salmonids (Winkowski et al. 2018a). Exotic species make up half of the vertebrate species in extensive surveys of floodplain off-channel habitats and commonly include species that prefer slow-moving water (e.g., basses, bullhead catfish, yellow perch and common carp). The mainstem is used by juvenile salmonids for rearing during all stages of development and as a migration corridor for adult salmon accessing spawning habitat in the upper reaches or tributaries.

The upper Chehalis River Reach D supports salmon and steelhead, lamprey, and other native fishes. Intrinsic Potential (IP) for salmonid species in aquatic habitats in Reach D is presented in Table A1-9. Actual salmonid fish use in mainstem Reach D and inflowing tributaries reported under SWIFD includes a total of 12.53 miles of mainstem and 165.01 miles of tributary used by salmonids for rearing, spawning, or general presence (Table A1-9).

Table A1-9
Modeled Intrinsic Potential (IP) for Salmonid Habitat Suitability and Miles of Stream Used by Anadromous Fish in Mitigation Reach A. No Available Date Is Indicated by–-

		CHINOOK SALMON		COHO SALMON		STEELHEAD	
STREAM IDENTIFIER	TRIBUTARY TO	IP	SWIFD (MILES)	IP	SWIFD (MILES)	IP	SWIFD (MILES)
Mainstem Chehalis River Reach D		*0.7*	11.7	*0.8*	12.53	*0.59*	12.53
South Fork Chehalis River	Chehalis Reach D	*0.69*	19.2	*0.98*	31.24	*0.49*	33.18
Hanlan Creek	South Fork Chehalis River		--		2.5		2.58
Trout Creek	South Fork Chehalis River		--		2.03		2.02
Black Creek	South Fork Chehalis River		--		3.94		5.16
Cedar Creek	South Fork Chehalis River		--		2.96		2.32
Cedar Creek	South Fork Chehalis River		--		1.71		2.6

		CHINOOK SALMON		COHO SALMON		STEELHEAD	
STREAM IDENTIFIER	TRIBUTARY TO	IP	SWIFD (MILES)	IP	SWIFD (MILES)	IP	SWIFD (MILES)
Sep Creek	South Fork Chehalis River		--		1.54		1.54
Wilson Creek	South Fork Chehalis River		--		0.67		--
Newland Creek	South Fork Chehalis River		--		1.62		0.98
Water Creek	South Fork Chehalis River		--		0.53		--
Sears Creek	South Fork Chehalis River		--		1.9		1.71
Slide Creek	South Fork Chehalis River	*0.66*	--	*0.99*	2.63	*0.48*	2.63
Point Hill Creek	South Fork Chehalis River		--		0.88		0.47
Bull Pen Creek	South Fork Chehalis River	*0.32*	--	*0.94*	2.38	*0.54*	2.37
Lentz Creek	South Fork Chehalis River	*0.18*	--	*1*	2.24	*0.46*	2.79
Root House Creek	South Fork Chehalis River	*0.18*	--	*0.95*	0.75	*0.54*	1.39
Neiman Creek	South Fork Chehalis River	*0.62*	--	*1*	1.44	*0.46*	1.7
Stillman Creek	South Fork Chehalis River	*0.73*	5	*0.93*	15.81	*0.55*	15.8
Stillman Creek	South Fork Chehalis River		--		2.58		2.69
Stillman Creek	South Fork Chehalis River	*0.57*	--	*0.9*	6.66	*0.55*	6.78
Stillman Creek	South Fork Chehalis River		--		2.66		18.1
Stillman Creek	South Fork Chehalis River	*0.45*	--	*0.96*	4.49	*0.53*	4.93
Beaver Creek	South Fork Chehalis River	*0.47*	--	*0.99*	2.41	*0.48*	1.73
Lake Creek	South Fork Chehalis River		--		11.65		24.36
Lake Creek	South Fork Chehalis River		--		2.23		2.18
Lake Creek	South Fork Chehalis River		--		3.66		1.95
Bunker Creek	Chehalis Reach D	*0.5*	--	*0.98*	11.84	*0.5*	26.73
Shaw Creek	Bunker Creek	*0.19*	--	*0.99*	1.57	*0.48*	1.61
Prairie Creek	Bunker Creek	*0.29*	--	*0.95*	1.82	*0.53*	2.58
Deep Creek	Bunker Creek	*0.43*	--	*0.94*	8.42	*0.53*	18.4
Deep Creek	Bunker Creek		--		1.42		--
Deep Creek	Bunker Creek	*0.06*	--	*0.91*	0.75	*0.54*	--
Deep Creek	Bunker Creek	*0.13*	--	*0.94*	1.28	*0.54*	0.38
Deep Creek	Bunker Creek		--		0.67		--
Deep Creek	Bunker Creek	*0.22*	--	*0.94*	1.51	*0.54*	0.98
Van Ornum Creek	Chehalis Reach D	*0.23*	--	*0.66*	1.76	*0.91*	3.19
Stearns Creek	Chehalis Reach D	*0.62*	--	*0.98*	10.51	*0.49*	12.2
West Fork Stearns Creek	Stearns Creek		--		3.92		2.97
Mill Creek	Chehalis Reach D		--		5.64		7.21
Wisner Creek	Mill Creek		--		0.79		--

Source: Statewide Washington Integrated Fish Distribution (SWIFD) Portal, Updated 4/2018.

Based on the Chehalis Fish Passage Barrier Prioritization, Reach D contains 151 culverts and other barriers to fish movement, 25 of which are complete barriers and 126 are partial barriers (33 to 67% passable). In total, approximately 309.3 miles of potential fish habitat for coho salmon and cutthroat trout and 190.7 miles of steelhead habitat exists upstream of these barriers located in various creeks as well as unnamed tributaries (Table A1-10) (WDFW 2022b). Loss of access in the Stearns, Van Ornum, and Bunker Creek Sub-basins has been identified as a limiting factor to more extensive salmonid use of those basins (Smith and Wenger 2001). Numerous culverts were identified in the Stearns, Mill, Scammon, and Deep Creek sub-basins, and this large quantity represents an opportunity to improve habitat availability for on salmonids.

Table A1-10
Summary of Fish Barrier Culverts within Reach D and Potential Linear Habitat Affected by Species

BARRIER TYPE	VALUE	COHO SALMON	STEELHEAD	CUTTHROAT TROUT
Complete Barrier count	25	25	25	25
Partial Barrier count	126	126	126	126
Unknown Barrier status	0	0	0	0
Potential Linear Habitat Affected (mi)	-	309.33	190.73	309.33

Source: WDFW 2022b.

Priority amphibian species documented in Reach D include the western toad (PHS 2022). Western toad egg masses and tadpoles were concentrated in Reach D on the mainstem Chehalis between bunker Creek and Van Ornum Creek. Other amphibians documented in mainstem reaches downstream of the FRE facility including Reach D were small numbers (4-31 individuals) of northern red-legged frog, roughskin newt, and pacific treefrogs. American bullfrogs were more common in mainstem reaches (100 individuals). Surveys in tributaries and off-channel habitat documented rare occurrences of northern red-legged frogs, roughskin newts and American bullfrogs (Hayes et al. 2018).

Eight mussel beds, two containing western pearlshell and six of floater mussels, were observed in the South Fork Chehalis River near the confluence of Stillman Creek. Additionally, nine western pearlshell mussel beds were observed upstream within the South Fork Chehalis River near Slide Creek. All beds found in the South Fork Chehalis River were small, containing less than 20 mussels per bed.

WDFW observed a total of 92 mussel beds within Reach D during the 2021 Chehalis River Basin Mussel survey (Douville et al. 2021). Three small beds, containing less than 20 mussels each, of floater and western pearlshell mussels were observed within the Chehalis River mainstem, near the confluence of Bunker Creek. Another five mussel beds were observed near the confluence of the Newaukum River, all of which contained western pearlshell mussels. Six mussel beds were observed downstream of the South Fork Chehalis River confluence, including three beds of floater mussels, two beds of western pearlshells and one bed was comprised of around 20 western ridged mussels (*Gonidea angulate*). The western ridged mussel is currently proposed for federal listing under the ESA (Blevins et al. 2020).

Bunker Creek contains a total of 61 mussel beds, 43 of which are located upstream of the confluence of the Chehalis River. These mussel beds contain both western pearlshell and floater mussels. The remaining 18 mussel beds within Bunker Creek were located near the confluence of Shaw Creek. With the exception of one bed of western pearlshell mussels, all mussel beds near Shaw Creek contained floater mussels. Additionally, 33 incidental observations of Asian clams, a non-native species, were observed in Bunker Creek.

5.4.6 Water Quality

Water quality in the mainstem Chehalis River within Reach D is impaired. Water quality issues are compounded by water rights concerns. Low flows have recently been less than Washington State's minimum instream flow requirements and have resulted in curtailment of junior water rights, cessation of recreational fishing, and further concern related to instream temperature which is considered impaired throughout this reach.

Summer temperatures frequently exceed the preferred temperature range criteria for salmon and steelhead (Ecology 2020a) (WAC Chapter 173-201A). Warm summer stream temperatures are assumed to limit the rearing potential, habitat use, and spatial distribution of aquatic species, especially Pacific salmon (Winkowski et al. 2018a). Similar to upstream Mitigation Reaches, DO monitoring by Ecology between 2004 - 2009 documented impairment in DO on Ecology's recent 303(d) list (Ecology 2021b). Bunker Creek and the South Fork Chehalis River, both tributaries to mainstem Reach D, are also categorized as having elevated stream temperatures and low dissolved oxygen due to loss of riparian cover or conversion, livestock waste, decreased flow, and urban stormwater.

The South Fork Chehalis River is identified in Ecology's 2014 Water Quality Assessment as a Category 4A water with TMDLs in place for water temperature, fecal coliform bacteria, and DO (Ecology 2016). In the river upstream of the community of Curtis, peak summer water temperatures were documented above applicable temperature criteria, peaking over 25°C; measurements of DO in this reach also exceeded applicable aquatic habitat criterion (Anchor QEA 2014).

There is an area of turbidity impairment in Reach D, upstream of the town of Chehalis likely caused by livestock waste, urban stormwater, and elevated temperatures (Smith and Wenger 2001). According to the Washington State Water Quality Assessment 303(d)/305(b) list, Hallock shows 4 excursions beyond the turbidity criterion for Aquatic Life – Salmonid Spawning, Rearing and Migration out of 12 samples collected between 1992 and 2001 derived by the difference between the upstream station 23A160 (Chehalis River at Dryad, WA) and the downstream station 23A130 (Chehalis River at Claquato, WA) (Ecology 2021b).

It is also possible that reduction in wetlands in this area has contributed to water quality problems in both mainstem Reach D, Bunker Creek, and the South Fork Chehalis River (Smith and Wenger 2001).

6 FUTURE BASELINE CONDITIONS

Physical processes that contribute to habitat quality and quantity as well as aquatic species use of habitat within the upper Chehalis River are dynamic. Some processes, like changes to stream flow, temperature, and associated habitat suitability, occur on a continuum affected by climate change, while other dynamic processes are human driven such as water rights, forest practices and schedules of timber harvest, rural infrastructure development, and other land uses.

Climate change models for the Puget Sound area scaled to the Chehalis River Basin predict increased precipitation and decreased summer flows (Mauger et al. 2016). The model developers indicate that warmer winter temperatures would mean less snow and more heavy rain events which are expected to increase the risk of winter flooding, and increase sediment transport, erosion, and landslides. With less snowpack to melt and less summertime precipitation expected, lower summer stream flows and warmer water temperatures are predicted for the Chehalis Basin. This section summarizes the best available data on future conditions within the Impact Area without consideration of Proposed Action. Modeling efforts provide predicted future scenarios for stream flow, habitat suitability, and in-river temperature. Forest practices that result in timber harvest in watersheds within the Impact Area and potential Mitigation Area are also scheduled and permitted well into the future and are summarized here as well.

6.1 Stream Flow

The information contained in the Chehalis River Basin Hydrologic Modeling technical memorandum combined with USGS flow records were used to develop flow predictions under future climate change conditions. The flows were input to the RiverFlow2D model to estimate flooding conditions under future climate change conditions. Peak flow increases due to climate change were estimated to range from 12% at mid-century to 26% by late-century (WSE 2019). The SEPA DEIS presents analysis of increased flows under climate change scenarios to predict the likelihood of major (>38,000 cfs) and catastrophic (>75,100 cfs) floods as measured at the Grand Mound USGS Gage. These flood likelihood calculations, presented in Table A1-11, are important for considering likely frequency of operation of the proposed FRE facility under future stream flow conditions, and potential impacts to aquatic habitats and species.

Table A1-11
Modeled Future Baseline Conditions for Flood Occurrence Frequency Under Mid-century and Late-century Time Frames

QUALITATIVE FLOOD CATEGORY (DEIS)	TIME FRAME	CHANCE OF ANNUAL OCCURRENCE[1]	ASSOCIATED FLOOD-YEAR TERM	FLOW (GRAND MOUND)	REFERENCE FLOOD
Major Flood	Current	14%	7-year	38,800 cfs	2009
	Mid-Century	20%	5-year		
	Late-Century	25%	4-year		
Catastrophic Flood	Current	1%	100-year	75,100 cfs	1996
	Mid-Century	2%	44-year		
	Late-Century	4%	27-year		

Source: SEPA DEIS Table N-5. Ecology 2021.
Notes:
1. % chance a flood of this size would occur in any given year.

Stream flow outside of peak flow periods were analyzed by WSE to determine the change in average monthly flows throughout the modeled period of record, projecting that flows will increase 4 and 5% during winter (November-April) and will decrease 11% and 16% during summer (May-October) based on mid- and late-century models, respectively.

6.2 Stream Temperature

Future-conditions modeling for the SEPA DEIS by PSU (PSU 2017) and by the Applicant (Appendix F) for this FRE HMP include predicted changes to hydrological and meteorological conditions associated with climate change. Climate change is projected to increase stream temperatures because of increases in air temperature, changes in dew point temperature, changes in hydrology, and lower summer flows throughout Washington State, including the Chehalis River (Mauger et al. 2016). The SEPA DEIS included the influence of climate change in the estimate of the Proposed Action's impacts on water temperature; however, it did not report what portion of the increase in water temperature could be attributed to climate change without the Proposed Action.

The Applicant used the existing 2-dimensional CE-QUAL-W2 temperature model to project long-term climate change effects on stream temperature in the Impact Area without the Proposed Action (Appendix D, FCZD 2021b). Model results suggest that surface water temperatures, accounting for climate change, would be warmer than under current conditions, with an increase in water temperatures proportional to the increase in air temperatures and associated decreases in summer stream flow (FCZD 2021b). These changes in baseline climate result in water temperatures that are 3°C to 5°C higher than current conditions.

6.3 Forest Practices

Forest Practices including road construction and timber harvest can have wide-spread impacts on the landscape, receiving waters, and habitats and species therein, but also to larger ecosystem functions that support the productive capacity of streams for fish and other wildlife. Removal of vegetation near streams increases solar radiation contributing to increased water temperature, primary production, and re-radiation, while decreasing input of organic matter to streams, bank stability, and wood supply that can serve as substrate for invertebrates, trap for sediment, and factor in formation of meso-scale habitat (Richardson and Béraud 2014).

Much of the land use in the higher elevation portions of the Mitigation Area is managed timber harvest, including a majority of the watershed upstream of the proposed FRE facility. These forestlands are owned by entities including private companies (industrial, non-industrial, and tribal) and agencies such as the Washington State Department of Natural Resources (WA DNR), U.S. Forest Service, and the Bureau of Land Management that manage forestlands on behalf of the public. In Lewis County, an average of 393,200 thousand board feet have been harvested annually over the past 20 years with an average of 45% harvested by private timber companies (Forest Industry Research Program 2022).

Most of the habitat within the Proposed Action area around the FRE facility and temporary reservoir is privately-owned evergreen forest that has been managed for many decades typically operating on a 40- to 50-year harvest cycle. Based on analysis of satellite imagery from 2018, approximately 12% of the upland area within 0.25 miles of the mainstem Chehalis River between the proposed FRE facility and upper inundation extent of the temporary reservoir was clearcut/bare of vegetation, 5% was in early regrowth period, and 83% was mature upland forest. Planned timber harvest activities above the proposed FRE facility will likely continue to impact aquatic and wildlife habitat, water quality, LWM input, and other ecosystem processes.

Current Forest Practices rules are in place to protect riparian areas and promote the development of the riparian forest and processes for recruitment of LWM. Riparian protection provided by these rules are site specific, with some flexibility to allow harvest outside the core buffer zone of 50 feet, but generally consist of 50 to 200-foot buffers (WAC 2001). While not all riparian tree stands are fully functioning, within the core zone, they are on a trajectory to mature and become a source of LWM in the future.

6.4 Habitat Suitability

The Ecosystem Diagnosis and Treatment (EDT) model was used to evaluate the biological significance of environmental changes with regard to the potential of the Chehalis Basin to support spring- and fall-run Chinook salmon, coho salmon, chum salmon, and steelhead (“modeled species”) at basin and sub-basin scales as a result of flood damage reduction and habitat restoration actions. The actions were evaluated under current climate conditions and under projected future climate conditions in the Chehalis Basin.

The EDT model (McConnaha et al. 2017) reported the following principal findings relative to the baseline and future conditions of aquatic habitat in the Chehalis.

- Future climate greatly reduced habitat potential for all modeled species throughout the Chehalis Basin independent of the FRE facility options or Aquatic Species Restoration Plan (ASRP).
- Under future climate conditions, habitat potential for most local populations of spring-run Chinook salmon was eliminated under a low climate scenario with only 85% of existing habitat remaining by the year 2040. Under a high climate change scenario, all habitat potential for spring Chinook salmon would be gone, affecting all local populations in the basin. These model results suggests that this species may not be viable under future climate conditions without substantial habitat restoration.
- Under a high climate change scenario, all habitat potential for coho salmon upstream of the South Fork Chehalis was eliminated.
- For fall Chinook salmon, habitat potential was eliminated for three sub-basins under the high climate change scenario. However, due to increase winter flow and channel width, fall Chinook salmon habitat potential actually increased for five of the local population downstream of the confluence with the Skookumchuck River.
- As modeled, the negative effect of future climate conditions depended on the length of a species' exposure to the conditions in the Chehalis watershed, in particular to increased summer water temperatures for spawning salmon. Chum salmon and fall-run Chinook salmon spend the least amount of time in the watershed and experience substantially less exposure to warmer water. Steelhead and coho salmon spawn higher in the system where project temperature increases were less. Spring-run Chinook salmon spend months in the river as pre-spawners and spawners, and will have the greatest exposure to lower summer flow and warmer summer temperatures.

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ATTACHMENT 1 – Fish Passage Barriers in the Mitigation Area

Figure included in Attachment 1:

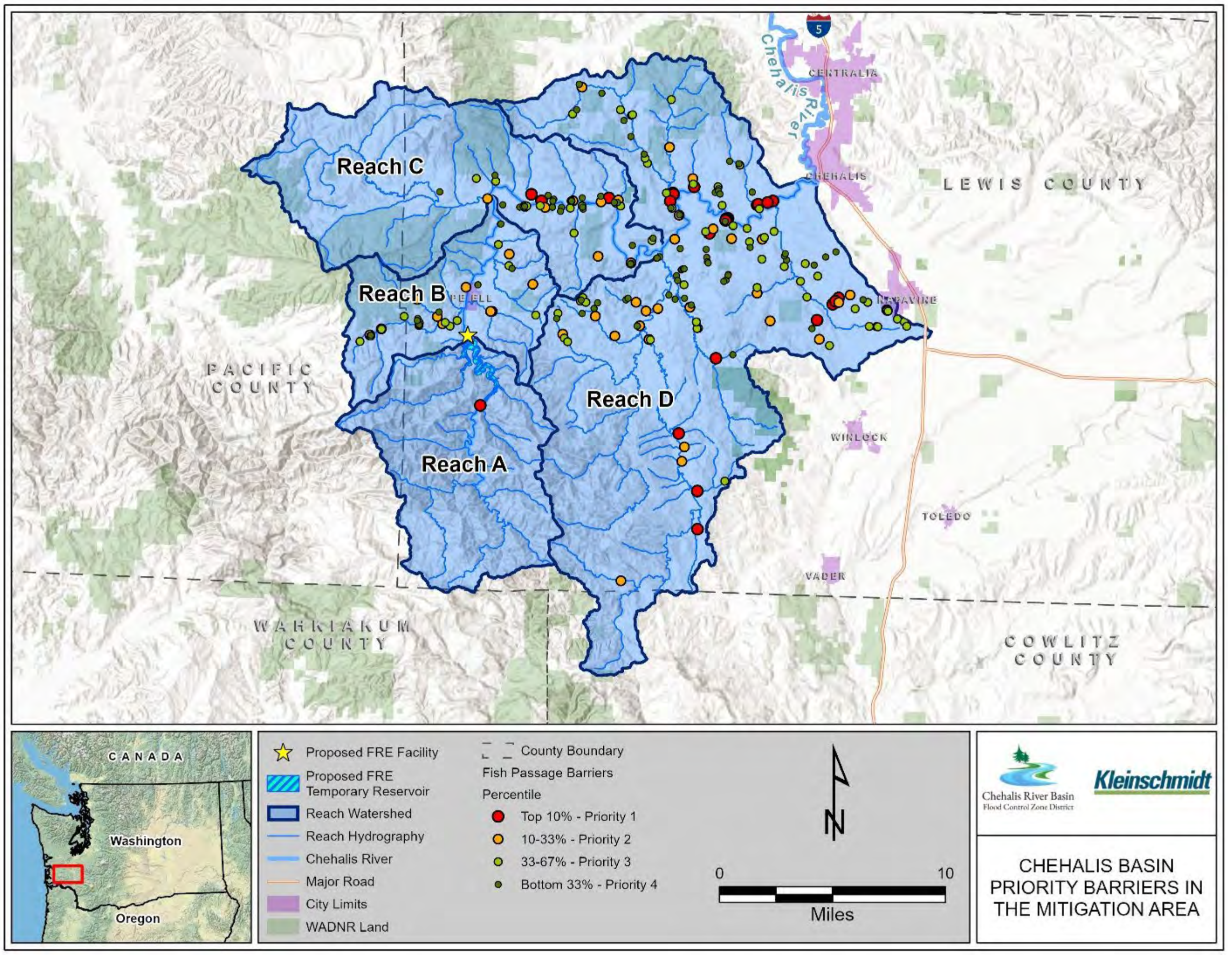
Figure 1. Chehalis Basin WDFW Priority Barriers in the Mitigation Area. The Location of the Proposed FRE Facility Is Indicated by the Yellow Star on the Mainstem Upper Chehalis River

Tables included in Attachment 1:

Table 1. Washington Department of Fish and Wildlife (WDFW) Prioritized Barriers Within the Chehalis River Basin Mitigation Reaches A Through D

Table 2. WDFW Fish Barriers Within Upper Chehalis Basin Mitigation Reaches A Through D That Are Not Included in the WDFW Prioritized Chehalis Fish Barriers

Attachment 1, Figure 1
Chehalis Basin WDFW Priority Barriers in the Mitigation Area. The Location of the Proposed FRE Facility Is Indicated by the Yellow Star on the Mainstem Upper Chehalis River



Attachment 1, Table 1

WDFW Prioritized Fish Barriers Within the Chehalis River Basin Mitigation Reaches A through D

REACH	TRIBUTARY	TRIBUTARY TO	BARRIER ID	OWNER TYPE	SCORE	RANK	PRIORITY (1-4)	BARRIER PASS-ABILITY	COHO (MILES)	COHO (QUAL)	STEEL-HEAD (MILES)	STEEL-HEAD (QUAL)	CUTTHROAT (MILES)
A	Roger Cr	Chehalis River	23.1181 0.05	State	59.67	166	1	33	2.51	0.51	2.39	0.36	2.51
B	unnamed	Salmon Cr	940385	Private	48.33	833	2	67	0.45	0.52	0.45	0.23	0.45
B	unnamed	Salmon Cr	940343	State	51.00	595	2	0	0.21	0.65	0.21	0.29	0.21
B	unnamed	Salmon Cr	940445	Private	44.00	1241	3	33	0.13	0.62	0.13	0.24	0.13
B	unnamed	Rock Cr	940345	State	51.67	545	2	33	0.64	0.32	0.26	0.15	0.64
B	unnamed	Rock Cr	990737	State	46.67	982	2	67	0.64	0.28	0.26	0.14	0.64
B	unnamed	Rock Cr	1080120	County	46.00	1048	3	67	0.09	0.77	0.09	0.5	0.09
B	unnamed	Rock Cr	940452	Private	39.33	1675	4	0	0.08	-	0.08	-	0.08
B	unnamed	unnamed	940453	Private	37.33	1819	4	33	0.15	-	0.15	-	0.15
B	unnamed	Rock Cr	940450	Private	41.33	1523	3	0	0.14	0.2	0.14	0.09	0.14
B	unnamed	Rock Cr	021(26210)(00127)	County	43.33	1297	3	0	0.85	0.19	0.64	0.1	0.85
B	unnamed	Rock Cr	940437	Private	40.33	1577	4	33	0.85	0.21	0.64	0.12	0.85
B	unnamed	Rock Cr	990738	State	42.33	1380	3	33	0.85	0.22	0.64	0.12	0.85
B	unnamed	Rock Cr	125 1205W06B	State	45.33	1094	3	33	0.91	0.33	0.7	0.32	0.91
B	unnamed	McCormick Cr	125 1303W31A	State	57.00	248	1	33	0.85	0.65	0.85	0.28	0.85
B	unnamed	McCormick Cr	132142127	Private	36.33	1878	4	67	0.18	0.43	0.18	0.16	0.18
B	unnamed	McCormick Cr	125 1205W05C	Private	51.33	583	2	0	0.3	0.38	0.3	0.16	0.3
B	unnamed	Rock Cr	990740	State	53.67	413	1	0	0.24	0.33	0.19	0.13	0.24
B	unnamed	Rock Cr	125 1205W05D	County	42.67	1371	3	67	0.27	0.38	0.23	0.16	0.27
B	unnamed	Rock Cr	940356	State	48.67	799	2	0	0.09	0.14	0.09	0.08	0.09
B	unnamed	Rock Cr	940455	Private	49.67	705	2	0	0.23	0.29	0.23	0.12	0.23
B	Sand Cr	Stowe Cr	021(25800)(00868)	County	55.67	304	1	33	1.15	0.6	1.15	0.28	1.15
B	Stowe Cr	Chehalis R	021(25800)(01097)	County	54.33	360	1	67	1.82	0.62	1.77	0.32	1.82
B	unnamed	Chehalis R	021(26390)(00612)	County	54.00	387	1	0	0.71	0.2	0.71	0.11	0.71
B	unnamed	Chehalis R	990741	State	38.67	1703	4	67	0.56	-	0.56	-	0.56
B	Halsea Cr	Jones Cr	125 1204W06A	County	46.67	987	2	67	0.11	0.53	0.11	0.2	0.11
B	Kowalski Cr	Jones Cr	125 1305W25A	Private	52.67	482	1	0	0.15	0.6	0.15	0.24	0.15
B	Katula Cr	Jones Cr	125 1305W25B	Private	37.67	1781	4	33	0.09	-	0.09	-	0.09
B	Katula Cr	Jones Cr	125 1305W23D	County	42.67	1350	3	67	1.25	0.57	0.37	0.31	1.25
B	South Branch	Fronia Cr	125 1305W23C	Private	51.33	582	2	0	0.46	0.66	0.46	0.23	0.46
B	Fronia Cr	Chehalis River	125 1305W23B	State	49.33	712	2	67	2.95	0.55	2.44	0.22	2.95
B	unnamed	Chehalis R	940362	State	38.67	1708	4	33	0.46	-	0.33	-	0.46
B	unnamed	Chehalis R	990749	State	33.67	1955	4	67	0.46	-	0.33	-	0.46
C	unnamed	Chehalis R	021(27071)(00405)	County	51.33	577	2	0	0.81	0.06	0.5	0.02	0.81
C	unnamed	Elk Cr	125 1305W05A	Private	36.33	1869	4	67	0.34	0.1	0	-	0.34
C	unnamed	Hay Cr	132151490A	Private	49.33	749	2	0	0.13	0.22	0.13	0.1	0.13
C	unnamed	Absher Cr	132151490C	Private	42.00	1435	3	33	0.22	-	0	-	0.22
C	Absher Cr	Chehalis R	021(27000)(02202)	County	46.33	995	2	67	1.9	0.45	0	-	1.9
C	unnamed	Chehalis R	930853	Private	39.67	1639	4	67	0.29	0.4	0.29	0.14	0.29

REACH	TRIBUTARY	TRIBUTARY TO	BARRIER ID	OWNER TYPE	SCORE	RANK	PRIORITY (1-4)	BARRIER PASS-ABILITY	COHO (MILES)	COHO (QUAL)	STEEL-HEAD (MILES)	STEEL-HEAD (QUAL)	CUTTHROAT (MILES)
C	unnamed	Chehalis R	930858	Private	41.33	1502	3	67	0.34	0.53	0.34	0.21	0.34
C	unnamed	Chehalis R	990912	Private	38.33	1730	4	67	0.69	0.45	0.69	0.16	0.69
C	unnamed	Chehalis R	991092	Private	37.00	1825	4	67	0.69	0.45	0.69	0.16	0.69
C	unnamed	Chehalis R	991552	Private	51.00	591	2	0	0.69	0.45	0.69	0.16	0.69
C	unnamed	Chehalis R	990535	County	47.00	949	2	0	0.29	-	0.29	-	0.29
C	Marcuson Cr	Chehalis R	021(27651)(00273)	County	58.00	204	1	33	2.49	0.51	2.31	0.24	2.49
C	Marcuson Cr	Chehalis R	021(27501)(02750)	County	59.00	184	1	33	3.56	0.52	3.08	0.23	3.56
C	unnamed	Chehalis R	990756	State	53.00	448	1	0	0.24	0.24	0.24	0.1	0.24
C	unnamed	Chehalis R	940507	Private	35.33	1918	4	67	0.08	0.24	0.08	0.1	0.08
C	unnamed	Chehalis R	940506	Private	42.33	1377	3	67	1.14	0.32	0.57	0.13	1.14
C	unnamed	Chehalis R	940505	Private	40.33	1576	4	67	0.91	0.06	0.91	0.02	0.91
C	unnamed	Chehalis R	021(27501)(02248)	County	39.33	1647	4	67	0.91	0.06	0.91	0.02	0.91
C	unnamed	Chehalis R	933802	Private	39.33	1681	4	33	0	-	0.22	0.15	0
C	unnamed	Chehalis R	930856	Private	33.33	1980	4	33	0	-	0.18	0.13	0
C	unnamed	Chehalis R	990405	State	46.00	1047	3	33	0.23	0.33	0.23	0.14	0.23
C	unnamed	Dell Cr	021(27501)(01438)	County	49.67	704	2	0	0.25	0.73	0.25	0.29	0.25
C	unnamed	Chehalis R	601407	County	38.67	1720	4	0	0	-	0	-	0
C	Dell Cr	Chehalis R	021(27501)(01365)	County	54.33	364	1	67	1.53	0.76	1.51	0.37	1.53
C	unnamed	Chehalis R	940367	State	42.33	1396	3	67	0.45	0.7	0.45	0.24	0.45
C	unnamed	Hope Cr	125 1304W17A	Private	48.00	855	2	33	0.22	0.32	0.22	0.14	0.22
C	unnamed	Hope Cr	933792	Private	35.33	1923	4	0	0	-	0	-	0
C	unnamed	Hope Cr	933791	Private	32.00	2005	4	0	0	-	0	-	0
C	unnamed	Hope Cr	990423	State	49.00	761	2	0	0.46	0.62	0.29	0.22	0.46
C	unknown	Chehalis R	021(27791)(02335)	County	50.00	680	2	0	0.23	0.17	0.23	0.08	0.23
C	unnamed	Chehalis R	601400	County	36.33	1862	4	67	0.48	-	0.48	-	0.48
C	Garret Cr	Chehalis R	021(27820)(02631)	County	62.33	112	1	0	1.07	0.61	2.16	0.24	1.07
C	unnamed	Chehalis R	021(27791)(01734)	County	37.00	1832	4	67	0.16	-	0.16	-	0.16
C	Nicholson Cr	Chehalis R	021(27820)(02365)	County	51.67	537	2	67	2.16	0.48	2.06	0.2	2.16
C	unnamed	Nicholson Cr	940492	County	47.33	927	2	0	0.28	0.61	0.28	0.22	0.28
C	unnamed	Nicholson Cr	940490	County	37.33	1809	4	67	0.28	0.43	0.28	0.19	0.28
C*	Nicholson Cr	Chehalis R	125 1304W03A	State	56.33	277	1	33	2.58	0.47	2.47	0.2	2.58
C	Miller Cr	Chehalis R	132062095	Private	50.33	665	2	0	0.14	0.46	0.14	0.19	0.14
C	Davis Cr	Chehalis R	990760	State	36.33	1877	4	67	0.18	0.58	0.18	0.24	0.18
C	Davis Cr	Chehalis R	125 1304W23A	Private	41.67	1471	3	33	0.28	0.61	0.28	0.24	0.28
C	Davis Cr	Chehalis R	021(28051)(00450)	County	50.67	626	2	0	0.28	0.62	0.28	0.24	0.28
C	unnamed	Chehalis R	940372	State	37.33	1808	4	33	0.31	-	0	-	0.31
C	unnamed	Chehalis R	125 1304W13C	Private	42.33	1407	3	0	0.31	0.23	0.31	0.08	0.31
C	unnamed	Chehalis R	940501	Private	42.67	1368	3	0	0.31	0.23	0.31	0.08	0.31
D	Hanlan Cr	SF Chehalis R	23.1065 0.90	State	53.33	420	1	67	1.49	0.46	1.58	0.38	1.49
D	Black Cr	SF Chehalis R	601430	Private	63.33	101	1	33	4.27	0.59	1.95	0.25	4.27
D	Cedar Cr	SF Chehalis R	021(92004)(05661)	County	62.00	113	1	67	5.24	0.55	4.49	0.24	5.24
D	Laughlin Cr	Cedar Cr	601537	Private	49.00	758	2	67	1.11	0.49	0.75	0.21	1.11

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D	Sears Cr	SF Chehalis R	021(92004)(07238)	County	54.00	385	1	33	1.12	0.52	0.72	0.23	1.12
D	Paint Hill Cr	SF Chehalis R	021(92004)(07883)	County	52.33	499	1	0	0.54	0.38	0.18	0.21	0.54
D	Bull Pen Cr	SF Chehalis R	021(92004)(08538)	County	60.67	143	1	0	1.82	0.49	1.73	0.2	1.82
D	unnamed	SF Chehalis R	021(25650)(00066)	County	43.67	1257	3	67	0.95	0.58	0.52	0.43	0.95
D	unnamed	SF Chehalis R	021(92006)(04507)	County	50.67	614	2	33	1.06	0.59	0.56	0.5	1.06
D	Halfway Cr	Stillman Cr	125 1204W05C	Federal	46.67	988	2	0	0.1	0.4	0.1	0.17	0.1
D	Halfway Cr	Stillman Cr	021(24019)(04032)	County	37.67	1773	4	33	0.27	-	0.17	-	0.27
D	Halfway Cr	Stillman Cr	021(24019)(04778)	County	54.33	363	1	33	1.61	0.53	1.51	0.23	1.61
D	unnamed	Halfway Cr	021(24019)(04966)	County	48.33	834	2	33	0.37	0.53	0.37	0.23	0.37
D	Halfway Cr	Stillman Cr	125 1204W08A	County	47.67	882	2	0	0.2	-	0.12	-	0.2
D	Lost Cr	Stillman Cr	021(25401)(03620)	County	42.33	1416	3	33	0.22	-	0.22	-	0.22
D	unnamed	unnamed Lost Cr trib	601549	Private	45.33	1139	3	0	0.16	0.08	0.16	0.04	0.16
D	unnamed	unnamed Lost Cr trib	601548	Private	44.67	1196	3	0	0.12	0.14	0.12	0.07	0.12
D	unnamed	unnamed Lost Cr trib	601547	Private	41.67	1481	3	0	0.07	0.06	0.07	0.03	0.07
D	unnamed	unnamed Lost Cr trib	601546	Private	43.33	1321	3	0	0.21	-	0.21	-	0.21
D	unnamed	Lost Cr	021(25510)(00722)	County	42.33	1382	3	33	0.78	0.48	0.09	0.2	0.78
D	unnamed	Lost Cr	601551	Private	40.33	1569	4	67	1.14	0.45	0.44	0.2	1.14
D	Lost Cr	Stillman Cr	021(25510)(00106)	County	56.33	275	1	33	3.96	0.46	2.65	0.21	3.96
D	unnamed	Lost Cr	021(25401)(01657)	County	50.67	605	2	33	1.65	0.51	0.22	0.27	1.65
D	unnamed	SF Chehalis R	601338	Private	36.33	1864	4	67	0.46	0.57	0.46	0.22	0.46
D	unnamed	SF Chehalis R	601339	Private	39.33	1655	4	33	0.46	0.57	0.46	0.22	0.46
D	unnamed	SF Chehalis R	021(25470)(00721)	County	51.67	546	2	0	0.61	0.57	0.61	0.22	0.61
D	Beaver Cr	SF Chehalis R	601419	Private	40.67	1545	4	67	0.85	0.5	0.13	0.25	0.85
D	unnamed	Beaver Cr	021(28261)(01813)	County	39.33	1651	4	67	0.65	0.47	0.09	0.24	0.65
D	Beaver Cr	SF Chehalis R	125 1304W35B	Private	53.67	401	1	33	2.16	0.49	0.88	0.24	2.16
D	Beaver Cr	SF Chehalis R	125 1304W36C	Private	57.67	214	1	33	3.24	0.5	1.97	0.24	3.24
D	unnamed	SF Chehalis R	125 1304W36B	County	50.33	640	2	33	0.73	0.63	0.93	0.22	0.73
D	unnamed	SF Chehalis R	021(24017)(12910)	County	35.33	1909	4	67	0.45	-	0.45	-	0.45
D	unnamed	Barney Cr	125 1203W10A	County	41.67	1453	3	67	0.71	0.34	0.11	0.21	0.71
D	Barney Cr	Lake Cr	021(24017)(08876)	County	63.00	106	1	0	2.94	0.47	1.29	0.23	2.94
D	unnamed	unnamed	125 1303W05A	Private	49.67	696	2	0	0.79	0.34	0.2	0.25	0.79
D	unnamed	Lake Cr	125 1203W05A	County	48.33	819	2	33	0.79	0.36	0.2	0.26	0.79
D	unnamed	Lake Cr	021(24017)(10900)	County	47.33	904	2	33	0.69	0.38	0	-	0.69
D	unnamed	Lake Cr	125 1303W32A	Private	41.33	1515	3	33	0.24	-	0.24	-	0.24
D	unnamed	Lake Cr	021(24017)(11680)	County	50.33	638	2	33	1.06	0.46	0.45	0.28	1.06
D	Lake Cr	SF Chehalis R	021(24017)(12550)	County	40.33	1568	4	67	1.28	0.38	0	-	1.28
D	unnamed	unnamed	021(24036)(01096)	County	35.67	1895	4	67	0.86	0.61	0	-	0.86
D	unnamed	Lake Cr	021(24036)(00519)	County	48.00	852	2	67	1.27	0.57	0.38	0.3	1.27

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D	unnamed	Lake Cr	021(24036)(00147)	County	33.33	1972	4	67	0.05	-	0.05	-	0.05
D	unnamed	unnamed Chehalis R trib	601418	Private	32.33	2002	4	33	0	-	0.07	0.09	0
D	unnamed	unnamed SF Chehalis R	601417	Private	36.33	1883	4	67	0.12	0.5	0.22	0.15	0.12
D	unnamed	SF Chehalis R	601416	Private	36.33	1884	4	67	0.12	0.55	0.22	0.18	0.12
D	unnamed	SF Chehalis R	021(23650)(02800)	County	39.33	1654	4	67	0.49	0.61	0.59	0.19	0.49
D	unnamed	SF Chehalis R	021(23650)(03116)	County	39.67	1637	4	67	0.37	0.44	0.26	0.15	0.37
D	unnamed	unnamed	990764	State	40.33	1610	4	67	0.17	0.7	0.17	0.23	0.17
D	unnamed	SF Chehalis R	601434	Private	39.33	1671	4	67	0.17	0.7	0.17	0.23	0.17
D	unnamed	Chehalis R	021(92006)(00053)	County	40.33	1598	4	67	0.32	0.74	0.32	0.25	0.32
D	unnamed	Chehalis R	934152	Private	40.33	1607	4	33	0.23	0.56	0.23	0.2	0.23
D	unnamed	Bunker Cr	125 1404W20B	County	45.33	1115	3	0	0.42	0.43	0	-	0.42
D	unnamed	Bunker Cr	125 1405W24A	Unknown	34.33	1943	4	67	0.24	-	0.24	-	0.24
D	unnamed	Bunker Cr	601258	Private	38.33	1747	4	67	0.27	0.46	0.27	0.18	0.27
D	Bunker Cr	Chehalis R	601172	County	56.67	252	1	67	8.83	0.59	3.45	0.39	8.83
D	unnamed	Bunker Cr	021(24034)(08899)	County	38.33	1725	4	67	0.86	0.56	0	-	0.86
D	unnamed	Bunker Cr	021(24034)(07649)	County	47.33	895	2	33	0.97	0.47	0.21	0.25	0.97
D	unnamed	Bunker Cr	601259	Private	45.00	1156	3	67	0.53	0.62	0.06	0.29	0.53
D	unnamed	Bunker Cr	125 1404W23A	Private	45.00	1155	3	67	0.63	0.66	0.17	0.29	0.63
D	unnamed	Bunker Cr	021(24034)(07124)	County	37.33	1802	4	67	0.5	0.34	0	-	0.5
D	unnamed	Bunker Cr	021(24034)(06273)	County	36.67	1841	4	33	0.41	-	0	-	0.41
D	unnamed	Bunker Cr	021(24034)(05319)	County	39.33	1662	4	67	0.29	-	0.29	-	0.29
D	unnamed	Bunker Cr	021(24034)(05135)	County	46.00	1041	3	33	0.6	0.36	0	-	0.6
D	unnamed	Bunker Cr	021(24034)(04886)	County	46.00	1043	3	33	0.36	0.17	0.36	0.08	0.36
D	unnamed	Deep Cr	021(24024)(03867)	County	46.00	1045	3	33	0.28	0.18	0.17	0.08	0.28
D	unnamed	Deep Cr	021(24024)(01701)	County	52.67	477	1	33	0.65	0.45	0.21	0.23	0.65
D	unnamed	Bunker Cr	132141065A	Private	44.33	1222	3	0	0.38	0.47	0	-	0.38
D	unnamed	unnamed Bunker Cr trib	601703	Private	33.00	1982	4	67	0.43	0.35	0.43	0.13	0.43
D	unnamed	Bunker Cr	601702	Private	53.00	435	1	67	4.76	0.56	3.61	0.25	4.76
D	unnamed	Bunker Cr	125 1303W07A	Private	49.67	681	2	67	4.96	0.57	3.73	0.25	4.96
D	unnamed	unnamed Chehalis R trib	021(28001)(06343)	County	34.67	1932	4	0	0	-	0	-	0
D	unnamed	Bunker Cr	125 1303W06A	Private	59.33	173	1	33	5.3	0.56	4.07	0.25	5.3
D	unnamed	Bunker Cr	601174	Private	65.00	71	1	33	6.8	0.56	5.12	0.26	6.8
D	Bunker Cr	Chehalis R	601177	Private	65.00	70	1	67	48.02	0.58	27.83	0.41	48.02
D	Van Ornum Cr	Chehalis R	125 1403W32D	Private	56.67	258	1	33	2.85	0.53	2.67	0.24	2.85
D	Van Ornum Cr	Chehalis R	125 1403W32C	Private	49.67	684	2	67	3.41	0.56	3.11	0.25	3.41
D	Van Ornum Cr	Chehalis R	021(24034)(02386)	County	59.33	175	1	33	3.41	0.56	3.11	0.25	3.41
D	unnamed	Chehalis R	125 1303W04A	Private	44.33	1215	3	0	0.56	0.48	0	-	0.56
D	unnamed	Chehalis R	125 1303W04C	Private	41.33	1495	3	0	0.56	0.51	0	-	0.56

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D	unnamed	Chehalis R	125 1303W04D	Private	38.67	1699	4	33	0.78	0.56	0	-	0.78
D	unnamed	unnamed	125 1303W04E	Private	40.33	1570	4	67	1.06	0.66	0	-	1.06
D	unnamed	Chehalis R	125 1303W04B	Private	38.67	1695	4	67	1.06	0.69	0	-	1.06
D	unnamed	Chehalis R	021(24034)(00730)	County	49.33	713	2	67	2.67	0.68	0.83	0.32	2.67
D	unnamed	unnamed	999144	Private	36.00	1889	4	67	0.04	0.57	0.04	0.2	0.04
D	unnamed	unnamed	999143	Private	37.00	1831	4	67	0.19	0.54	0.19	0.2	0.19
D	unnamed	unnamed	999142	Private	38.67	1711	4	33	0.35	0.57	0.35	0.21	0.35
D	unnamed	unnamed	999141	Private	41.67	1445	3	67	1.25	0.59	1.25	0.22	1.25
D	unnamed	unnamed	999127	Private	49.00	759	2	33	0.97	0.43	0.79	0.2	0.97
D	unnamed	unnamed	125 1303W17A	Private	58.00	206	1	0	1.58	0.5	1.58	0.22	1.58
D	unnamed	unnamed	125 1303W09B	Private	55.00	329	1	33	3.34	0.45	2.61	0.21	3.34
D	unnamed	unnamed	999126	Private	35.33	1913	4	67	0.26	0.34	0.26	0.14	0.26
D	unnamed	Chehalis R	999124	Private	42.33	1388	3	33	0.6	0.42	0.6	0.16	0.6
D	unnamed	unnamed	021(22601)(03319)	County	40.67	1550	4	67	0.6	0.5	0.6	0.19	0.6
D	unnamed	Chehalis R	125 1303W21B	Private	40.67	1549	4	67	0.6	0.49	0.6	0.19	0.6
D	unnamed	Chehalis R	601314	County	50.33	643	2	0	0.69	0.29	0.69	0.12	0.69
D	unnamed	unnamed	999121	Private	34.67	1929	4	67	0.68	0.59	0.33	0.23	0.68
D	unnamed	Chehalis R	999119	Private	58.33	194	1	67	9.3	0.51	6.93	0.23	9.3
D	unnamed	Chehalis R	991544	State	59.33	171	1	67	9.3	0.51	6.93	0.23	9.3
D	unnamed	Chehalis R	991757	State	63.00	104	1	67	9.3	0.52	6.93	0.24	9.3
D	unnamed	Chehalis R	021(24021)(02976)	County	48.33	804	2	33	1.57	0.3	1.57	0.13	1.57
D	Gold Cr	Chehalis R	125 1303W15B	Private	41.67	1474	3	33	0.2	0.53	0	-	0.2
D	Gold Cr	Chehalis R	125 1303W15A	Private	46.33	1015	2	0	0.43	0.49	0	-	0.43
D	unnamed	Chehalis R	125 1303W10A	Private	45.33	1091	3	33	1.52	0.52	0	-	1.52
D	Mill Cr	Chehalis R	23.0930 0.10	State	47.67	873	2	67	0.99	0.89	0.99	0.44	0.99
D	unnamed	Stearns Cr	021(30001)(01301)	County	42.67	1354	3	67	1.04	0.6	1.04	0.2	1.04
D	unnamed	Stearns Cr	601392	Private	48.67	775	2	33	1.9	0.65	1.9	0.22	1.9
D	unnamed	Stearns Cr	601391	County	42.67	1346	3	67	1.9	0.66	1.9	0.22	1.9
D	unnamed	Stearns Cr	601389	Private	51.67	532	2	33	3.09	0.56	2.49	0.2	3.09
D	unnamed	Stearns Cr	601390	County	44.67	1165	3	67	2.19	0.59	2.19	0.2	2.19
D	unnamed	Stearns Cr	021(93006)(07898)	County	51.67	531	2	33	3.09	0.56	2.49	0.2	3.09
D	Stearns Cr	Chehalis R	125 1202W03A	Private	47.67	881	2	33	0.24	0.69	0.24	0.24	0.24
D	Stearns Cr	Chehalis R	125 1202W04A	Private	46.67	972	2	67	1.1	0.65	0.75	0.25	1.1
D	unnamed	unnamed Stearns Cr trib	021(31004)(00058)	County	46.33	1022	2	33	0.28	0.53	0.28	0.2	0.28
D	unnamed	Stearns Cr	125 1202W06B	Private	51.33	585	2	0	0.27	0.32	0	-	0.27
D	unnamed	Stearns Cr	125 1202W06A	Federal	40.00	1620	4	33	0.21	0.05	0	-	0.21
D	unnamed	Stearns Cr	125 1302W31B	Private	59.67	167	1	0	2.19	0.39	1.98	0.2	2.19
D	unnamed	Stearns Cr	021(31013)(00854)	County	47.67	860	2	67	3.86	0.57	3.26	0.2	3.86
D	unnamed	unnamed Stearns Cr trib	601394	Private	40.67	1564	4	33	0.18	0.5	0.18	0.2	0.18
D	Ripple Cr	Stearns Cr	125 1302W28B	Federal	57.67	210	1	33	5.5	0.57	4.4	0.22	5.5

REACH	TRIBUTARY	TRIBUTARY TO	BARRIER ID	OWNER TYPE	SCORE	RANK	PRIORITY (1-4)	BARRIER PASS-ABILITY	COHO (MILES)	COHO (QUAL)	STEEL-HEAD (MILES)	STEEL-HEAD (QUAL)	CUTTHROAT (MILES)
D	Ripple Cr	Stearns Cr	125 1302W29B	County	69.33	39	1	33	7.01	0.57	5.52	0.23	7.01
D	unnamed	Ripple Cr	021(31006)(00294)	County	43.67	1282	3	33	0.15	0.5	0.15	0.2	0.15
D	unnamed	Ripple Cr	125 1302W32A	Private	53.33	423	1	33	1.22	0.54	1.22	0.22	1.22
D	Ripple Cr	Stearns Cr	021(31013)(02326)	County	64.67	75	1	67	7.37	0.57	5.89	0.23	7.37
D	Ripple Cr	Stearns Cr	021(31013)(02557)	County	67.00	54	1	67	7.84	0.58	6.35	0.23	7.84
D	unnamed	Stearns Cr	125 1302W30A	Private	45.00	1147	3	67	1.85	0.47	0	-	1.85
D	unnamed	Stearns Cr	125 1302W19B	Private	47.33	897	2	33	0.86	0.45	0.14	0.24	0.86
D	unnamed	Stearns Cr	125 1303W25A	Private	43.67	1250	3	67	1.66	0.52	0.94	0.24	1.66
D	unnamed	WF Stearns Cr	125 1303W35A	Private	50.67	615	2	33	1.01	0.32	0.02	0.29	1.01
D	WF Stearns Cr	Stearns Cr	021(22850)(02861)	County	54.00	381	1	67	3.5	0.56	0.92	0.3	3.5
D	unnamed	WF Stearns Cr	021(22850)(02609)	County	43.33	1292	3	67	1.18	0.53	0.6	0.23	1.18
D	unnamed	Stearns Cr	601399	County	41.67	1478	3	33	0.16	0.5	0.16	0.17	0.16
D	unnamed	Stearns Cr	125 1302W19A	Private	44.67	1183	3	33	0.53	0.43	0.53	0.17	0.53
D	unnamed	Stearns Cr	132111375	Private	45.33	1133	3	0	0.24	0.32	0	-	0.24
D	unnamed	Stearns Cr	125 1303W24G	Private	41.67	1479	3	33	0.13	0.36	0	-	0.13
D	unnamed	Stearns Cr	125 1303W24A	Private	41.67	1464	3	67	0.43	0.49	0.3	0.32	0.43
D	unnamed	Stearns Cr	125 1302W20A	County	40.33	1609	4	67	0.21	0.55	0.21	0.23	0.21
D	unnamed	Stearns Cr	125 1303W24B	Private	40.67	1558	4	67	0.32	0.5	0.32	0.42	0.32
D	unnamed	Stearns Cr	125 1303W23A	Private	45.00	1151	3	33	0.95	0.51	0.31	0.24	0.95
D	unnamed	Stearns Cr	021(24038)(07422)	County	53.00	440	1	0	1.75	0.47	1.12	0.22	1.75
D	unnamed	Stearns Cr	125 1303W14B	Private	44.00	1236	3	67	2.91	0.49	1.52	0.22	2.91
D	unnamed	Stearns Cr	125 1303W14A	Private	45.67	1049	3	67	3.2	0.56	1.81	0.24	3.2
D	unnamed	Stearns Cr	132051003	Private	40.67	1559	4	67	0.29	0.7	0.28	0.23	0.29
D	unnamed	Mill Cr	021(24002)(01773)	County	42.33	1424	3	0	0.1	0.21	0	-	0.1
D	unnamed	Mill Cr	021(24002)(01321)	County	41.33	1503	3	67	0.33	0.42	0.33	0.18	0.33
D	Mill Cr	Chehalis R	021(24002)(01242)	County	48.67	767	2	67	3.17	0.54	0.77	0.22	3.17
D	unnamed	Mill Cr	021(24007)(00707)	County	42.33	1376	3	67	1.51	0.5	0.31	0.22	1.51
D	Mill Cr	Chehalis R	021(24005)(01131)	County	63.67	92	1	33	8.13	0.6	3.34	0.34	8.13
D	Mill Cr	Chehalis R	601165	Private	63.67	93	1	33	8.13	0.6	3.34	0.34	8.13
D	Mill Cr	Chehalis R	601310	Private	59.67	156	1	33	9.27	0.6	3.9	0.34	9.27
D	Mill Cr	Chehalis R	601311	Private	73.00	23	1	0	9.53	0.6	4.07	0.33	9.53

Source: WDFW. 2020. Prioritized Chehalis Barriers – May 2020. Available Online: https://www.arcgis.com/apps/mapviewer/index.html?webmap=f6292ce1e0c24c3ea69285d4aa7cc716 [Accessed April 21, 2022]

- A GIS online map and Excel based prioritization tool to help promote restoration of top 10 to 33 percent of ranked barriers within the Chehalis River Basin.
- Includes data from WDFW Fish Passage Data, SWIFD Fish Distribution, WDFW Thermalscape, and NOAA Life Cycle Inputs datasets.
- Model designed to produce Score to indicate Prioritization
  - Model metrics include: barrier passability, habitat quantity and quality, number of species benefitting, number of downstream and upstream barriers, road density, water quality, stream temperature, predicted future stream temperatures, and canopy cover.

- Culverts assigned rank by score
- Priority (1-4) determined by quartile of score
  - 1 = top 25% of ranked scores, high priority
  - 2 = 25 to 50 % ranked scores, medium priority
  - 3 = 50 to 75% ranked scores, medium priority
  - 4 = 75 to 100% ranked scores, lower priority
- Fish barriers that are currently funded for removal or modification by the Washington Department of Transportation have been removed.

* Barrier no. 125 1304W03A on Nicholson Creek in Reach C was also included in the WDFW Fish Passage Sites inventory and was indicated to be potential Chinook salmon habitat. No linear habitat gain, specific to Chinook was indicated.

Attachment 1, Table 2
Additional Fish Passage Barriers Identified by WDFW Within the Upper Chehalis Basin Mitigation Reaches A Through D

REACH	TRIBUTARY	TRIBUTARY TO	BARRIER ID	OWNER TYPE	PRIORITY INDEX	BARRIER PASSABILITY	LINEAR HABITAT GAIN (MILES)	COHO (PRESENCE)	STEELHEAD (PRESENCE)	CUTTHROAT (PRESENCE)	RESIDENT TROUT (PRESENCE)
A	Alder Cr	Chehalis R	23.1185 0.0 0	Private		33	1.50	Yes	Yes		Yes
B	unnamed	Salmon Cr	940387	Private	3.90	0	0.01	Yes	Yes	Yes	Yes
B	unnamed	Rock Cr	990079	State		Unk now n	0.31	Yes	Yes	Yes	Yes
B	unnamed	Rock Cr	991654	State	3.74	0	0.10		Yes	Yes	Yes
B	unnamed	Rock Cr	940347	State	6.88	0	0.49		Yes	Yes	Yes
B	unnamed	Rock Cr	990141	State		33	0.09				Yes
B	unnamed	Rock Cr	940352	State	2.17	33	0.24				Yes
B	unnamed	Rock Cr	125 1205W0 5B	State	12.8 4	0	0.07	Yes	Yes	Yes	Yes
B	Water Mill Cr	Rock Cr	990473	State		67	0.12				Yes
C	unnamed	Deer Cr	132081574	Private		0	0.31				Yes
C	unnamed	Deer Cr	132081575	Private		0	0.34				Yes
C	unnamed	Chehalis R	930854	Private	5.02	33	0.03	Yes	Yes	Yes	Yes
C	unnamed	Chehalis R	930852	State	5.39	67	0.29	Yes	Yes	Yes	Yes
C	unnamed	Chehalis R	930851	Private	7.24	67	0.33	Yes	Yes	Yes	Yes
C	unnamed	Chehalis R	938430	Private	9.28	33	0.41	Yes	Yes	Yes	Yes
C	unnamed	unnamed Chehalis R trib	990751	State	6.24	67	0.52	Yes	Yes	Yes	Yes
C	unnamed	Chehalis R	990753	State	1.64	33	0.58				Yes
C	unnamed	Chehalis R	991542	State		0	0.01				Yes
C	unnamed	Chehalis R	930857	Private	2.18	0	0.29				Yes
C	unnamed	Hope Cr	933486	Private	6.96	0	0.38	Yes	Yes	Yes	Yes
D	unnamed	Chehalis R	940375	State		33	0.02				Yes
D	unnamed	unnamed	021(23655)(00173)	County	10.7 6	0	0.66	Unk no wn fish use			
D	unnamed	Chehalis R	999125	Private	5.69	0	0.18		Yes	Yes	Yes

REACH	TRIBUTARY	TRIBUTARY TO	BARRIER ID	OWNER TYPE	PRIORITY INDEX	BARRIER PASSABILITY	LINEAR HABITAT GAIN (MILES)	COHO (PRESENCE)	STEELHEAD (PRESENCE)	CUTTHROAT (PRESENCE)	RESIDENT TROUT (PRESENCE)
D	unnamed	Chehalis R	999122	Private	21.64	67	7.46				

Source: WDFW. 2022. Washington State Fish Passage, WDFW Fish Passage Sites. Available Online: https://geodataservices.wdfw.wa.gov/hp/fishpassage/index.html [Accessed April 21, 2022].

- Fish barriers documented in the WDFW Fish Passage database that were not included in the WDFW Prioritized Chehalis Fish Barriers dataset.
- Fish barriers that are currently funded for removal or modification by the Washington Department of Transportation have been removed.
- Priority index indicates relative priority of a fish barrier removal based on the benefits to fish.
  - Priority Index model metrics include quantity and quality of fish habitat upstream, fish usage of the stream, status of the fish stock, cost of culvert replacement.
- Table only includes fish barriers with an indicated Linear Habitat Gain
  - Linear Habitat Gain is the miles of potential habitat that would be accessible should the barrier be corrected. These data were measured/calculated by conducting a physical survey of habitat upstream of the barrier.

ATTACHMENT 2 – Species List

Tables included in Attachment 2:

Table 1. Fish Species Present in the Mitigation Area

Table 2. Special Stats and Priority Fish Species and Essential Habitat in the Mitigation Area and Chehalis Basin

Table 3. Bird Species That Could Potentially Be Present in the FRE Facility Impact Area and Do Not Have Species Status (source: Ecology 2020a)

Table 4. Wildlife Species with Special Status That Could Potentially Occur in the FRE Impact Area (Source Ecology 2020a)

Attachment 2, Table 1

Fish Species Present in the Mitigation Area. Sources: Hiss and Knudsen 1993; Wydoski and Whitney 2003; Hughes and Herlihy 2012; Hayes et al. 2015, 2019.

FAMILY GROUP	COMMON NAME	SCIENTIFIC NAME	HABITAT USE
Native Fishes			
Lampreys	Western brook lamprey	*Lampetra richardsonii*	Freshwater
Minnows	Longnose dace	*Rhinichthys cataractae*	Freshwater
Minnows	Northern Pikeminnow	*Ptychocheilus oregonensis*	Freshwater
Minnows	Peamouth	*Mylocheilus caurinus*	Freshwater
Minnows	Redside shiner	*Richardsonuis balteatus*	Freshwater
Minnows	Speckled dace	*Rhinichthys sculus*	Freshwater
Minnows	Mountain whitefish	*Prosopium williamsoni*	Freshwater
Salmonids	Rainbow trout	*Oncorhynchus mykiss*	Freshwater
Salmonids	cutthroat trout	*Oncorhynchus clarkii*	Freshwater/ Anadromous
Salmonids	Coast range sculpin	*Cottus aleauticus*	Freshwater/ Brackish
Sculpins	Prickly sculpin	*cottus asper*	Freshwater/ Brackish
Sculpins	Reiculate sculpin	*Cottus perplexus*	Freshwater
Sculpins	Riffle sculpin	*cottus gulosus*	Freshwater
Sculpins	Shorthead sculpin	*cottus confusus*	Freshwater
Sculpins	Torrent sculpin	*Cottus rhotheus*	Freshwater
Sticklebacks	3-spined stickleback	*Gasterosteus aculeatus*	Freshwater/Brackish/ Anadromous
Suckers	Largescale sucker	*Catostomuc macrocheilus*	Freshwater
Non-native Fishes			
Carps	common carp	*Cyprinus carpio*	Freshwater
Carps	goldfish	*Carassius auratus*	Freshwater
Catfishes	Brown bullhead	*Ameriurus nebulosus*	Freshwater
Perches	Yellow perch	*Perca flavescens*	Freshweter
River Herrings	American shad [2,3]	*Also sapidissima*	Anadromous
Sunfishes	Black crappie	*Promoxis nigromaculatus*	Freshwater
Sunfishes	Bluegill	*Lepomis macrochirus*	Freshwater
Sunfishes	Largemouth bass	*Micropterus salmonides*	Freshwater
Sunfishes	Pumpkinseed	*Lepomis gibbosus*	Freshwater
Sunfishes	Rock bass	*amblolites rupestris*	Freshwater
Sunfishes	Smallmouth bass	*Micropterus dolomieu*	Freshwater

Notes:
1. Indicates lower Chehalis River species.
2. No significant spawning populations known to occur in the Chehalis River.

Attachment 2, Table 2

Special Stats and Priority Fish Species and Essential Habitat in the Mitigation Area and Chehalis Basin

FAMILY GROUP	COMMON NAME	SCIENTIFIC NAME	STATE PRIORITY SPECIES STATUS	FEDERAL ENDANGERED SPECIES ACT STATUS	PRIORITY AREA	HABITAT USE
Lampreys	Pacific lamprey	*Entosphernus tridentata*	Non listed, tribal importance	Not listed, Species of Concern	any occurrence	Anadromous
Lampreys	western river lamprey	*Lampetra ayresi*	Candidate [2]	Not listed	any occurrence	Anadromous
Mudminnow	Olympic mudminnow	*Novumbra hubbsi*	Sensitive [2]	Not listed	any occurrence	Freshwater
Salmonids	Chehalis fall-run Chinook salmon	*Oncorhynchus tshawytscha*	Candidate	Washington Coast evolutionarily significant unit (ESU), not listed	any occurrence	Anadromous
Salmonids	Chehalis spring-run Chinook salmon	*Oncorhynchus tshawytscha*	Candidate	Washington Coast ESU, not listed	any occurrence	Anadromous
Salmonids	Grays Harbor fall-run chum salmon	*Oncorhynchus keta*	Candidate	Pacific Coast ESU: not listed	any occurrence	Anadromous
Salmonids	Coastal/Puget Sound bull trout	*Salvelinus confluentus*	Candidate [2]	Threatened	any occurrence	Anadromous
Salmonids	Coastal resident-sea run cutthroat trout	*Oncorhynchus clarkii*	Priority	Not listed	any occurrence	Freshwater or Anadromous
Salmonids	Chehalis coho salmon	*Oncorhynchus kisutch*	Priority	Southwest Washington ESU: Not listed	any occurrence	Anadromous
Salmonids	Steelhead	*Oncorhynchus mykiss*	Candidate (steelhead)	Southern Washington Distinct Population Segment (DPS): Not listed	any occurrence	Freshwater or Anadromous
Smelt	Eulachon	*Thaleichthys pacificus*	Candidate [2]	Southern DPS: Threatened	Regular concentration	Anadromous

FAMILY GROUP	COMMON NAME	SCIENTIFIC NAME	STATE PRIORITY SPECIES STATUS	FEDERAL ENDANGERED SPECIES ACT STATUS	PRIORITY AREA	HABITAT USE
Smelt	Longfin smelt	*Sprinchus tahleichthys*	Priority	Under Review	Breeding areas and regular concentrations	Anadromous
Sturgeons	Green sturgeon	*Acipenser medirostris*	Priority	Southern DPS: Threatened	any occurrence	Anadromous
Sturgeons	White sturgeon	*Acipenser transmontanus*	Priority [2]	Not listed	any occurrence	Anadromous

Notes:
Sources WDFW 2019 a, 2019b.
1. Species are a priority only when occur within known limiting habitats or priority areas. If limiting habitats are unknown, or species are rare, the priority area is described as "any occurrence."
2. Included as a Species of Greatest Conservation Need in Washington State's Wildlife Action Plan.
3. No spawning populations of green sturgeon are known to occur in the Chehalis River.

Attachment 2, Table 3
Bird Species That Could Potentially Be Present in the FRE Facility Impact Area and Do Not Have Species Status

COMMON NAME	SCIENTIFIC NAME	COMMON NAME	SCIENTIFIC NAME
Band-tailed pigeon	*Columba fasciata*	Oregon vesper sparrow	*Pooecetes gramineus affinis*
Black-backed woodpecker	*Picoides arcticus*	Pileated woodpecker	*Dryocopus pileatus*
Cavity-nesting ducks	*NA*	Shorebirds	*NA*
Cavity-nesting ducks: Barrow's goldeneye	*Bucephala islandica*	Slender-billed white-breasted nuthatch	*Sitta carolinensis aculeata*
Cavity-nesting ducks: Bufflehead	*Bucephala albeola*	Sooty grouse	*Dendragapus fuliginosus*
Cavity-nesting ducks: Common goldeneye	*Bucephala clangula*	Trumpeter swan	*Cygnus buccinator*
Cavity-nesting ducks: Hooded merganser	*Lophodytes cucullatus*	Tundra swan	*Cygnus columbianus*
Cavity-nesting ducks: Wood duck	*Aix sponosa*	Vaux's swift	*Chaetura vauxi*
Common loon	*Gavia immer*	Waterfowl concentrations (Anatidae excluding Canada geese in urban areas)	*(Anatidae excluding Canada geese in urban areas)*
Golden eagle	*Aquila chrysaetos*	Western grebe	*Aechmophorus occidentalis*
Great blue heron	*Ardea herodias*	Western Washington breeding concentrations of: Cormorants, Storm-petrels, Terns, Alcids	*Phalacrocoracidae, Hydrobatidae, Laridae, Alcidae*
Harlequin duck	*Histrionicus histrionicus*	Western Washington nonbreeding concentrations of: *Charadriidae, Scolopacidae, Phalaropodidae*	*Charadriidae, Scolopacidae, Phalaropodidae*
Mountain quail	*Oreortyx pictus*	Western Washington nonbreeding concentrations of Loons, Grebes, Cormorants, Fulmar and Shearwaters, Storm-petrels, Alcids	*Gaviidae, Podicipedidae, Phalacrocoracidae, Procellariidae, Hydrobatidae, Alcidae*
Northern goshawk	*Accipiter gentilis*	Wild turkey	*Melegris gallopavo*

Source: Ecology 2020a.

Attachment 2, Table 4
Wildlife Species with Special Status That Could Potentially Occur in the FRE Impact Area

COMMON NAME	SCIENTIFIC NAME	FEDERAL STATUS	STATE PRIORITY SPECIES STATUS
Amphibians			
Dunn's salamander	*Plethodon dunni*	NA	Candidate
Van Dyke's salamander	*Plethodon vandykei*	NA	Candidate
Western toad	*Anaxyrus boreas*	NA	Candidate
Mammals			
Roosevelt elk	*Cervus elaphus roosevelti*	NA	NA
Big brown bat	*Eptesicus fuscus*	NA	NA
Little brown bat	*Myosotis lucifugus*	NA	NA
Townsend's big-eared bat	*Corynorhinus townsendii*	NA	Candidate
Yuma myotis	*Myotis yumanensis*	NA	NA
Mazama (western) pocket gopher	*Thomomys Mazama*	Threatened	Threatened
Wolverine	*Gulo gulo*	Candidate	Candidate
Birds			
Golden eagle	*Aquila chrysaetos*	NA	Candidate
Marbled murrelet	*Brachyramphus marmoratus*	Threatened	Endangered
Northern spotted owl	*Strix occidentalis*	Threatened	Endangered
Oregon vesper sparrow	*Pooecetes gramineus affinis*	NA	Candidate
Band-tailed pigeon	*Columba fasciata*	NA	NA
Easter wild turkey	*Melegris gallopavo silvestris*	NA	NA
Wood duck	*Aix sponsa*	NA	NA
Cavity-nesting ducks	*NA*	NA	NA
Harlequin duck	*Histrionicus histionicus*	NA	NA
Invertebrates			
Taylor's checkerspot	Euphydryas editha taylori	Endangered	Endangered
Puget blue	*Icaria icarioides blackmorei*	NA	Candidate

Source: Ecology 2020a.

Appendix A2
Riparian Buffer Expansion

1 EXISTING CONDITIONS

To support the Aquatic Species Restoration Plan in the Chehalis River basin, National Oceanic and Atmospheric Administration (NOAA) developed a process-based analysis for quantifying historical, current, and future habitat conditions (Beechie et al. 2021). NOAA segmented the stream network into 200 meters (m) (656 feet [ft]) segments and calculated a variety of metrics for each stream segment, including a model of riparian shade based on Seixas and others (Seixas et al. 2018). Seixas and others (Seixas et al. 2018) used light detection and ranging (LiDAR) data to measure canopy opening angle, the angle formed between the channel center and trees on both banks, and then assumed historical tree heights and calculated the change in canopy angle relative to historical conditions. Reductions in riparian vegetation correspond with increases in canopy opening angle.

The Applicant conducted a reanalysis of the NOAA data to identify stream reaches below the FRE facility where the riparian canopy has undergone considerable change. For this analysis, a threshold of a 30 degree change in angle opening was used to indicate degradation from historic conditions. NOAA data show that a change of canopy angle of 30 degrees was associated with stream temperature increases of over 1 degree C.

Current canopy opening angles ranged between 0° (canopy completely closed) and 180° (both banks bare) in the Chehalis Basin (Seixas et al. 2018). The Applicant summarized the distribution of changes in canopy opening angle downstream of the proposed temporary reservoir in Mitigation Reaches B, C, and D. Mainstem Chehalis River and tributary segments were distinguished and were further divided based on bankfull widths into large rivers (>20 m [66 ft]) and small streams (<20 m [66 ft]) within NOAA's data (Beechie et al. 2021).

Reach B included approximately 8.65 miles of stream segments in the mainstem Chehalis River, 40.5 miles of tributary segments classified by NOAA Fisheries as small streams, and 0.6 miles of tributary segments classified as large rivers (Figure A2-1). Canopy angle changes ranged from 68 degrees to less than 1 degree in segments in the mainstem Chehalis River, with approximately 3.25 miles with canopy angle changes between 30 and 68 degrees (Table A2-1). Canopy angle changes ranged from 20 degrees to 12 degrees in segments classified as large rivers. Canopy angle changes ranged from 92 degrees to less than 1 degree in small streams, with approximately 10.9 miles with canopy angle changes over 30 degrees.

Reach C included approximately 12.7 miles of stream segments in the mainstem Chehalis River, 86.8 miles of tributary segments classified by NOAA Fisheries as small streams, and 2.5 miles of tributary segments classified as large rivers (Figure A2-2). Canopy angle changes ranged from 63 degrees to 1 degree in segments in the mainstem Chehalis River, with approximately 4.8 miles with canopy angle changes between 30 and 63 degrees (Table A2-1). Canopy angle changes ranged from 38 degrees to less than 1 degree in segments classified as large rivers, with approximately 0.4 miles with canopy angle changes between 30 and 38 degrees (Table A2-1). Canopy angle changes ranged from 179 degrees to 0 degrees in small streams, with approximately 14.2 miles with canopy angle changes over 30 degrees.

Reach D included approximately 13.45 miles of stream segments in the mainstem Chehalis River, 208.1 miles of tributary segments classified by NOAA Fisheries as small streams and 36.5 miles of tributary segments classified as large rivers (Figure A2-3). Canopy angle changes ranged from 105 degrees to 10 degrees in segments in the mainstem Chehalis River, with approximately 7.3 miles with canopy angle changes between 30 and 105 degrees (Table A2-1). Canopy angle changes ranged from 133 degrees to less than 1 degree in tributary segments classified as large rivers, with approximately 21.9 miles with canopy angle changes between 30 and 133 degrees (Table A2-1). Canopy angle changes ranged from 179 degrees to 0 degrees in small streams, with approximately 82.9 miles with canopy angle changes over 30 degrees.

Table A2-1
Summary of Changes in Canopy Opening Angle by Impact Area, Macrohabitat Type, and Reach of the Chehalis River

				CANOPY OPENING CHANGE >30 DEGREE	
IMPACT AREA	**HABITAT TYPE**	**REACH**	**STREAM MILES**	**SEGMENT COUNT**	**STREAM MILES**
Upstream of Temporary Reservoir	Large River	A	13.26	43	5.37
	Small Stream	A	28.20	78	9.70
Temporary Reservoir Tributaries	Small Stream	A	11.69	26	3.24
Reach A Subtotal			**53.15**	**147**	**18.31**
Downstream Mainstem	Large River	B	8.65	26	3.25
		C	12.67	39	4.82
		D	13.45	59	7.32
Downstream Mainstem Subtotal			**34.77**	**124**	**15.39**
Downstream Tributaries	Large River	B	0.61	0	0.00
		C	2.51	3	0.37
		D	36.53	176	21.91
	Small Stream	B	40.53	88	10.92
		C	86.80	114	14.21
		D	208.09	667	82.87
Downstream Tributary Subtotal			**375.07**	**1,048**	**130.28**
	Total		**409.8**	**1,172**	**145.7**

Figure A2-1
Changes in Canopy Opening Angle in Segments of the Mainstem, Small Stream Tributaries and Large River Tributaries in Reach B of the Chehalis River Basin

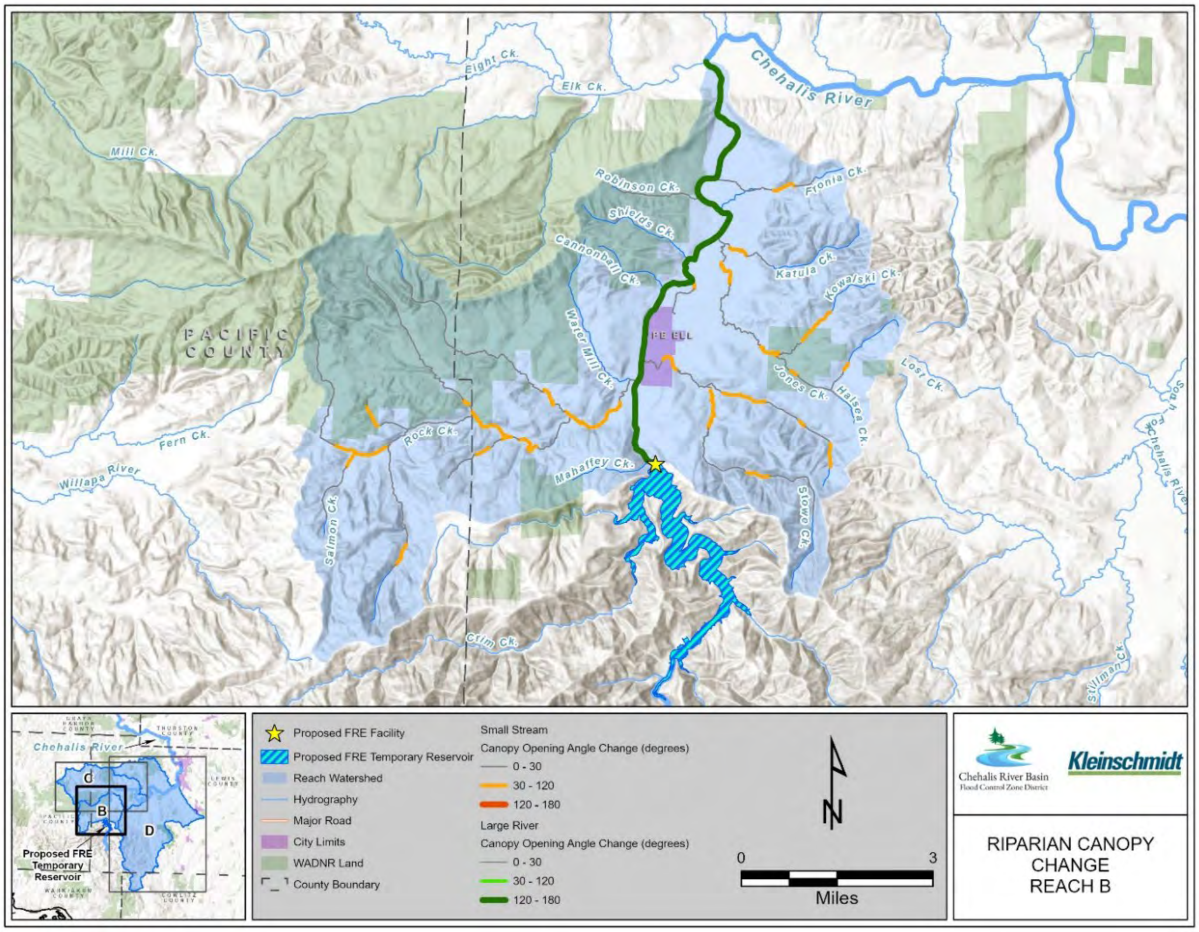


Figure A2-2
Changes in Canopy Opening Angle in Segments of the Mainstem, Small Stream Tributaries and Large River Tributaries in Reach C of the Chehalis River Basin

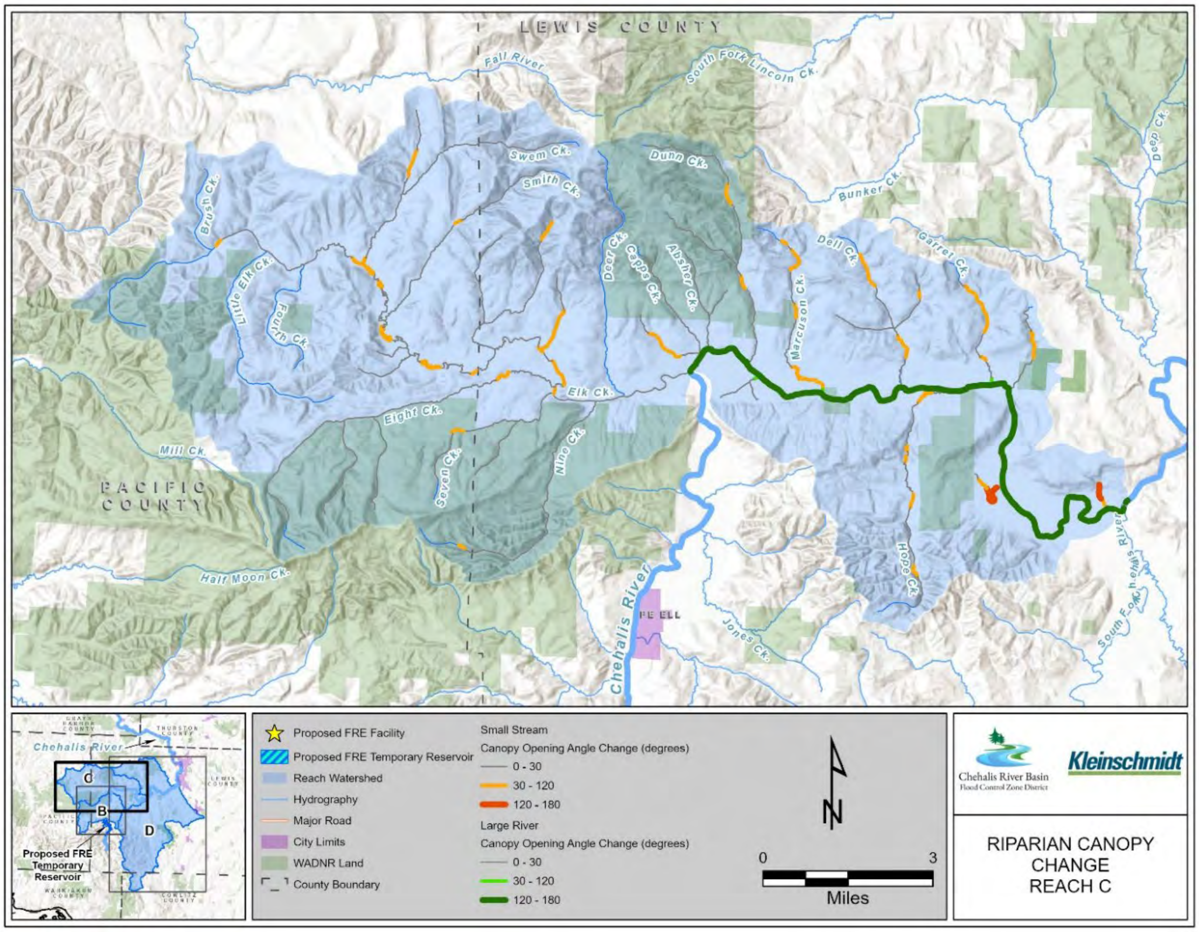
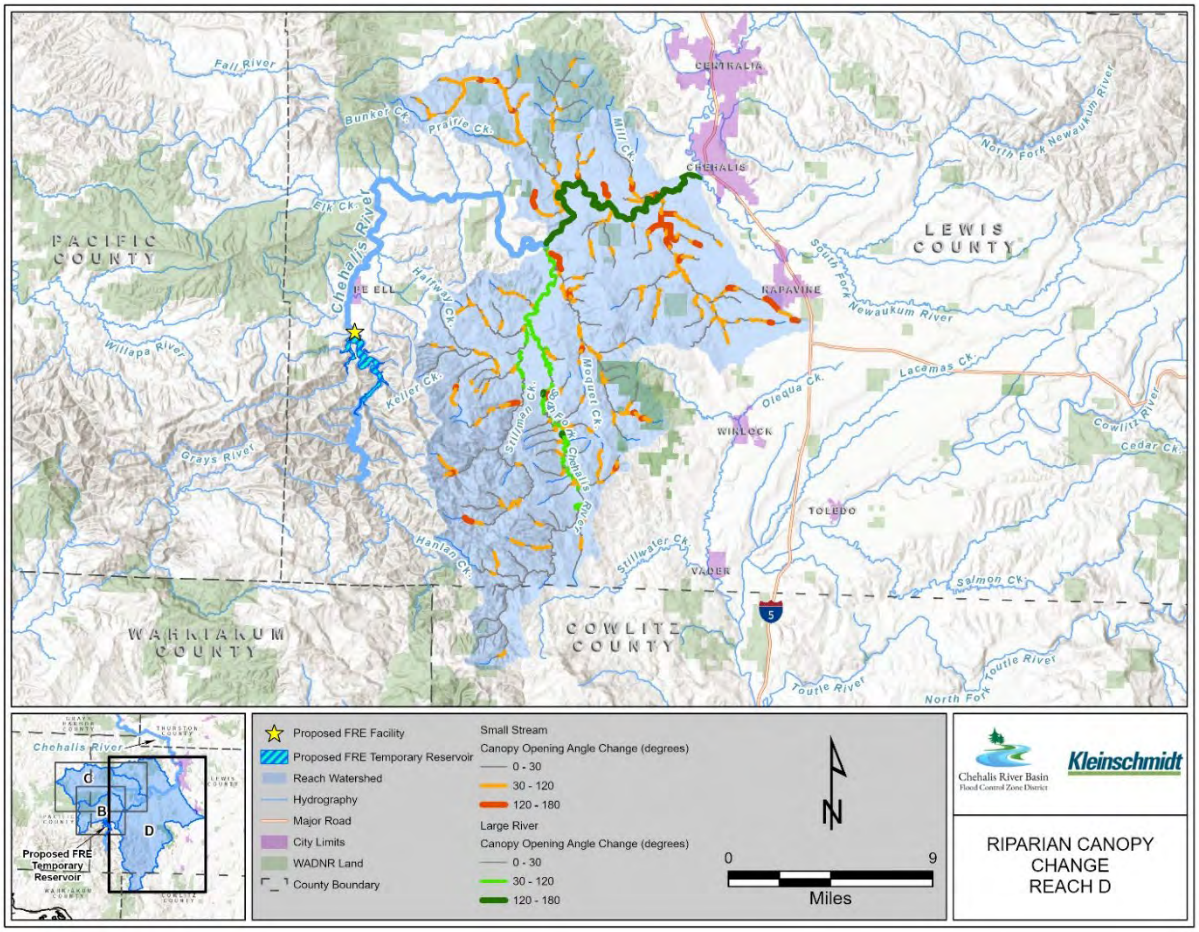


Figure A2-3
Changes in Canopy Opening Angle in Segments of the Mainstem, Small Stream Tributaries and Large River Tributaries in Reach D of the Chehalis River Basin



2 MITIGATION PRIORITIZATION

This reanalysis of existing riparian shade information has identified a total of 145.7 miles of degraded riparian habitat that provide opportunity for riparian enhancement and improved thermal buffering. In Mitigation Reaches B, C, and D within the mainstem Chehalis River, 15.4 miles of potential opportunity was evident, while 130.3 miles were evident in tributaries. The ecological benefit associated with restoring stream canopy open angles would be increased stream shade, decreased solar radiation, and correspondingly reduced water temperatures. The enhanced riparian forest would act to locally buffer air temperatures for wildlife species and over time increase large wood for instream and wildlife habitat.

3 REFERENCES

Beechie, T. J., C. Nicol, C. Fogel, J. Jorgensen, J. Thompson, G. Seixas, J Chamberlin, J. E. Hall, B. Timpane-Padgham, P. Kiffney, S. Kubo, and J. Keaton, 2021. Modeling effects of habitat change and restoration alternatives on salmon in the Chehalis River basin using a salmonid life cycle model. Phase 1 Contract Report. NOAA Contract Report NMFS-NWFSC-CR-2021-01, Seattle.

Seixas G.B., T.J. Beechie, C. Fogel, and P.M. Kiffney, 2018. Historical and future stream temperature change predicted by a Lidar-based assessment of riparian condition and channel width. JAWRA Journal of the American Water Resources Association. 2018 Aug;54(4):974-91.

Appendix A3
Approach for Aquatic Habitat Enhancements Site Selection

1 INTRODUCTION

The Kleinschmidt team performed reach-scale geomorphic analyses to support the assessment and prioritization of river and fish habitat restoration opportunities in the Chehalis River. Candidate project opportunities that were identified in the Mitigation Opportunities Assessment Report (MOAR; Kleinschmidt 2020) were reviewed for consistency and compatibility with natural reach-scale hydraulic and sediment transport processes so they are as effective as possible in restoring and protecting salmon habitat, while considering constraints of land use and infrastructure. The Kleinschmidt team analyzed data specific to the geomorphic assessment with the following goals:

1. Identify reach scale patterns of flooding and channel morphology;
2. Evaluate hydraulic and sediment transport processes that will influence future conditions and channel location in the reach;
3. Identify the most geomorphically active and inactive segments with each reach relative to vertical and lateral instability and stability, respectively;
4. Identify the frequency of channel-floodplain connectivity for existing floodplain flow paths and off-channel habitats; and
5. Qualify the likelihood of project success associated with different restoration activities for each level of geomorphic activity and channel-floodplain connectivity.

The conceptual analytical framework is based on the concept that specific habitat enhancement action types will have the highest probability of success if they are matched to the dominant reach-scale geomorphic processes that affect their function and persistence. For example, actions that provide habitat more commonly found under dynamic channel shifting conditions have the highest probability of functioning properly when they are located where hydraulic and sediment transport processes strongly favor deposition of sediments and channel migration. These segments tend to be the most active geomorphically. Conversely, actions that provide instream habitat structure will function best when they are located in reaches that are in approximate equilibrium in terms of sediment transport and channel movement (i.e., most inactive geomorphically). Matching action type accordingly is a critical first step towards implementation. In addition, the results of this assessment could be used to help stakeholders better understand river processes that may affect them and how the actions were identified to minimize the potential for unintended consequences.

2 METHODS

2.1 Longitudinal Profile

Longitudinal elevation profiles provide an indication of the effects of large-scale slope changes on longer term sediment transport and deposition patterns than may be indicated by hydraulic modeling alone. Special focus is placed on project types that are located below slope breaks, where long-term deposition can be expected on concave profiles, and greater long-term sediment transport capacity on convex profiles. Longitudinal profiles were developed for water surface and thalweg elevations over the analyzed reach using the existing Chehalis River HEC-RAS model data and predictions for the 2-year flood event.

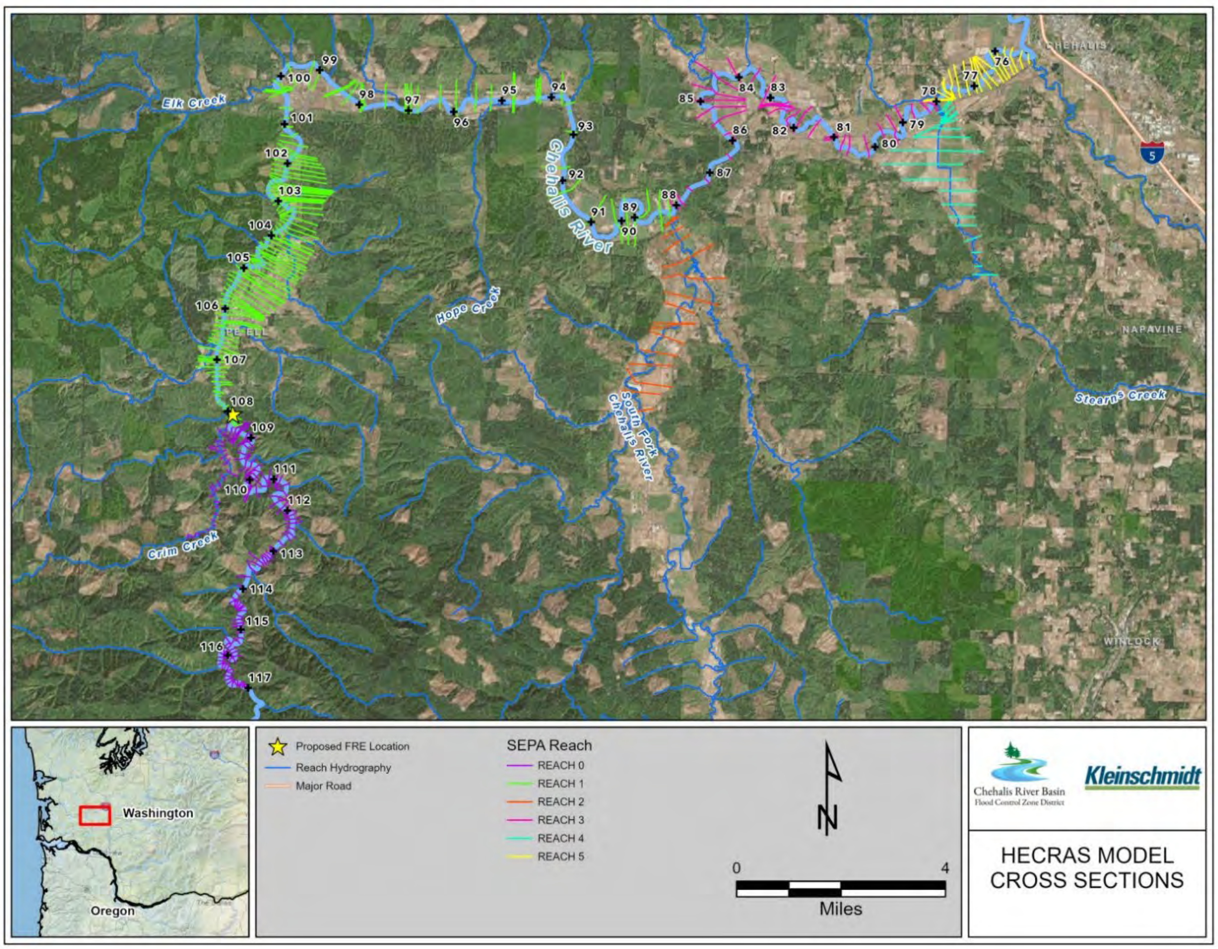
The 2-year flood peak water surface elevation (WSEL) profiles were used to identify general locations of change in stream gradient on a graph. Distance-WSEL data pairs in the HEC-RAS model were accordingly segregated into sub-reaches based on the approximate location of slope breaks, and a linear regression was performed of the distance-elevation profile within each sub-reach to determine the local sub-reach slope. Adjacent sub-reach regression lines were then matched at their crossing points to delineate the slope break locations along the Chehalis River.

2.2 Hydraulic Modeling

A one-dimensional (1D) HEC-RAS model was developed previously for the Chehalis River channel and floodplain to simulate flooding patterns, water temperature, and sediment transport in the mainstem river and significant tributaries (Elliot and Karpack 2014; Van Glubt et al. 2017; Ecology 2020). The model was used for this assessment to ensure consistency. It was run to predict water surface elevations and mean column velocities; and also to predict bedload transport rates in the main channel that could subsequently be used for predicting off-channel habitat connectivity potential and bedload transport, erosion, and depositional patterns in reaches of the Mitigation Area (Figure A3-1). The model and associated geometry, flow, and hydraulic analysis files were obtained through Ecology and Anchor QEA. The model parameters were reviewed, and channel Manning's 'n' roughness values were adjusted initially within selected sub-reaches based on field and aerial photograph observations of substrates and bank vegetation. Roughness values within the steeper, confined sub-reaches upstream of Pe Ell were subsequently increased after a review of model predictions of hydraulic conditions indicated that roughness values resulted in conditions that were too close to critical flow for the prevailing slopes. This condition can arise in 1D modeling when roughness values are underestimated.

The model was used to simulate hydraulics and sediment transport with the flood retention expandable (FRE) facility in place, which under its current design configuration does not start affecting flood hydraulics for flows less than approximately the seven-year recurrence interval event (as determined by projections of flood discharge reaching 38,800 cubic feet per second (cfs) at the Grand Mound stream gage). It is noted that hydraulics with the FRE facility in operation may change with developing design, and that more frequent flood recurrence interval levels under existing conditions (e.g., 2- and 5-year) will occur for a longer duration with the facility in place. The assessment is therefore focused on the feasibility of mitigation projects with the FRE facility in operation. The results are not expected to change substantially should the design or base hydrology change in the future, as the results of this assessment focus primarily on distinguishing floodplain connectivity at the 2-year vs. higher flood levels, and predictions of trapping efficiency should primarily reflect the most geomorphically effective flood levels for sediment transport (cf. Wolman and Miller 1960), such that the model output can be used. In any case, revised flows can be re-evaluated in this assessment if necessary for confirmation when they are made available. The model can also be adapted as needed to predict depths, velocities, and riverbed shear stresses for input as design parameters for specific project elements that are identified as a result of this assessment.

Figure A3-1
Plan Geometry of HEC-RAS Model Cross Sections Used in the Reach Assessment



2.3 Hydrology

Hydrology flow files used previously, and provided with the model, were adopted for this assessment. This was done to ensure consistency with previous modeling efforts. As indicated above, the hydrology reflects the Proposed Action setting. Two sets of flows were simulated depending on the objective of the modeling, as follows:

- An unsteady flow file containing a 30-year daily flow time series from 1988-2018 was simulated for the sediment transport modeling, so that net bedload transport rate differences between consecutive HEC-RAS model cross-sections could be integrated over the 30-year period to calculate a net trapping efficiency (see below for details).
- Flood flows at the 2-, 10-, and 100-year flood levels were extracted from an unsteady flow file provided with the model. Uniform line source inflows that were defined in the provided HEC-RAS model flow files were distributed across bracketed model cross-sections with local flow accretion values calculated proportional to the length of river between cross-sections.

2.4 Vertical Stability Assessment Through Sediment Transport Modeling

A quasi-unsteady sediment transport analysis was performed to characterize vertical stability of the riverbed using the HEC-RAS model. This analysis was based on hourly flow and reservoir elevation data between the upstream extent of the model near approximately River Mile (RM) 117 (HEC-RAS Station 118.17) and the Newaukum River at approximately RM 75 (HEC-RAS station 75.31). The model was used to evaluate cumulative sediment trapping efficiency over the 30-year period simulated, relative to whether the active riverbed area between successive model cross-sections (termed 'analysis segment') was predicted to tend toward net aggradation, net degradation, or the intermediate case where the average active bed elevation would remain effectively unchanged over time. Sediment trapping efficiency, which indicates whether a section of river is likely to aggrade, degrade, or remain relatively unchanged, was computed as the difference in net input and output transport volumes divided by the average width of the active channel bottom and the distance between cross-sections bounding each analysis segment. This calculation was expressed as an annual rate of change in average riverbed elevation.

The sediment transport modeling parameters used by Ecology (2020) were retained, with the primary exception that the estimated incoming sediment load values established for the SEPA analysis were zeroed out at the model boundaries and junctions. Otherwise, the model would have distributed that load and predicted a net increase in bed elevation and stored sediment volume over time throughout most of the modeled reach. This would have masked local variation in aggradation-degradation tendency. A key premise of this assessment is that this tendency is what affects project function and persistence over typical design lifetimes.

Four different total load sediment transport equations that are available in HEC-RAS were evaluated independently. The Wilcock-Crowe equation is the most representative of the four for simulating bedload transport in gravel bed rivers and was therefore the primary basis for evaluating vertical stability. The next most representative, the Yang equation, was based on gravel transport data as well, and was evaluated as corroboration for identification of reaches that are more strongly aggradational or degradational. For example, analysis segments where both equations yielded results consistently indicating an aggradational tendency gave greater confidence in the determination of tendency than where opposing signs (i.e., where + and – represent aggradation and degradation, respectively) were calculated. The Ackers-White and Engelund-Hansen equations were run primarily for additional, analogous corroboration. In general, different sediment transport equations give different results, so consistency in the sign (+/-) of the result was considered to be the best confirmation of overall tendency. Analysis segments with opposing signs of the Wilcock-Crowe and Yang equations will be reviewed more closely as individual project sites are visited in the field for further evaluation of mitigation action suitability.

2.5 Lateral Channel Stability Inferences from Aerial Photograph Interpretation

Lateral migration rates were calculated from aerial photographs. However, the magnitude of calculated annual migration rates reported were within a range that may be representative of typical digitizing measurement error, especially if the data were calculated based on non-georeferenced aerial photographs. The GIS shapefile data were not available at the time of writing, so non-georeferenced, historical Google Earth aerial photographs were reviewed instead to identify locations where notable channel migration has occurred over the past 30 years. General areas were delineated where the channel clearly changed location over time, and the resulting polygons drawn in GIS were used to identify subreaches with the greatest lateral instability. As part of this, the presence of more extensive gravel bar area changes visible in the photographs was used as a surrogate indicator of lateral channel stability.

2.6 Floodplain Connectivity

GIS shape files were obtained from the work of Slaughter and Hubert (2014), in which floodplain and off-channel flow paths were delineated and characterized. A script was run in GIS that identified the highest elevation along each delineated flow path to define the inlet control elevation, thereby allowing identification of the return interval event at which each segment and connected segments downstream and upstream would become connected. The suitability of each flow path for a mitigation project primarily reflected the frequency of connection, which was determined broadly by identifying whether the channel was connected at the 2-year, 10-year, or 100-year event peak flows, based on water surface elevations predicted by the HEC-RAS model for each flow level. Channels connected at the 2-year flood level are considered most effective for restoring floodplain connectivity and may be considered higher priority for selection, whereas channels not connected at the 10-year or higher flood level may not warrant consideration. Channels connected at the 10-year (and not the 2-year) flood level may be considered second tier and could be assessed on a case-by-case basis to determine if there is a road, dike, or other artificial obstruction along the flow path whose removal could present a restoration opportunity for re-engaging more frequent flood levels.

2.7 Criteria for Identifying Feasible MOAR Candidate Sites

A summary of habitat enhancement action types identified in the MOAR (Kleinschmidt 2020) and reach-scale attributes conducive to the function and persistence of each project type are summarized in Table A3-1. Rationales are summarized below accordingly. Each action site was identified as primary if all of the criteria were met and secondary if the site was suitable but not ideal.

2.7.1 Riparian Buffer Expansion

There are various opportunities to establish forest vegetation along channel margins to provide shade and other ecological functions of riparian forests. Washington State’s 2006 Forest Practices Habitat Conservation Plan (HCP) includes measures intended to protect and restore the riparian buffer zone for shade, reduce summer water temperatures, prevent fine sediment delivery from surface erosion, and provide a source of large woody material. For the most part, riparian buffer zones in the mainstem and tributaries upstream of the proposed FRE facility appear to be consistent with the HCP requirements, although there may be selected locations that could benefit from buffer zone expansion. Downstream of the FRE facility, there are various locations along the Chehalis River with floodplain-edge open areas that would benefit from restoration where the results of this assessment can provide greater confidence that buffer zone expansion efforts will be successful. Sites best suited for establishing riparian vegetation are associated with negligible channel migration and stable banks, and with frequent floodplain inundation so that roots are closer to the water table for longer and there is a greater likelihood of seed rain and propagules being transported onsite by floodwaters. The special case of cottonwood forest restoration requires large, active gravel bar areas and a disturbance regime for colonization, which can be associated with notable channel migration and aggradation.

Table A3-1
Summary of Reach-Scale Attributes Suitable for Various Restoration Project Types and Subtypes

PROJECT TYPE	PROJECT SUBTYPE	AGGRADATION (A), NEUTRAL (N) OR DEGRADATION (D) TENDENCY	HISTORIC CHANNEL MIGRATION ACTIVITY	FLOODPLAIN CONNECTIVITY AT FLOOD RECURRENCE INTERVAL	ACTIVE GRAVEL BAR AREA	REACH SLOPE BREAK
Riparian Buffer Expansion	Floodplain Edge Open Areas	N	No	2-Year	N/A	No
	Cottonwood Forest Restoration	A	Yes	2-Year	Yes	Concave
Water Temperature Improvements	Enlarge Identified Lateral Cool Water Inputs	N, D	No	2-Year	No	Convex
	Enlarge Identified Pool Vertical Stratification Area/ Volume	N, D	No	10/ 100-Year	No	No
	Re-meander Straightened Alluvial Reaches	N	N/A	2-Year	N/A	Locally Steeper
	Cool water Tributary Inflows	N, D	No	2-Year	No	N/A
	Reactivate Paleochannels	A(u/s) & D,N(d/s)	Yes	2-Year	N/A	N/A
	Off-Channel Alcoves	N, D	No	2-Year	No	N/A
Instream Modifications	Habitat Complexity	N	No	2-Year	No	No
Off-channel Modifications	Off-Channel Habitat Connectivity	A	Yes	2-Year	No	Concave
Gravel Retention Jams/Boulder Arrays	Promote Deposition via Channel Roughness	A	No	2-Year	Yes (u/s)	Concave Break
	Create hydraulically sheltered gravel deposits in steep channels draining landslide/debris-flow prone hillslopes	A	No	N/A	Yes	Concave

2.7.2 Water Temperature Improvements

The actions most likely to achieve localized reductions in warm water temperatures are those that expand cool water refugia and retard mixing of cool water inputs with the river water column. As such, the results of the geomorphic reach analysis cannot generally discern such locations, and field sampling is required. However, since actions to expand cooler water refuge habitat availability include instream and bank modifications, the results of the assessment can be used primarily to discern locations promoting their persistence. Several types are proposed based on differences in the form thermal refuge habitat is presented:

- Structures that enlarge lateral cool water inputs will persist longer in locations with negligible channel migration to reduce the likelihood of structure failure, and with a neutral aggradation/degradation tendency to reduce the likelihood of structures being buried/scoured away. In addition, locations where overbank flow and floodplain connectivity occur at the 2-year flood would be associated with lower flood energy acting on structures and greater groundwater recharge to lateral inflows. As a subset, channel splits with vegetated islands can be associated with more persistent hyporheic flow expression zones. Actions to maintain split flows would be more persistent under the above conditions.
- Structures or bedrock channel modifications to enlarge the area or volume of pools with identified vertical stratification during summer low flows will function and persist best at locations with a neutral or degradation tendency such that the pool would be less likely to fill with gravel and stay clean. In addition, pool filling is less likely where overbank flow and floodplain connectivity are limited to the 10- or 100-year flood, indicting higher flood energy available for maintaining pool form.
- Re-meandering of straightened reaches is best accomplished where there is a locally steeper reach gradient such that the constructed reach grade is more in line with upstream and downstream gradients. This condition increases the likelihood of maintaining a stable grade after lengthening the channel and reducing the slope locally. In addition, the reach should generally be located within an unconfined alluvial floodplain with overbank flow and floodplain connectivity at the 2-year flood. These conditions are associated with lower required excavation volumes, presence of hyporheic flow, less flow concentration, and stabilizing floodplain vegetation to counter avulsion.

Locations of structures and channel modifications that increase access to, or spatial extent of, features positioned to intercept colder groundwater or hyporheic flow and maintain a cool water pocket to provide thermal refugia (floodplain channels, backwater alcoves, and channel margin pockets) are best associated with negligible channel migration, overbank flow and floodplain connectivity at the 2-year flood, and neutral aggradation/degradation tendency in the vicinity of the connection with the mainstem. The same is true for structures that retard mixing and expand the volume of cool water tributary inflows at their confluence with the Chehalis River. These attributes collectively favor the persistence of structural measures and a reduced likelihood of filling at the junction, and of structure failure through hydraulic forces, burial, or scouring. In the case of reactivating paleochannels with confirmed groundwater expression, conditions most conducive to persistence of connectivity with the mainstem include a history of more active channel migration, aggradation tendency upstream, and neutral or degradation tendency downstream. In those instances, there is a greater likelihood of the river reactivating channels, which has the added benefit of potentially requiring simpler designs that capitalize on the river doing most of the work.

2.7.3 Instream Modifications

This measure involves constructing habitat features in the perennial wetted channel to increase habitat complexity, typically installing large wood material as individual pieces, in arrays, and as distinct engineered log jam (ELJ) structures in various forms. Suitable locations are associated with a neutral aggradation/degradation tendency, negligible channel migration, and absence of a large-scale reach slope break upstream. These characteristics minimize the likelihood of burial, scouring, or abandonment of the modification. In the case of a reach scale slope break, a higher slope upstream is associated with a greater likelihood of burial or abandonment, and a lower slope with scouring out of a structure. While not a general condition for siting, it is noted that locations with floodplain connectivity only at the 10-year flood or higher would require a more robust design.

2.7.4 Off-channel Modifications

Off-channel habitat enhancements include actions to reconnect, enhance, and expand off-channel habitat through side channels, alcoves, and floodplain water bodies. In general, this type of project functions better and lasts longer where floodplain channel connectivity occurs at the 2-year flood level so there is an increased likelihood of flood flows accessing and/or enlarging floodplain channels. In addition, less earthwork and installation of in-channel roughness is required where there is an aggradation tendency and a greater likelihood of channel migration as evidenced by historic channel migration. These conditions also increase the likelihood of flood flows accessing and enlarging floodplain channels into side channels.

2.7.5 Gravel Retention Jams/Boulder Arrays

In general, the goal of gravel retention is to create and maintain spawning habitat. Two important constraints are that there is a sufficient long term gravel supply to the reach, and that gravel retention is not concentrated over a short distance. Otherwise, the risk of scouring of salmonid redds is high due to sediment transport rate imbalances, and species such as Chinook Salmon may not select isolated gravel patches for spawning(Isaak et al. 2007; DeVries 2008; Carnie et al. 2016). Another constraint is that the reach gradient should be steep enough to maintain sufficient throughput of fine sediments that could otherwise impact survival-to-emergence of salmonid embryos. This action involves constructing instream structures composed of large wood pieces or installing boulder roughness elements in arrays to provide hydraulic roughness and hydraulic sheltering. These features promote accumulation and retention of salmonid spawning gravels. Sub-reaches with an aggradation tendency favor the creation, function and persistence of these types of gravel retention actions, and the longer the section of river predicted to exhibit this attribute, the greater the likelihood that sufficient spawning habitat area can be provided. In addition, the presence of gravel bars upstream and locally with a grain size distribution D_{50} that is not substantially coarser than the upper limit of spawning suitability as defined by Kondolf and

Wolman (Kondolf and Wolman 1993), indicates a higher likelihood of being able to settle out gravels that can then provide suitable spawning habitats. This is because increasing roughness leads to fining of gravel deposits, so the initial value should be reasonably close to (if not already within) the target range. Other factors that increase likelihood of gravel sorting include where floodplain channel connectivity occurs at the 2-year flood (which is indicative of lower flood energy and thus reduced washing out of gravels), and evidence of landslides and debris flows originating in geologic units containing gravel material (Miller et al. 2008). Accordingly, supply-limited channels are likely not appropriate sites for this project type.

2.7.6 Fish Passage

Fish passage improvements including removal of small dams and replacement of fish passage barrier culverts with passable stream crossings— are cost-effective mitigation actions (Roni et al. 2002). The geomorphic assessment results cannot be used specifically for assessing the feasibility of this project type because the analysis is restricted to mainstem channels without barriers. However, WDFW's Fish Barrier database can be used to identify candidate barriers requiring correction in tributaries and includes information regarding the amount of spawning and rearing habitat area upstream which can be used to prioritize actions. The geomorphic assessment results can be used to provide supplemental information regarding likelihood of future passage restrictions at the mouth in terms of aggradation potential, after specific tributaries are identified.

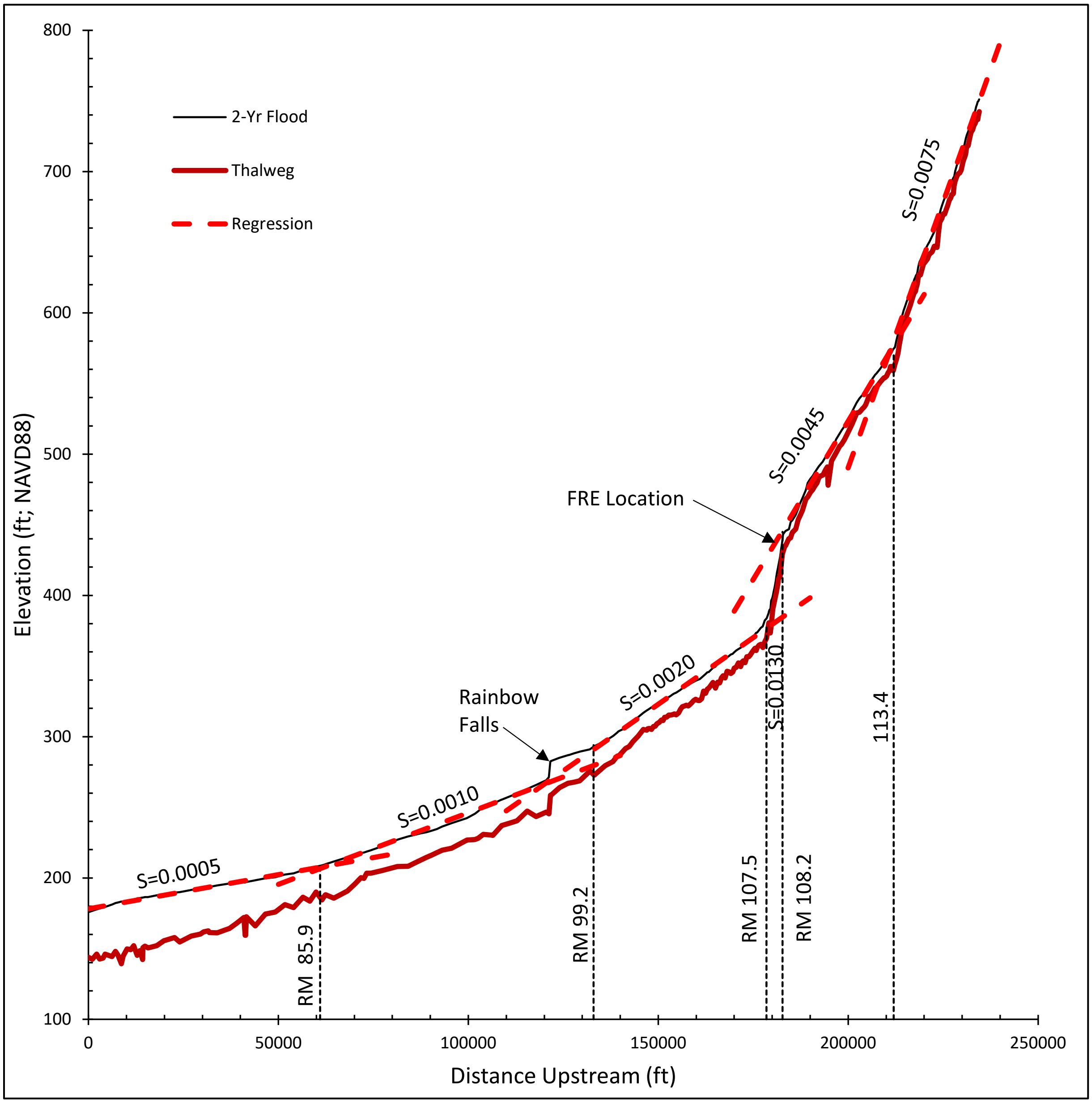
3 RESULTS

3.1 Analytical Results

3.1.1 Longitudinal Profile

The HEC-RAS model indicates the presence of five major breaks in reach slope, with six relatively uniformly graded slopes in between each break (Figure A3-2). This is in contrast to the seven reach breaks defined in the draft SEPA analysis (Ecology 2020). The reach containing the discontinuity that represents Rainbow Falls exhibits a similar slope upstream and downstream of the falls, and thus the two sub-reaches are considered to be similar from a sediment transport process perspective and are combined within the same slope reach. The reach breaks at RM 85.9 and 107.5 are consistent with geomorphic reach breaks delineated in the SEPA analysis, whereas the other break locations differ across the two analyses. All but one of the slope breaks are for a concave profile. The slope break located approximately at the FRE facility is convex, with a steeper, confined transport reach extending downstream to the next slope break at approximately RM 107.5, at the head of the Chehalis River alluvial valley.

Figure A3-2
Longitudinal Profile of Chehalis River Upstream of the Newaukum River, Showing Approximate Locations of Significant Slope Breaks and Corresponding Reach Gradients (S); Regression Lines of the 2-Year Flood Water Surface Elevation Predictions Are Indicated by the Dashed Lines



3.2 Vertical Channel Stability

Figure A3-3 depicts a summary of the sediment transport modeling results for all four transport equations analyzed. In general, the Wilcock-Crowe equation predicts annual average bed elevation change values that are lower than those generated by the other equations, but the calculated magnitudes are generally consistent with values derived using Parker's (Parker 1990) surface-based equation in other assessments (DeVries and Aldrich 2015). A comparison between Wilcock-Crowe and Yang equation predictions indicates approximately 86 percent of the HEC-RAS analysis segments had a similar sign where both equations predicted either aggradation or degradation consistently. The results for Wilcock Crowe are depicted in Figure A3-4.

Figure A3-3
Streamwise Variation in Sediment Trapping Efficiency In The Chehalis River Upstream of Newaukum River, Calculated via Four Transport Equations and Delineated According to Geomorphic Reach Breaks Defined in the SEPA (Ecology 2020; Top) and this Analysis (Bottom). Approximate Extent of Maximum Reservoir Inundation Zone Delineated by Dashed Line Box

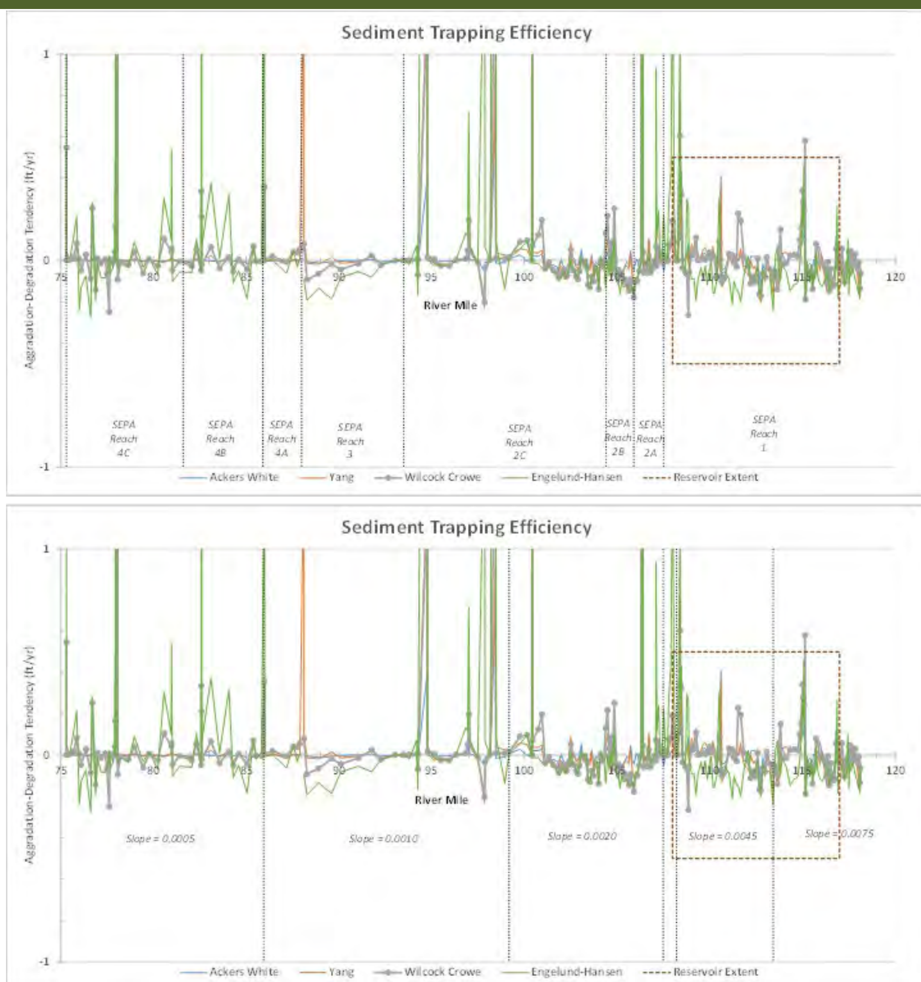
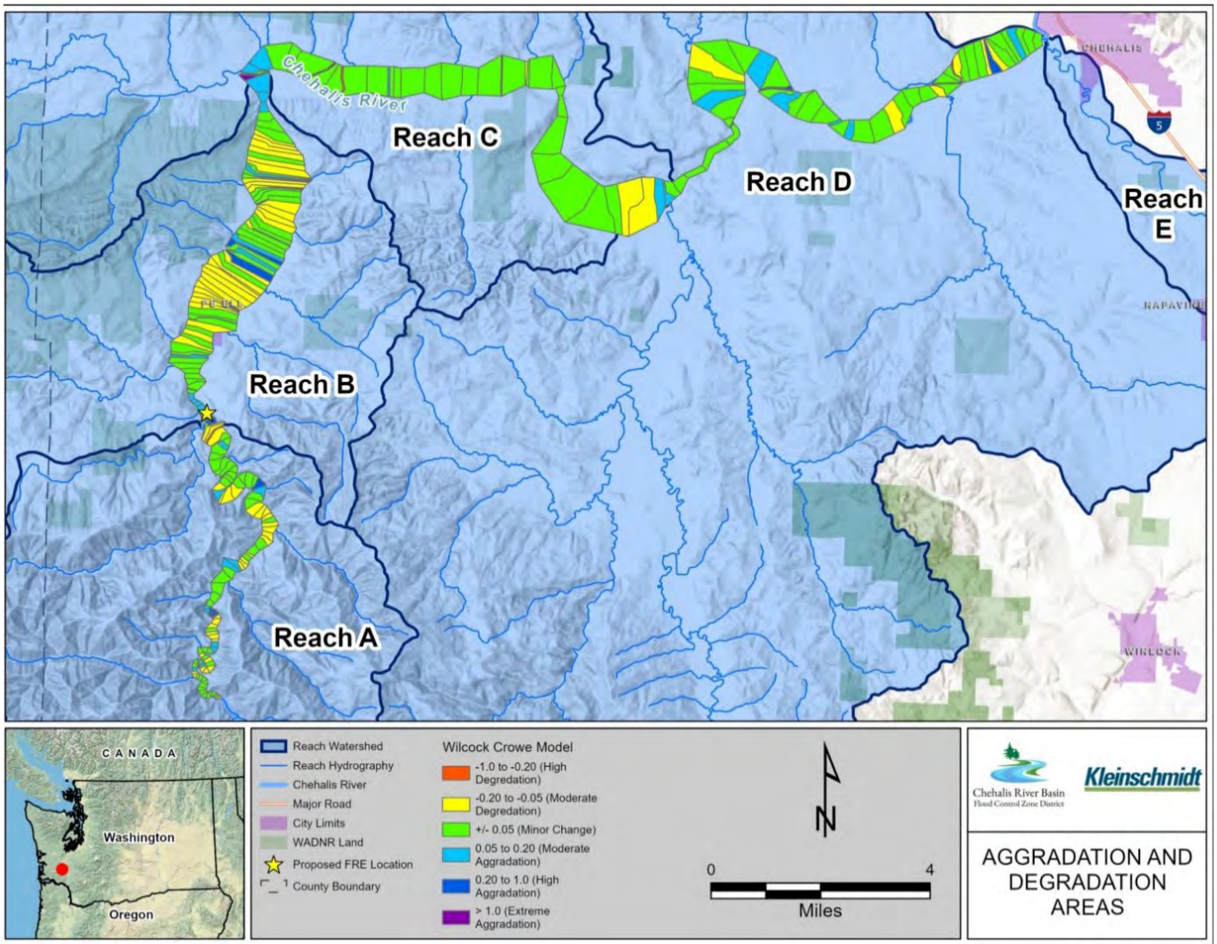


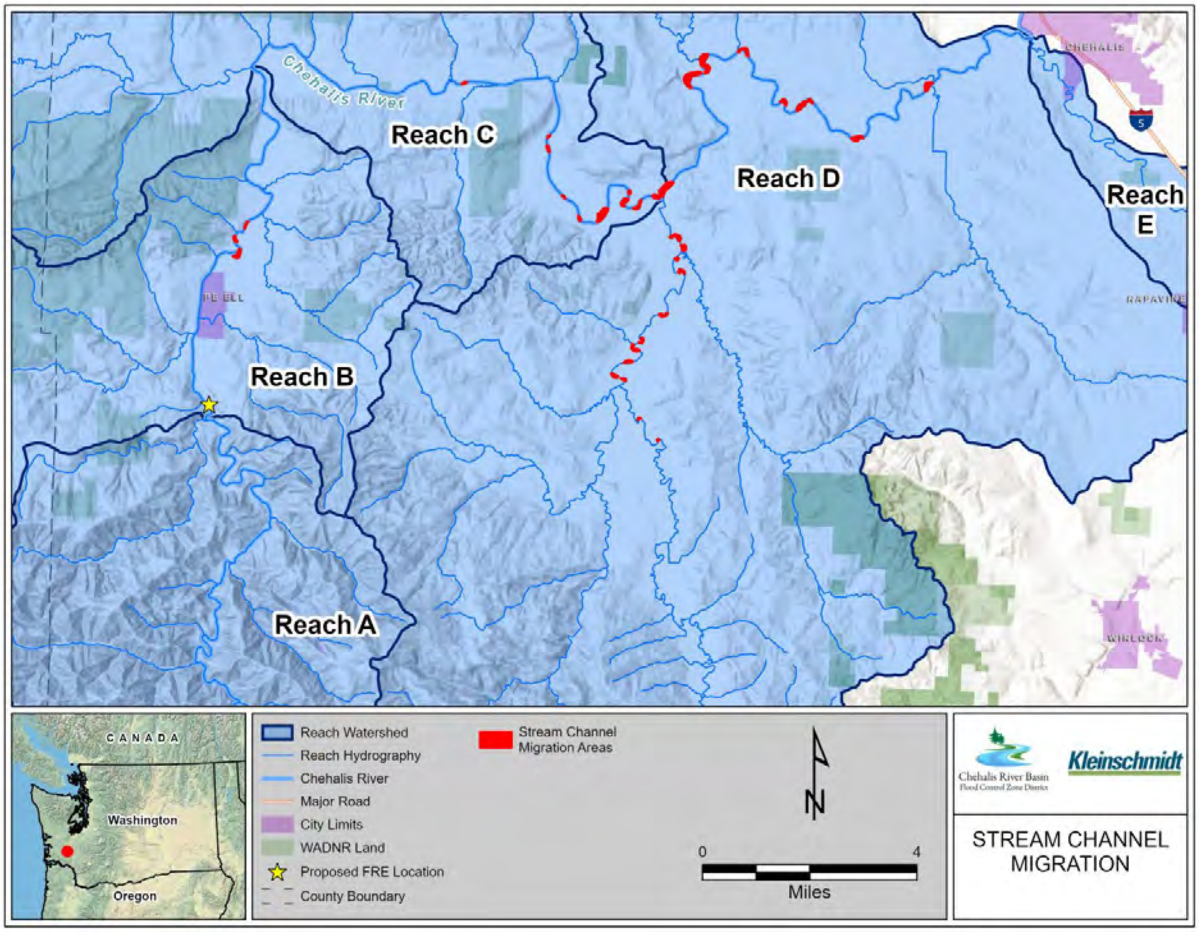
Figure A3-4
Predicted General Aggradation-Degradation Tendency of Analysis Segments in the Chehalis River Integrated Over a 30-year Period, Based on Wilcock-Crowe (Wilcock and Crowe 2003) Bedload Transport Equation and Hydrology Developed Previously for the 1988-2018 Period



3.3 Lateral Channel Stability

Figure A3-5 depicts approximate locations where notable channel migration has occurred over the past 30 years, as seen in Google Earth aerial photographs.

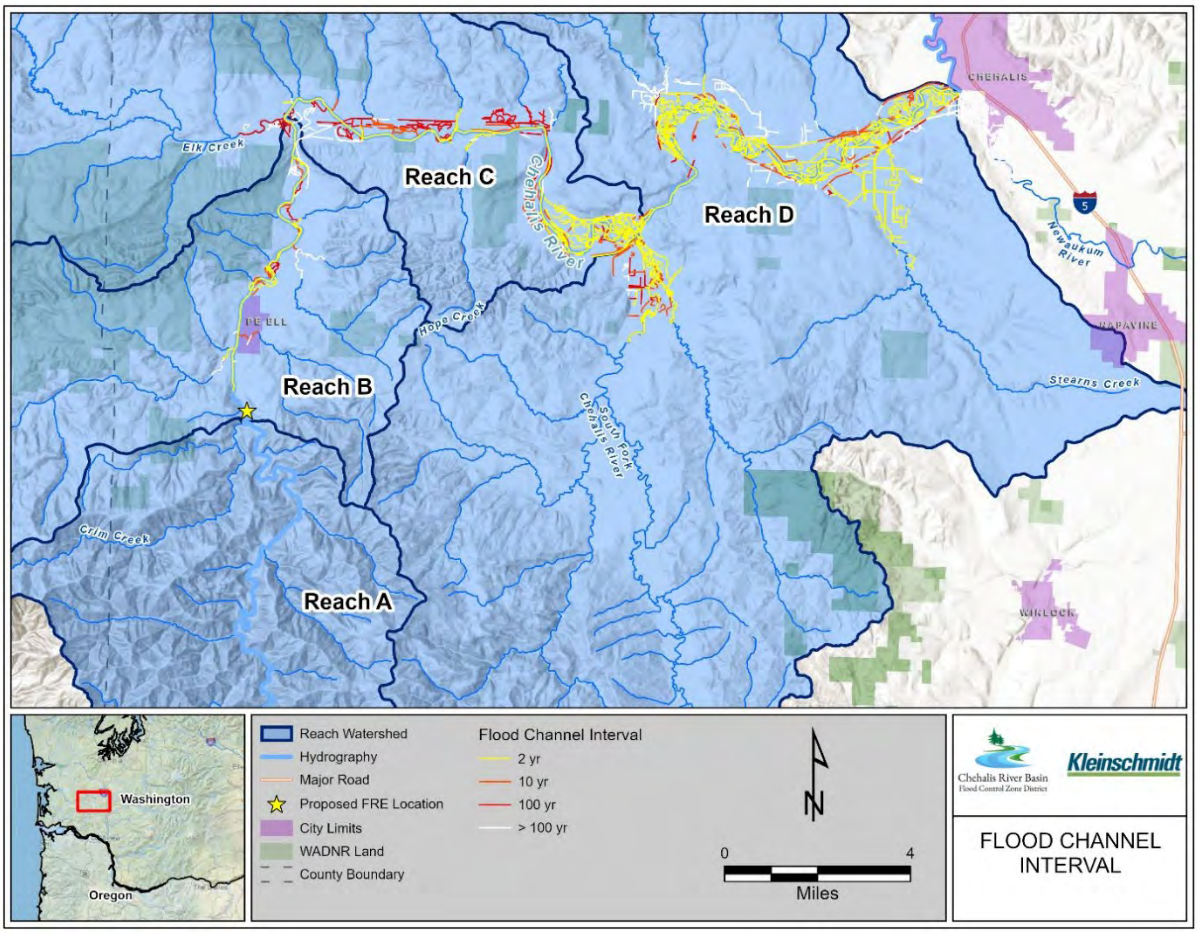
Figure A3-5
Mapped Locations of Major Channel Migration Over Past 30 Years



3.4 Floodplain Connectivity

Figure A3-6 depicts the classifications of floodplain channels according to whether they are engaged at the 2-, 10-, 100-, or greater flood peak flows. There is effectively no significant floodplain connectivity in the steeper confined reaches upstream of RM 107.5. There are limited floodplain connectivity opportunities downstream of RM 107.5 until approximately RM 98.5. Most floodplain connectivity at the 2-year flood appears to occur between RM 92.2 and 87.7, and downstream of RM 85.9. The channel is highly confined between RM 88 and 85.9, downstream of the South Fork Chehalis River, consistent with the reach delineation in the draft SEPA analysis (Ecology 2020). This confinement, combined with the confluence of the South Fork Chehalis and mainstem alluvial valleys, appears to be associated with increased number and degree of cool water inputs to the mainstem in the vicinity of the confluence measured as part of Kleinschmidt's field temperature measurements collected in late summer 2021. The geological control of the constriction, combined with converging down-valley groundwater flows, results in the reach upstream of the confluence containing more opportunities for water temperature improvement projects than other areas.

Figure A3-6
Floodplain Connectivity Characteristics of the Chehalis River As Represented by Differences in Recurrence Intervals at Which Floodplain Channels Are Engaged



3.5 Feasible MOAR Candidate Sites

The MOAR identified a total of 319 sites with 434 aquatic habitat mitigation possibilities (Table A3-2). This application of geomorphic criteria was constrained to the spatial extent of the model of hydraulic and sediment transport processes, which included 107 sites with 132 enhancement actions. These sites represented approximately 33 percent of the sites identified in the MOAR. The most common action types were water temperature improvements (70) and off-channel modifications (37). The potential actions evaluated were relatively more abundant in reaches A (34) and D (51) with fewer sites evaluated in Reaches B, and C, which had 15 and 26 evaluated actions respectively.

Application of geomorphic criteria advanced 56 of the 123 actions identified in the MOAR at 42 of the 107 sites. Sites advanced for further evaluation included 32 actions identified at primary sites and 24 actions identified at secondarily suitable sites. The proportion of actions compatible with reach-scale geomorphic processes varied by project type; a lower proportion of water temperature improvements (23%) were advanced whereas a relatively high proportion of the instream modifications (78%) and gravel retention jam locations (100%) were advanced.

Spatially, actions evaluated with respect to geomorphic criteria were advanced at rates between 42 and 62% in Reaches A, B, and C, but only 30 percent of actions in Reach D met the criteria to be advanced. Many sites were identified as suitable for more than one mitigation action, including both primary and secondary suitability. The number of unique sites identified as candidates for further evaluation included 11 sites in Reach A (Figure A3-7), 7 sites in Reach B (Figure A3-8), 10 sites in Reach C (Figure A3-9) and 14 sites in Reach D (Figure A3-10). Additional sites in each of these reaches may be suitable in areas outside of the spatial extent of the modeling. Although modeling covered the majority of the gravel retention jam sites, the proportion of the other project types evaluated ranged between 11 and 35 percent.

Table A3-2

MOAR Opportunities Advanced as Primary or Secondary Enhancement Actions Based on Reach Scale Attributes Conducive to Function and Persistence

REACH		INSTREAM MODS	OFF CHANNEL MODS	GRAVEL RETENTION JAMS	WATER TEMPERATURE IMPROVEMENTS	WETLAND ENHANCEMENTS	TOTAL ACTIONS	TOTAL SITES
A	MOAR Sites	78	0	8	111	0	197	112
	KA Evaluated	9	0	7	18	0	34	18
	KA Primary	3	0	5	1	0	9	8
	KA Secondary	4	0	2	6	0	12	10
B	MOAR Sites	0	13	0	10	0	23	23
	KA Evaluated	0	6	0	9	0	15	15
	KA Primary	0	1	0	5	0	6	6
	KA Secondary	0	1	0	0	0	1	1
C	MOAR Sites	0	16	0	12	5	33	30
	KA Evaluated	0	11	0	12	3	26	25
	KA Primary	0	4	0	3	0	7	6
	KA Secondary	0	2	0	0	2	4	4
D	MOAR Sites	3	45	0	42	16	106	89
	KA Evaluated	0	20	0	31	6	51	49
	KA Primary	0	8	0	1	1	9	8
	KA Secondary	0	6	0	0	1	6	6
NA	MOAR Sites	2	36	0	24	13	75	65
TOTAL	MOAR Sites	83	110	8	199	34	434	319
	KA Evaluated	9	37	7	70	9	132	107
	KA Primary	3	13	5	10	1	32	28
	KA Secondary	4	9	2	6	3	24	21

Figure A3-7
Enhancement Actions Advanced in Reach A

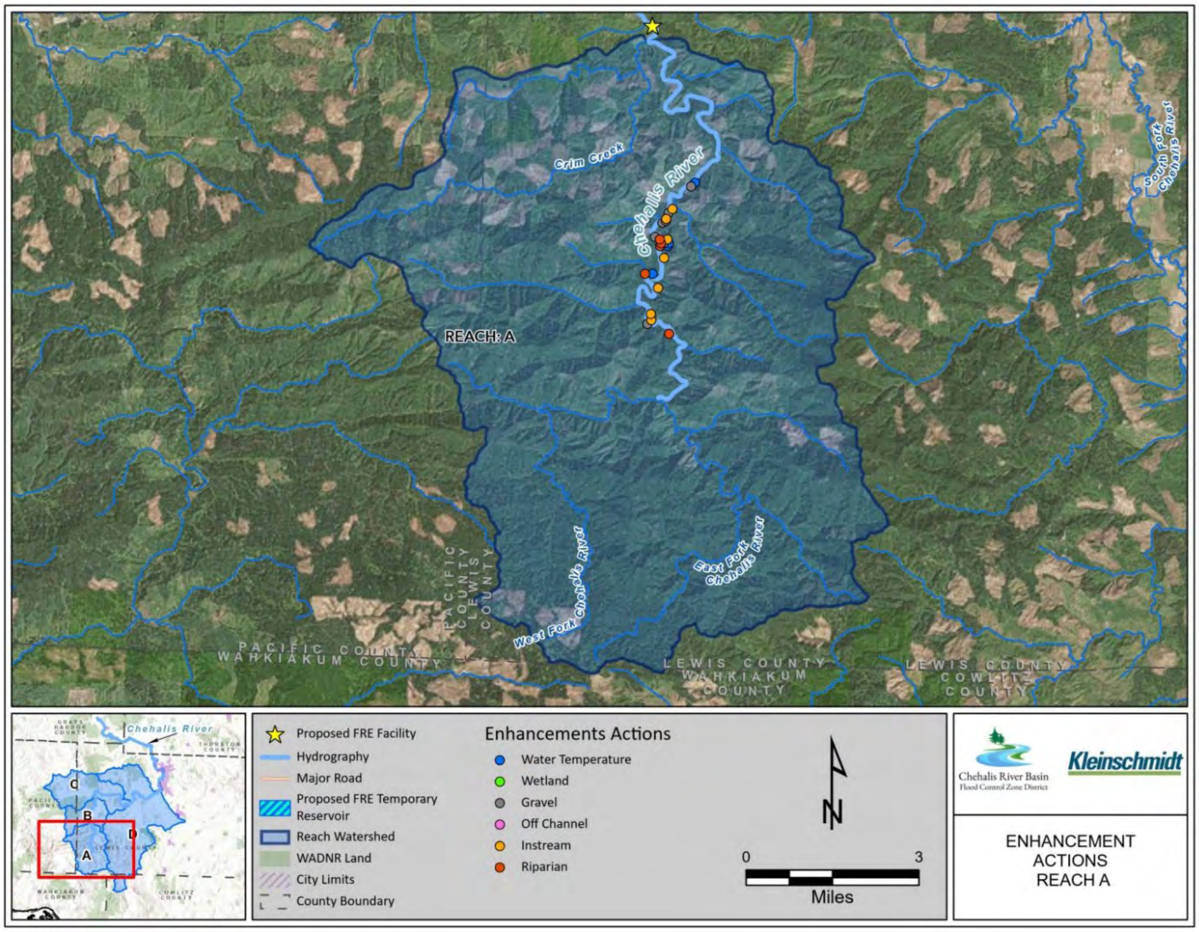


Figure A3-8
Enhancement Actions Advanced in Reach B

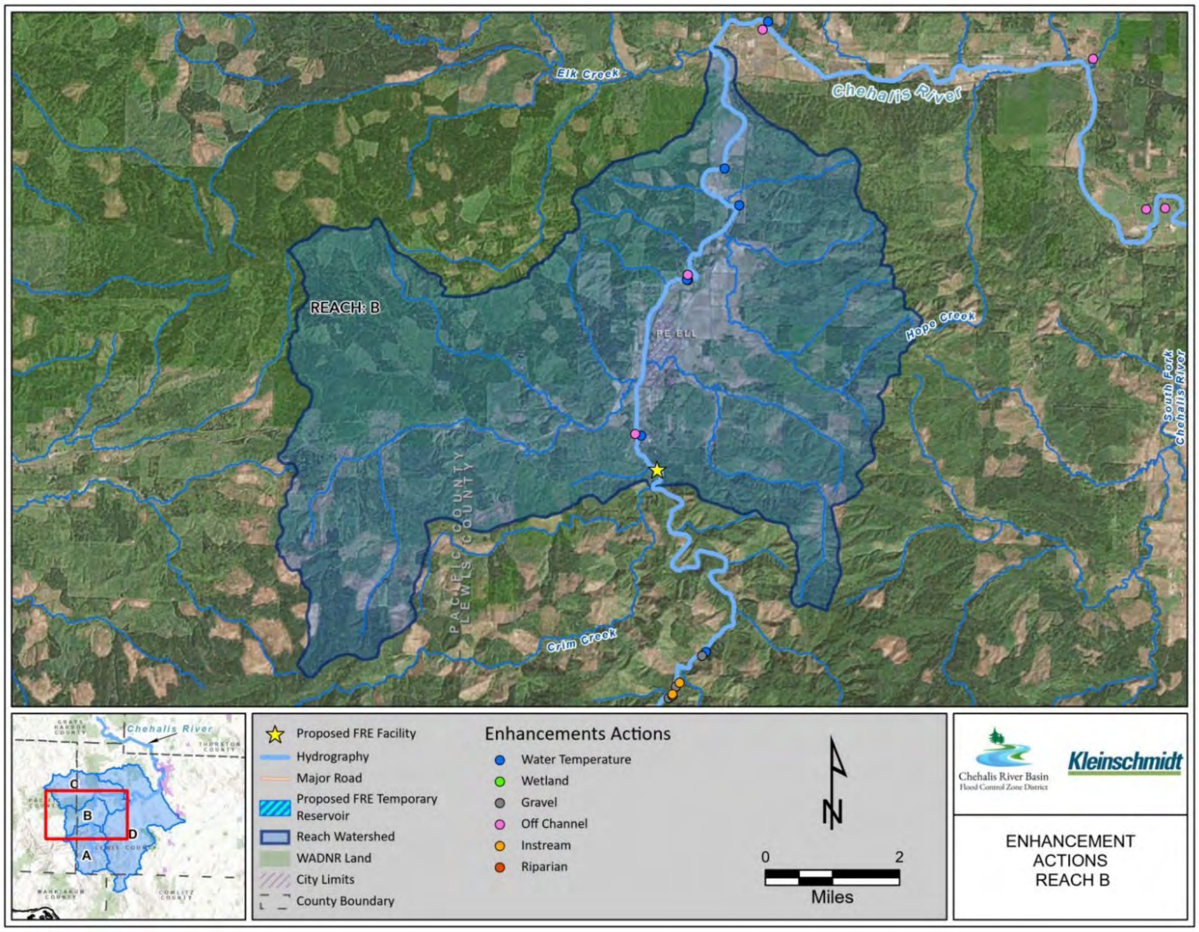


Figure A3-9
Enhancement Actions Advanced in Reach C

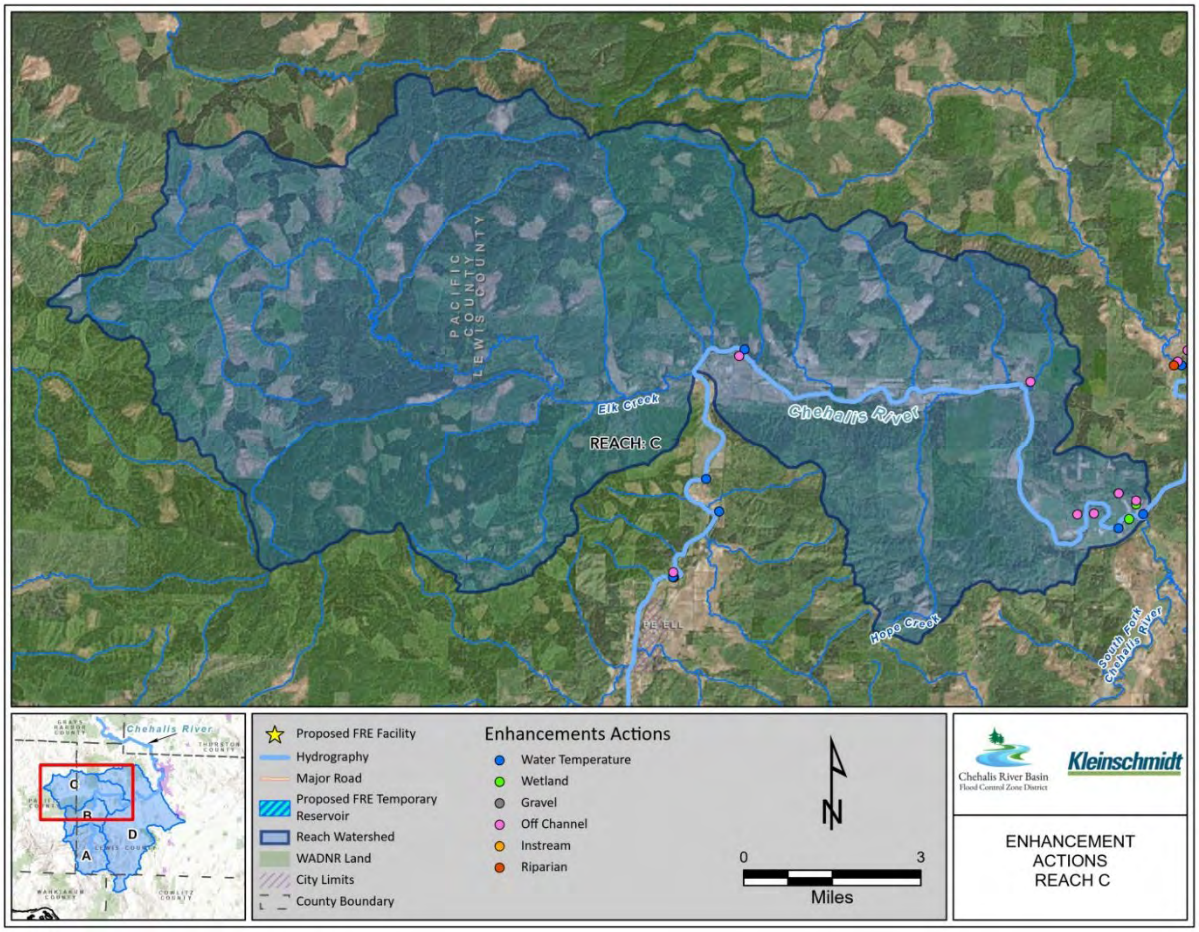
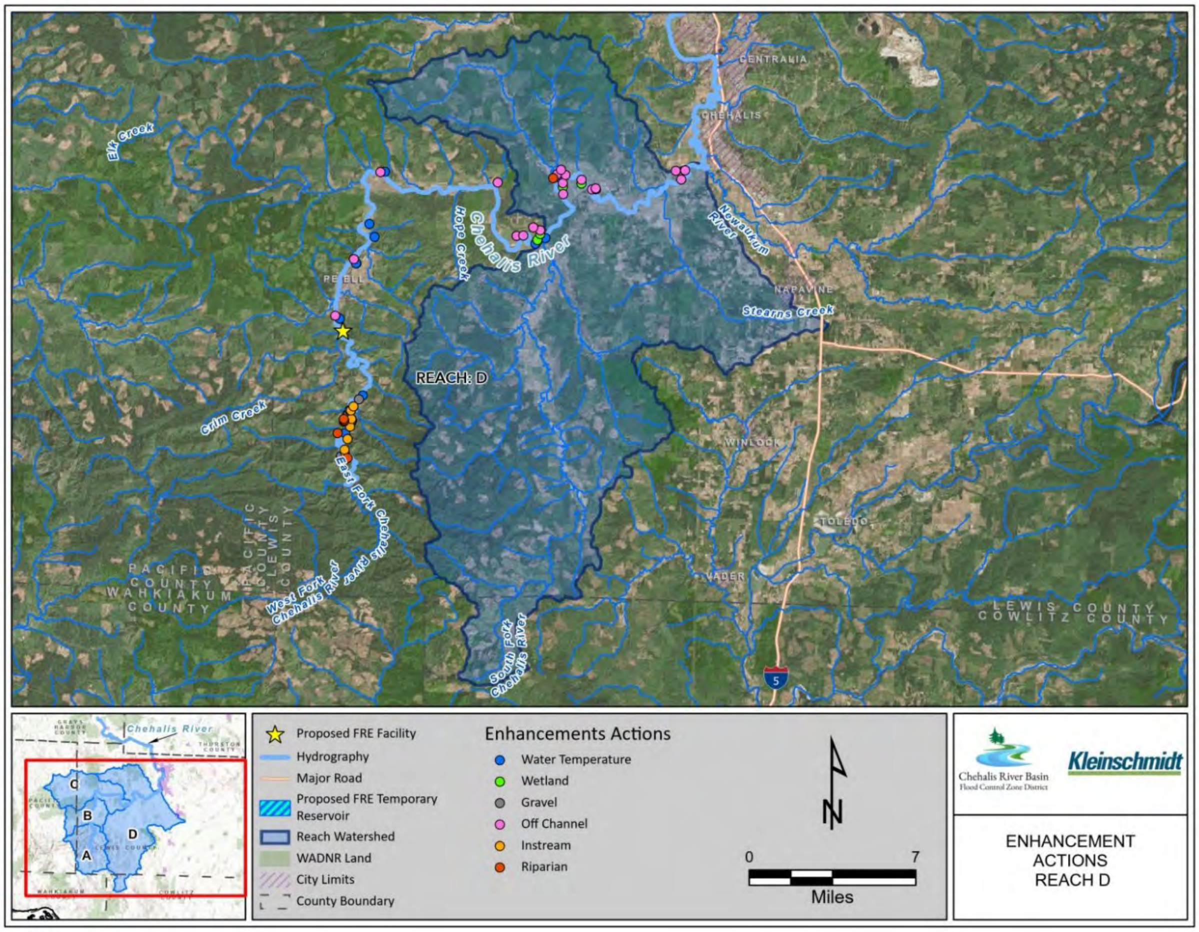


Figure A3-10
Enhancement Actions Advanced in Reach D



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Appendix B
Construction Phase Upstream Fish Passage Alternatives and 10% Design

Technical Memorandum

Date	Friday, February 25, 2022
Project:	Chehalis River Basin Flood Damage Reduction Project
To:	Chehalis Basin Flood Control Zone District
From:	Matt Prociv, PE; Rachel Ainslie; Nicole Loo; Emma Pazoff; and Theo Malone, PE
Subject:	Construction Phase Upstream Fish Passage Alternatives Selection and 10% Design

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Executive Summary

The Chehalis River Basin Flood Control Zone District (District) is proposing to construct a new flood retention structure to reduce damage to life and property along the Chehalis River. Construction is anticipated to last three to five years and fish passage must be provided during this time. The consultant team was asked to develop and compare alternatives for a fish passage during construction, recommend an alternative, and develop the recommended alternative to a 10 percent design level. The construction phase fish passage is required to pass target fish species and life stages throughout the duration of the construction period. The following process was used to develop and evaluate these alternatives: (1) assemble data to establish project design objectives based on agency criteria and guidelines, (2) formulate array of potential construction phase fish passage and barrier technologies, (3) define feasibility criteria and evaluate feasibility of passage and barrier technologies, (4) formulate alternatives from array of fish passage and barrier technologies that meet minimum feasibility requirements (5) evaluate alternatives against established design criteria and recommend a single alternative for design development, (6) develop the recommended alternative to a 10 percent design level.

Biological and technical fish passage criteria refined through collaboration with WDFW (January 2021) were incorporated into this process. The two primary types of biological design criteria that most influence facility type, size and configuration include: (1) target species and migration timing, and (2) species abundance. Several potential construction phase upstream fish passage technologies were formulated based on these criteria, and were evaluated against feasibility criteria. Each technology must meet the minimum feasibility requirements to be considered viable and to be advanced for further evaluation. Based on these requirements, the only viable technology identified for further evaluation was a trap and transport with a velocity barrier.

Three conceptual design alternatives for a trap and transport facility with a velocity barrier downstream of the diversion tunnel outlet were developed and compared against evaluation factors. Ultimately, Alternative 3 – Trap and Transport Facility at Location 1 Using Permanent Facility Elements was recommended. Following District concurrence with the recommended alternative, this alternative was developed to a 10 percent design level. The description of the 10 percent design of the construction phase fish passage includes: refined design criteria, preliminary design of the facility, theory of operation for the facility, and construction sequencing.

1.0 Introduction

The Chehalis River Basin Flood Control Zone District (District) is proposing to construct a new flood retention structure and temporary reservoir near the town of Pe Ell, Washington to reduce damage to life and property along the Chehalis River. The development of fish passage alternatives is an integral component of the flood retention structure (Flood Retention Only - Expandable [FRE]) design for both the construction and operational phases. Fish passage options for the permanent FRE facility were advanced to an early, preliminary level of design in collaboration with the Fish Passage Technical Subcommittee[1] (Subcommittee). These options included run-of-river conduits through the FRE facility to provide passage during non-operational periods, and a Collect, Handle, Transfer, and Release (CHTR) fish passage facility for use during flood retention operations (HDR 2018a, 2018b).

Design efforts for the proposed permanent fish passage facility have advanced to a conceptual design level sufficient to assess the effectiveness and performance of the proposed design. Design of the construction phase upstream fish passage facility has not been advanced to the conceptual level. In 2019, Washington state Department of Ecology (Ecology) and the U.S. Army Corps of Engineers (USACE) requested additional information on the anticipated provisions that will be implemented during construction to provide fish passage through the project area. This information would support development of the Draft Environmental Impact Statements (EISs) prepared pursuant to the State Environmental Policy Act (SEPA; Ecology 2020) and National Environmental Policy Act (NEPA; USACE 2020), respectively. In response to these requests, the District advanced conceptual fish passage options for the construction period but did not identify a single recommended design to be incorporated as part of the project.

The District's review of the Draft SEPA EIS found that Ecology had assumed the use of a picket weir as a key component of the construction phase fish passage facility. In August 2021 the District sent Ecology a Technical Memorandum (TM) identifying a velocity barrier as a barrier technology more likely to be employed than a picket barrier. Although the August 2021 Technical Memorandum identified a single barrier technology, the District had yet to develop and evaluate alternatives to provide fish passage during construction. Currently, Ecology and USACE are developing final EIS documents.

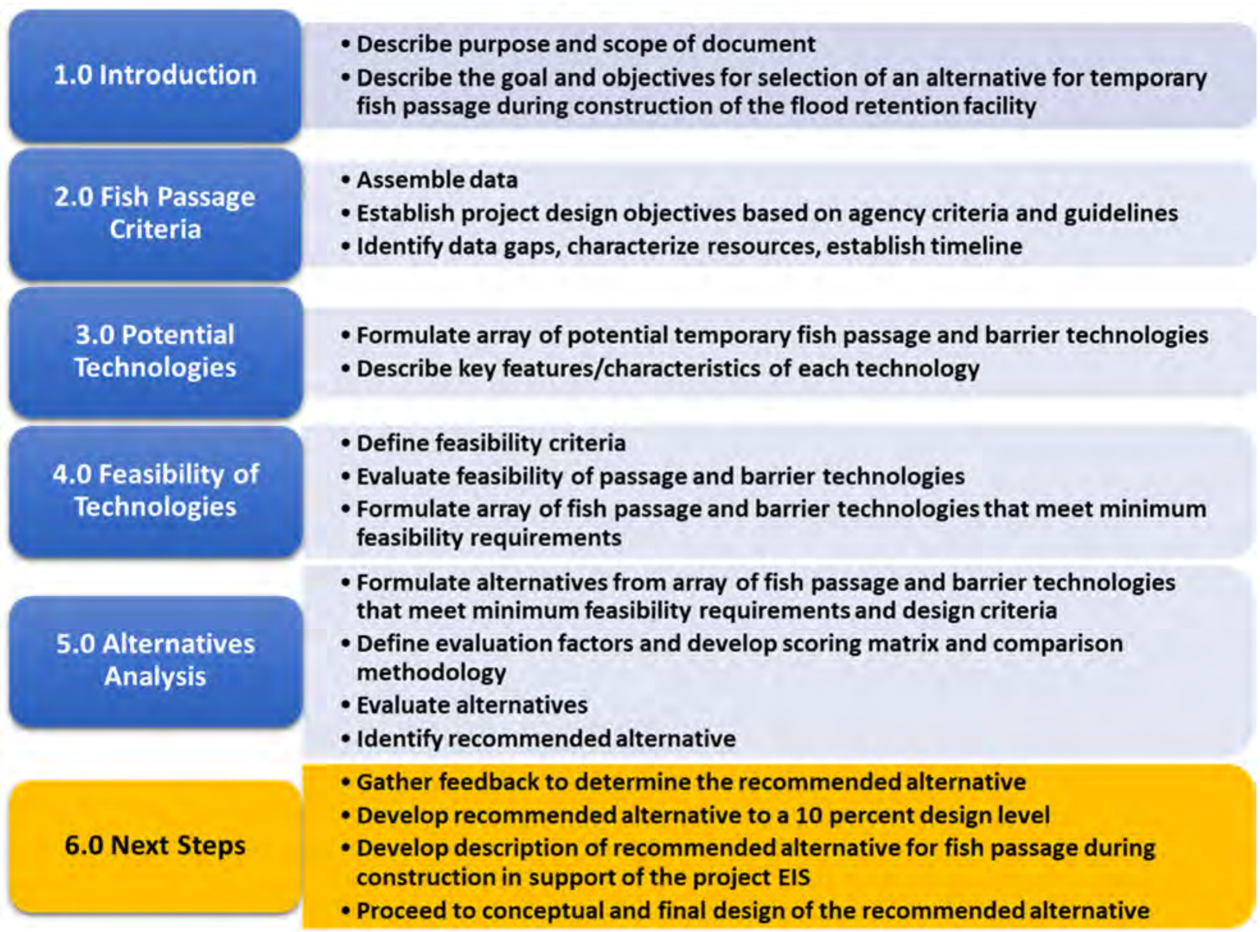
1.1 Purpose and Scope of Document

The purpose of this TM is to communicate to Ecology and USACE the District's further conceptual design conclusions regarding the construction phase fish passage facility. This conceptual design will be the basis for more detailed final design development and is recommended to the District for inclusion in the proposed Project Description. This TM presents

[1] The Fish Passage Technical Subcommittee was a collaborative working group consisting of representatives from the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), Washington Department of Ecology (Ecology), Washington Department of Fish and Wildlife (WDFW), and the Quinault Indian Nation (Quinault) that met in 2016 and 2017. Subcommittee meeting notes are found in HDR 2017 Attachment A and HDR 2018b Appendix A.

construction phase upstream fish passage technologies and alternatives to be implemented during the construction phase of the FRE facility for consideration and provides a recommended construction phase upstream fish passage alternative. Downstream fish passage is planned to be accomplished through the diversion tunnels (District 2019, HDR 2018b). This TM focuses on the upstream FP design. Figure 1 presents a process flowchart that was used to develop and evaluate construction phase upstream fish passage alternatives. The descriptions encompass the sections of this TM, with the development of the recommended alternative described in Section 0, as next steps.

Figure 1. Process Flowchart for Development and Selection of Construction Phase Upstream Fish Passage Alternative



1.2 Goal and Objectives

The goal and objectives for the selection of an alternative for construction phase upstream fish passage during FRE facility construction are provided below. The goal describes the future state that is desired to be achieved. The objectives are specific, measurable actions that help define when the goal is achieved. Subsequent sections of this TM refer to this section while discussing the suitability of construction phase upstream fish passage facility alternatives meeting the goal and achieving the objectives.

Goal: Provide construction phase upstream fish passage of the Chehalis Flood Retention Structure for target fish species and life stages.

Objectives:

- Construct and operate a facility in compliance with National Marine Fisheries Service (NMFS) and Washington Department of Fish and Wildlife (WDFW) engineering principals and guidelines.
- Provide reliable upstream passage for target species and life stages of fish in the Chehalis River (described in Section 2.1.1) throughout the anticipated range of operating and environmental conditions during periods when fish are anticipated to migrate during FRE construction.
- Conform to the usual and customary fish passage efficiencies observed at like facilities in operation elsewhere.
- Implement a facility that considers cost effectiveness and limits the anticipated Operations and Maintenance (O&M) effort and level of complexity.
- Accommodate and limit delay or injury to downstream migrating fish that are passed downstream of the construction site through the FRE construction diversion tunnel.
- Limit impact of construction phase fish passage facility on the construction footprint of the permanent flood retention structure.

2.0 Fish Passage Criteria

The biological and technical fish passage criteria used in previous reports and TMs (HDR 2018b, 2021) were refined based on collaboration with WDFW (January 2021). These fish passage criteria are described in the sections below and used to develop evaluation factors and feasible alternatives. These criteria will be used in future design development of the selected construction phase upstream fish passage facility alternative.

2.1 Biological Criteria

Biological fish passage criteria pertinent to the construction phase upstream fish passage facility are presented in previous reports and TMs (HDR 2018b, 2021) and reproduced in the following sections. The two primary types of biological design criteria that most influence facility type, size, and configuration are repeated below:

- **Target species and migration timing:** The species and life stages targeted for fish passage design as well as their seasonality, anticipated hydrologic conditions present during migration, and duration of periods where these target fish species may be expected to migrate upstream and/or downstream of the flood retention structure location.
- **Species abundance:** The annual number of fish that require passage as well as the peak daily rate of migration that influences facility size and operation requirements.

Target species are those species that have been identified as inhabiting or transiting the area of the proposed flood retention structure construction. All designs considered for this facility will take into account each of the target species' characteristics (such as swimming ability, size, migration timing, among others) and consider the facility impact on the species.

WDFW asked the District in January 2021 to "set the bar high" early in the design process by providing passage for all species and life stages. Identifying target species by name provides the specificity that is appropriate when moving from conceptual planning into detailed design. Identifying target species meets both the intent and letter of WDFW's request as the list of target species includes "all (aquatic) species present at all mobile life stages" (WAC 2015).

2.1.1 Target Species and Migration Timing

For development of the construction phase upstream fish passage facility alternatives, anadromous and resident species known to occur within the influence of the flood retention structure, in the inundation area of the associated reservoir, and upstream of the reservoir were targeted for upstream passage only. These primary species and their known swimming and leaping abilities influenced specific technical design criteria. Species known to occur downstream of the FRE facility were selected for consideration, but did not directly influence the development of specific technical design criteria. Table 2-1 provides targeted target fish species and their respective life stages as specified in past reports (HDR 2018b).

Table 2-1. Target Fish Species and Life Stages Targeted for Construction Phase Upstream Fish Passage Facility

Species	Upstream Passage
Spring-Run Chinook Salmon	Adult, juvenile
Fall-Run Chinook Salmon	Adult, juvenile
Coho Salmon	Adult, juvenile
Winter-Run Steelhead Trout	Adult, juvenile
Coastal Cutthroat Trout	Adult, juvenile
Pacific Lamprey	Adult
Western Brook Lamprey	Adult
Resident fish, including: River Lamprey, Largescale Sucker, Salish Sucker, Torrent Sculpin, Reticulate Sculpin, Riffle Sculpin, Prickly Sculpin, Speckled Dace, Longnose Dace, Peamouth, Northern Pikeminnow, Redside Shiner, Rainbow Trout, Mountain Whitefish	Adult

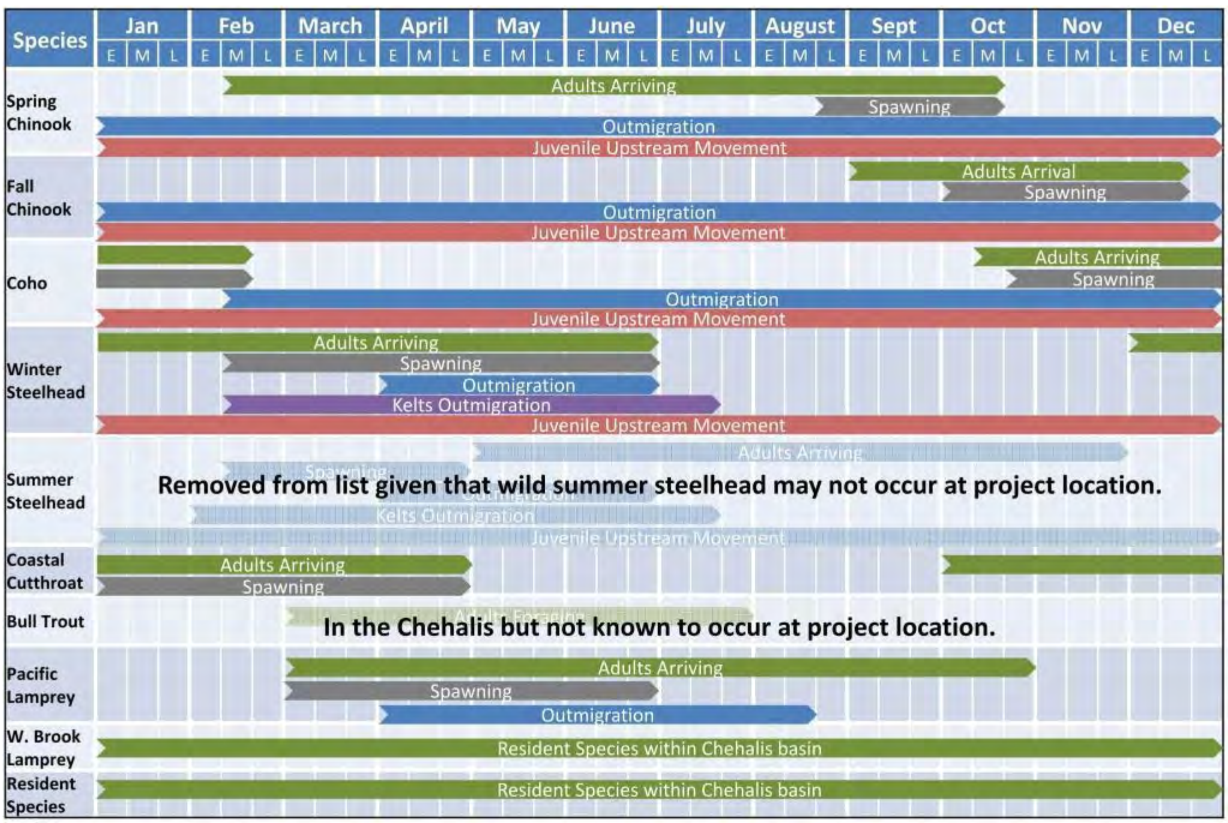
Adapted from CHTR Report (HDR 2018b)

In addition to salmonids and the anadromous Pacific Lamprey, multiple resident fish species and two species of resident lamprey (western brook and river) have been identified to inhabit and transit the proposed flood retention structure area. As such, these resident species are also included as target species. Passage technologies for lamprey are relatively new, and few facilities exist in the western United States that target lamprey for passage or collection and transport above dams. Where applicable, readily available best practices, lessons learned from experimental facilities on the Columbia River, and interviews with researchers who specialize in the understanding of lamprey behavior and navigational capabilities were used to inform lamprey passage facility requirements and anticipated performance.

Bull trout solely occur downstream of the proposed flood retention structure location so they were removed by the Fish Passage Technical Subcommittee as a target species but remained a species of consideration throughout alternative development and concept design (HDR 2018b).

Fish species migration timing and duration influence the design and operation of proposed fish passage facilities by defining the physical, operational, and environmental conditions expected to occur while passage is required. The migration timing and duration for the target fish species and life stages were discussed at Subcommittee meetings as new information was collected in the field and from literature sources. The resulting conclusions (HDR 2017) were used in fish passage alternative design development (Figure 2).

Figure 2. Anticipated Migration Periods of the Targeted Species and Life Stages (Periodicity)



Reprinted from CHTR Report (HDR 2018b)

2.1.2 Species Abundance

Documents and information provided by WDFW during Subcommittee meetings were used to assess construction phase upstream fish passage facility sizes and capacities (WDFW 2016a, 2016b). Table 2-2 provides the resulting peak rate of annual migration for adult salmonids moving upstream.

Table 2-2. Peak Number of Annual Upstream-Migrating Fish

Species	Peak Annual Migration
Spring-run Chinook salmon	1,350
Fall-run Chinook salmon	3,900
Coho salmon	12,900
Winter-run steelhead	5,630

Reprinted from CHTR Report (HDR 2018b)

Numbers for adult upstream migrating Pacific Lamprey, Cutthroat Trout, resident fish, and juvenile salmonids were not available for the construction phase upstream fish passage facility alternatives analysis.

An estimation of peak daily counts was adapted from the CHTR Preliminary Design Report (HDR 2018b) as follows:

> *The peak daily counts of salmon and steelhead migrating upstream were estimated as 10% of the maximum annual run (WDFW 1992), and peak hourly counts were estimated as 20% of the peak daily count based on Bell (1991) and as cited in NOAA Fisheries (2011). Applying both criterion results in the peak hourly count being 2% of the annual run for each species. Using this methodology and based on the run timing information in the periodicity chart (*Figure 2*), a combined peak daily count of roughly 2,000 adult salmonids and a peak hourly count of 400 adult salmonids was used in the consideration of (construction phase) upstream fish passage facilities.*

2.1.3 Resident Fish

The Subcommittee, with support from the U.S. Fish and Wildlife Service (USFWS) representative, assembled relevant biological data for the target resident species, as well as for lamprey and salmonids. A summary of what data was compiled for each species is reproduced in Table 2-3 (HDR 2018b).

Swim speed and jump height data for resident species will be compared with the same data for the other target species. The construction phase upstream fish passage facility will be designed to accommodate passage of the resident species listed in Table 2-3 to the extent possible, and without adversely affecting facility performance for listed priority species (salmonids, cutthroat trout, and lamprey).

Table 2-3. Locomotive and Biological Data Availability

Species		Data Collected*	
Life stage	Common Name	Swim Speed	Jump Height
Adult	Spring-run Chinook Salmon	●	●
Adult	Fall-run Chinook Salmon	●	●
Adult	Coho Salmon	●	●
Adult	Winter-Run Steelhead Trout	●	●
Adult	Summer-Run Steelhead Trout	●	●
Juvenile	Spring-run Chinook Salmon	●	●
Juvenile	Fall-Run Chinook Salmon	●	●
Juvenile	Coho Salmon	●	●
Juvenile	Winter-Run Steelhead Trout	●	●
Juvenile	Summer-Run Steelhead Trout	●	●
Adult	Coastal Cutthroat Trout	●	●
Adult	Bull Trout	●	●
Adult	Pacific Lamprey	●	Not applicable
Adult	Western Brook Lamprey	●	Not applicable
Adult	River Lamprey	●	Not applicable
Adult	Largescale Sucker	●	
Adult	Salish Sucker	●	
Adult	Torrent Sculpin	Not applicable	
Adult	Reticulate Sculpin	Not applicable	
Adult	Riffle Sculpin	Not applicable	
Adult	Prickly Sculpin	Not applicable	
Adult	Speckled Dace	●	
Adult	Longnose Dace	●	
Adult	Peamouth	●	
Adult	Northern Pikeminnow	●	
Adult	Redside Shiner	●	
Adult	Rainbow Trout	●	
Adult	Mountain Whitefish	●	

Note: ● = Indicates that a data source has been identified
Reprinted from CHTR Report (HDR 2018b)

2.2 Technical Criteria

This section identifies technical design criteria, sources, and guidance relevant to the development of fish passage designs. Technical fish facility design criteria fall into two categories – criteria and guidelines. Criteria are specific standards for fish passage design that require an approved variance from the governing state or federal agency before a design can deviate from the established criteria.

Deviating from an agency-established criterion requires establishing a site-specific, biological- or physical-based rationale for the deviation. In contrast, guidelines provide a range of values, or in some instances, specific values that the designer should seek to achieve, but that can be adjusted in light of project-specific conditions, if needed, to achieve the overall fish passage objectives by supporting better performance or solving site-specific issues. Adjustments to a design may be requested from the governing agencies during design development.

The list of criteria provided herein is not intended to be an all-inclusive list used for the design of a construction phase upstream fish passage facility, but that guided alternative formulation and concept development. The following documents provide the criteria and guidelines that were considered during development of the construction phase upstream fish passage facility alternatives. If two or more agencies provide differing guidance on a specific design criterion, the most conservative guidance from a fish passage and protection standpoint was followed. Further design criteria applicable to the recommended technology is provided in Section 5.1.1.

- Anadromous Salmonid Passage Facility Design (National Oceanic and Atmospheric Administration [NOAA] Fisheries 2011)
- Best Management Practices to Minimize Adverse Effects to Pacific Lamprey (USFWS 2010)
- Draft Fishway Guidelines for Washington State (WDFW 2000a)
- Draft Fish Protection Screen Guidelines for Washington State (WDFW 2000b)
- Water Crossing Design Guidelines (WDFW 2013)
- Fisheries Handbook of Engineering Requirements and Biological Criteria (Bell 1991)
- Introduction to Fishway Design (Katopodis 1992)
- Rock Ramp Design Guidelines (U.S. Department of the Interior Bureau of Reclamation 2007)
- Design of Fishways and Other Fish Facilities (Clay 1961)

2.2.1 Hydrologic and Hydraulic Criteria

2.2.1.1 Fish Passage Design Flows

NOAA Fisheries and WDFW provide guidelines for when fish passage facilities must be operated throughout the full range of river flows. Fish passage design flow criteria influences several factors associated with fish passage facility size and complexity. The established guidelines are used to set instream flow depths, flow velocities, debris and bedload conditions, fish attraction requirements, tailwater fluctuations, and numerous other factors that a facility might experience while target fish species are migrating. Fish passage design flows were calculated and reported in the CHTR Preliminary Design Report (HDR 2018b). The following narrative and tables are reproduced from the CHTR Preliminary Design Report (HDR 2018b) for reference:

NOAA Fisheries (2011) requires the high fish passage design flow to be the mean daily streamflow that is exceeded 5% of the time during periods when target fish species are migrating. WDFW (2000a) suggests a 10% exceedance flow be used as a high design flow. NOAA Fisheries (2011) requires a low fish passage design flow equal to the mean daily streamflow that is exceeded 95% of the time during periods when migrating fish are typically present. WDFW recommends that a low flow be established based upon site- specific conditions.

Mean daily flows for water years 1940 through 2012 from U.S. Geological Survey gage 12020000 near Doty were reduced using basin area and mean annual precipitation to estimate flows at the proposed flood retention structure site. An exceedance analysis was then performed on the estimated flows at the proposed flood retention structure site. The probability for exceedance of mean daily flows is summarized in Table 2-4.

At the flood retention structure site, adjacent to the proposed (construction phase fish) passage facility, 5% and 95% exceedance flows were also calculated for each adult species using their respective upstream migration timing. These results are provided in Table 2-5. The lowest 95% exceedance flow and the largest 5% exceedance determined the fish passage design flow for which the selected (construction phase) upstream fish passage facility will be designed. The lowest 95% exceedance flow is the 95% exceedance flow of 16 cubic feet per second (cfs), which occurs during the fall-run Chinook salmon migration period. The highest 5% exceedance flow is 2,197 cfs, which occurs during the coho salmon migration period. Therefore, (construction phase) upstream fish passage facilities will be designed to operate from a low fish passage flow of 16 cfs to 2,200 cfs.

Table 2-4. Annual Flow Exceedance at the Proposed Flood Retention Structure Site

Percent Time Exceeded	Flow ([cfs)
99	15
95	19
90	24
80	37
75	48
50	171
25	437
10	960
5	1,447
1	2,957

Reprinted from CHTR Report (HDR 2018b)

Table 2-5. Flow Exceedance during Fish Migration Periods at the Proposed Flood Retention Structure Site

Fish Species	95% Exceedance (cfs)	5% Exceedance (cfs)
Spring-run Chinook salmon	18	882
Fall-run Chinook salmon	16	1,592
Coho salmon	36	2,197
Winter-run steelhead	63	1,724
Coastal cutthroat trout	34	1,908
Pacific lamprey	17	737
Western brook lamprey	19	1,447

Reprinted from CHTR Report (HDR 2018b)

2.2.1.2 River Flood and Exceedance Flows

Anticipated stage fluctuations are significant factors in determining the type, size, and complexity of the construction phase upstream fish passage facility. As stage fluctuations increase, facilities become larger and more complex. Historical river flows were used to calibrate the HEC-HMS simulation model to estimate the flood flows and fish passage design flows (Watershed Science & Engineering 2016). Additional hydraulic modeling will be performed for future design development to estimate water surface elevations within the Chehalis River near the construction phase upstream fish passage facility. To provide an estimated range of stages, the design fish passage flows and select floods associated with their respective tailwater elevations in the FRE facility stilling basin are provided in Table 2-6. Design fish passage flows were estimated based on efforts described in Section 2.2.1.1

Table 2-6. Tailwater Elevations for Fish Passage Design Flows and Select Floods

Flow Event	Flow (cfs)	Tailwater Elevation (feet)
Low fish passage design flow	16	417.0
High fish passage design flow	2,200	419.3
2-year flood	7,300	427.4
10-year flood	10,300	430.1
25-year flood	12,200	431.7
100-year flood	15,000	433.9
Probable maximum flood	69,800	444.0

Adapted from CHTR Report (HDR 2018b)

3.0 Potential Technologies

Potential construction phase upstream fish passage technologies were formulated and segregated into five categories: nature-like fishways; fish ladders; fish passes (e.g., elevators, lifts, and locks); pneumatic fish transport tube system (Whooshh); and trap and transport. Section 3.1 provides descriptions of each technology category. The recommended alternative may be comprised of multiple technologies based on their ability to meet the objectives and unique operating environment within which they are to be placed.

Potential fish passage barrier technologies are presented in Section 3.2. All construction phase upstream fish passage alternatives will use a fish passage barrier to prevent fish from attempting to pass upstream through the water diversion tunnel. The fish passage barrier will be installed directly upstream of the construction phase upstream fish passage facility and help direct fish into the facility entrance.

3.1 Passage Technologies

3.1.1 Nature-Like Fishways

Nature-like fishways are composed of constructed concrete or earthen channels configured at lower gradients that provide quasi-natural hydraulic conditions and typically mimic low gradient cascades and runs. In most cases, nature-like fishways use an array of rocks or other objects to add roughness, hydraulic depth, and cross-sectional diversity to create multiple hydraulic navigational pathways for fish to ascend. With typical gradients ranging from 3 to 4 percent, nature-like fishways would be long and likely require large amounts of cut and fill to maintain the targeted slope requirements.

Because nature-like fishways have a shallow fixed cross-section, additional structural and hydraulic control provisions would be needed at the fishway exit to accommodate headwater fluctuations greater than 2 feet. Therefore, a nature-like fishway would require transition back to a technical fish ladder or constructed exit before connecting back to the Chehalis River. Without such a feature, the nature-like fishway on its own would be unable to maintain hydraulic connectivity with a headwater or control flow into the fishway during high flows. As a result, similar to other fishway technologies, complex hydraulic controls and multiple exit ports would be required to maintain hydraulic connectivity and volitional passage during the anticipated migration periods. A nature-like fishway example is shown in Figure 3.

Figure 3. Nature-like fishway on the Oswegatchie River in New York.

3.1.2 Fish Ladders

Technical fish ladders consist of a concrete fish ladder traversing one side of the flood retention structure construction area. The design target hydraulic differential between baffles in the ladder would follow standard agency design guidelines for the upstream passage of adult salmonids. Pool geometry would be established using NMFS 2011 guidelines but would also consider the specific baffle type selected for the ladder. A fish ladder would be composed of typical pools, resting pools, turning pools, and potentially multiple exit pools to account for reservoir stage fluctuations. This technology requires consideration of guidance, attraction, and collection strategies for the fish ladder entrance as well as debris, temperature, and flow control provisions at the entrance. Figure 4 through Figure 6 provide photos of example fish ladder technologies.

Figure 4. Faraday Diversion and North Fork Dams' 2.1-Mile-Long, Half Ice-Harbor Baffle (pool, weir, and orifice) Fish Ladder

Figure 5. River Mill Dam Half Ice-Harbor Baffle (pool, weir, and orifice) Fish Ladder

Figure 6. Crooked River Central Vertical Slot Fishway near Prineville, Oregon

Source: ODFW 2021

3.1.3 Fish Passes

Another means of transporting fish to a point upstream of the flood retention structure construction area is to carry them up over an adjacent hillside in a transportation vessel either suspended from cables or pulled along rail tracks similar to a trolley system via a fish elevator or lift. A fish elevator system would include design and construction of hoists, concrete foundations, rails, structural members, ramps, pumps, and piping. The elevator, or trolley, would require a life support system and means to offload fish in case of mechanical failure while in route. An example of a fish elevator is provided in Figure 7.

Prior to transport, fish would be collected in a similar manner as other trap and transport type technologies and therefore similar guidance, attraction, water control, fish ladder, and holding gallery components would be required.

Figure 7. Skokomish Dam No. 2 Adult Collection Facility Fish Lift

Another type of fish passage technology which uses a mechanical means to lift fish up and over an established structure is called a fish lock. Fish enter the bottom of the lock, water is fed into the lock from the bottom, and fish are crowded upwards with a braille system as the lock slowly fills. As the lock continues to fill, the braille crowds fish upward until they have moved to the top of the water column. Near the top, a gate is opened, and fish are allowed to swim out of the lock.

An example of a fish lock is provided in Figure 8.

Figure 8. Fish Lock at the Trap and Transport Facility on Baker River Operated by Puget Sound Energy

3.1.4 Pneumatic Fish Transport Tube System (Whooshh)

A pneumatic fish transport tube system (also known as “Whooshh”) is an experimental technology from the agricultural and fish processing industry that has been adapted over the past decade to provide transport of live fish over distances of 1,700 feet at heights of over 250 feet. The technology is undergoing extensive pilot testing throughout the Pacific Northwest and Northeast on fish species ranging from salmon and steelhead to shad and sturgeon. Overall, the technology is gaining popularity with some resource agencies as a viable and potentially permittable option for safe and timely passage of fish over high- and low-head barriers. The technology is already being used successfully at hatcheries and aquaculture facilities around the world. An example of a pneumatic fish transport tube system is shown in Figure 9.

Figure 9. Six-Lane Pneumatic Fish Transport Tube System (Whooshh) at the Big Bar Emergency Fish Transport Site, Frasier River, British Columbia.

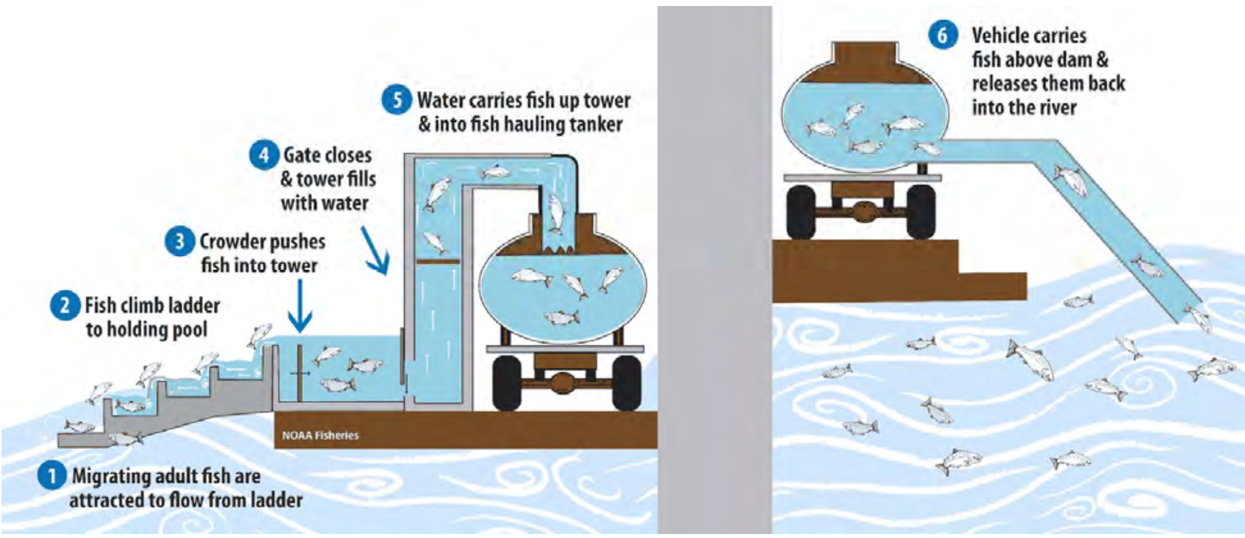
The pneumatic fish transport tube system consists of a flexible plastic tube that is connected to an air pump. A pressure differential of about 1 to 2 pounds per square inch is induced in the tube in front and back of the fish, thus pulling and pushing the fish through the tube. Once in the tube, fish travel at a speed of approximately 15 to 30 feet per second and exit the tube directly into receiving waters. Misters are located within the tube and keep the inside surface of the tube wet and relatively frictionless.

Conventional techniques similar to those used in a fish ladder, trap and transport facility, fish lift, or fish lock are used to provide volitional entry into the pneumatic fish transport tube system. Fish would be attracted to a fish passage entrance; they would enter a short section of fish ladder that leads to a small transition pool. A false weir at the end of the transition pool would lead fish to a transport flume that conveys fish into the entrance of the pneumatic fish transport tube system. Different tube diameters are required to transport different sized fish. Therefore, a system accommodating several species of upstream migrating fish would require a multiple tube system.

3.1.5 Trap and Transport

Trap and transport technologies (Figure 10 and Figure 11) are generally composed of five main components that include a barrier or guidance structure; a fish entrance (sometimes consisting of a short fish ladder); a collection, sorting, and holding facility (Figure 12); a vehicle with a transport vessel (tank of water; Figure 13); and a designated release location or locations. For example, a short fish ladder with attraction flow from an auxiliary water system would be used to attract fish and collect them from the river. Migrating fish would ascend the ladder and then stage within the existing holding gallery. Next, fish would be transferred to a vehicle fitted with a transport tank with life support systems. The tank would be transported to a pre-determined release point or points. At the pre-determined release point, fish would be transferred back to a reservoir or the selected tributaries where they would be able to continue their migration upstream.

Figure 10. Trap and Transport Facility Example



Source: NMFS

Figure 11. Lower Baker River Adult Trap and Transport Facility: Barrier Dam and Collection/Crowding Gallery

Figure 12. Overview of Adult Collection and Sorting Facility at North Fork Dam

Figure 13. Trap and Transport Facility: Truck with Fish Transport Vessel

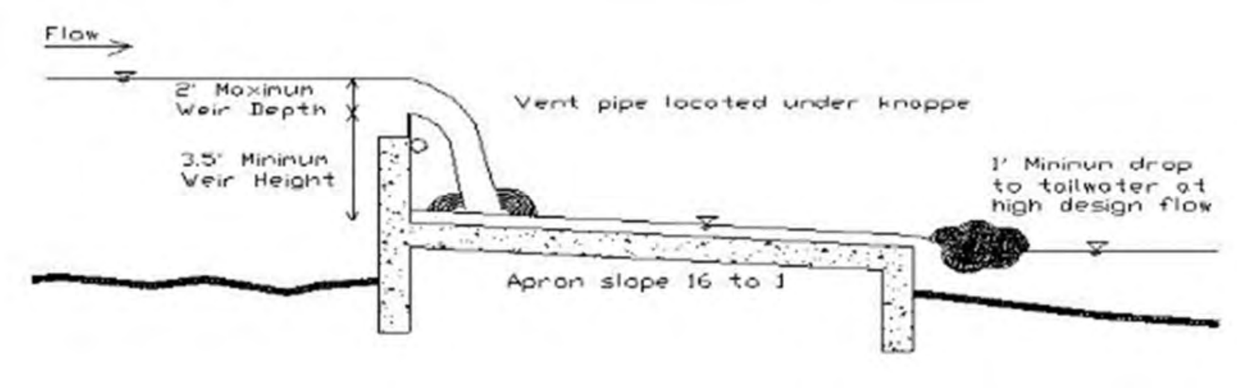
3.2 Barrier Technologies

A fish passage exclusion barrier will be used as part of the construction phase upstream fish passage facility to prevent the upstream migration of aquatic species. A fish passage barrier is necessary for proper performance of all fish passage technologies. The channel-spanning barrier will be located adjacent to the construction phase upstream fish passage facility entrance and help guide fish into, and prevent them from bypassing, the facility. Flow past the barrier can be concentrated near the facility entrance, thereby increasing attraction flow to the facility during the low fish passage design flow. The following sections describe the barrier technologies considered.

3.2.1 Velocity Barrier

A velocity barrier is a non-mechanical fish barrier that consists of a weir and concrete apron preventing upstream passage by producing a shallow flow depth and high velocity on the apron followed by an impassable vertical jump over the weir (NFMS 2011). There are no moving parts, no systems that require human intervention, nor obstructions that may impede flow or downstream fish movement. During passage conditions (95% to 5% exceedance flow; NMFS 2011, WDFW 2000a), river elevations and flow depths and velocities prevent upstream movement of aquatic species while allowing safe passage for fish moving downstream. At higher flows and flood events, mobilized debris and sediment pass downstream over the barrier without impairing its ability to be a barrier to aquatic species during passage conditions. An example section of a velocity barrier, designed according to NMFS 2011, is depicted in Figure 14.

Figure 14. Velocity Barrier



Source: NMFS (2011)

3.2.2 Jump Barrier

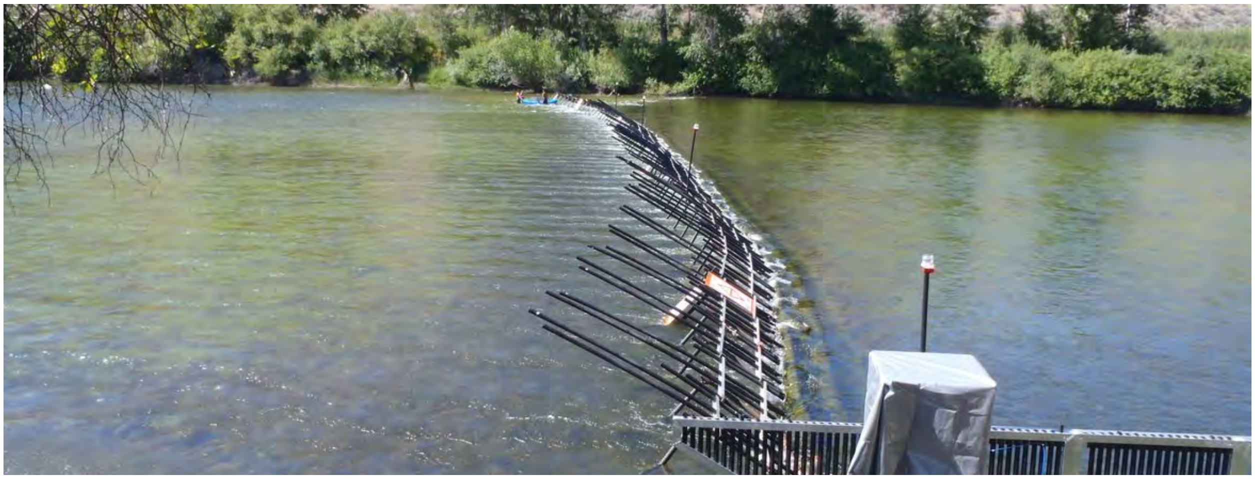
A jump barrier (or vertical drop structure) can function as an exclusion barrier by providing head in excess of the leaping ability of the target fish species (NMFS, 2011). The jump barrier must be a minimum height to prevent fish from leaping over the barrier and a provision must be made to ensure that fish leaping at the jump barrier flow will land in a pool of a minimum depth, without contacting any solid surface. An example of a jump barrier is provided in Figure 15.

Figure 15. Jump barrier on the Baker River operated by Puget Sound Energy

3.2.3 Picket Barrier

Picket barriers diffuse nearly the entire streamflow through pickets extending the entire width of the impassable route, sufficiently spaced to provide a physical barrier to upstream migrant fish (NMFS 2011). Picket barriers include a fixed bar rack and a variety of hinged floating picket weir designs. They have clear openings between pickets and between pickets and abutments, and the picket array must have a minimum percentage of open area.

Figure 16. Picket Barrier on the Okanogan River Operated by the Chief Joseph Hatchery



Source: The Spokesman-Review (2012)

3.2.4 Barrier Nets

Barrier nets are channel-spanning nets suspended from cables attached to floats or anchored adjacent to a waterbody. They are typically only effective under low water velocity and light debris load conditions.

4.0 Feasibility of Technologies

Each technology must meet minimum requirements to be considered viable. Those that do not meet these minimum requirements are considered infeasible and not advanced for further evaluation.

4.1 Feasibility Criteria

For this TM, feasibility is defined by the ability to meet the minimum requirements listed:

- **Anticipated Fish Passage Performance and Survival** – The anticipated fish passage performance and survival of each technology reflects its ability to meet all fish passage performance and survival goals for the target species and life stages. A technology is unable to meet this feasibility requirement if any of the target species or life stages are excluded from passage, or if survival is anticipated to be negatively affected.
- **Cost Effectiveness** – The cost effectiveness of each technology reflects the economic impact of facility construction from a qualitative perspective. A technology is unable to meet the cost effectiveness feasibility requirement when the cost of construction of the construction phase facility rivals the cost of the permanent FRE facility.

- **Environmental and Cultural Impact** – The environmental and cultural impact of each technology reflects the effects of the facility on, and its compatibility with, the surrounding environment. A technology is unable to meet the environmental and cultural impact feasibility requirement when its impact on the surrounding environment rivals that of the permanent FRE facility.
- **Water Supply** – The water supply of each technology reflects the capability of the technology to perform adequately with the available water supply in the river. A technology is unable to meet the water supply feasibility requirement when there is insufficient flow available to meet the function of the technology or the fish passage design criteria.
- **Maintenance and Reliability** – The reliability of the facility reflects the potential of the facility to continuously perform at peak efficiency. A technology is unable to meet the reliability feasibility requirement when the facility is inoperable due to environmental conditions or required maintenance, including following a flood event, for appreciable periods of time.

4.2 Feasibility of Passage Technologies

The feasibility of each construction phase upstream fish passage facility technologies listed in Section 3.0 was qualitatively evaluated and is discussed in the following sections. Technologies that do not meet the minimum requirements of the feasibility criteria outlined in Section 4.1 were not considered for further development or evaluation.

4.2.1 Nature-Like Fishways

A nature-like fishway at the project site would consist of a bypass channel that avoids the flood retention structure construction area and could be located on either the eastern or western bank of the Chehalis River.

Figure 17 shows the approximate location and elevation profile to provide a nature-like fishway as construction phase upstream fish passage on the western (left bank) side of the Chehalis River. The river is at approximate elevation 400 feet at the nature-like fishway entrance. The nature-like fishway could be oriented along the existing alignment of Mahaffey Creek. After 1,500 feet, the alignment would turn south to parallel the Chehalis River upstream. This potential alignment would need to be configured through the hillside via open-cut or tunnel. Open-cut would require an approximately 400-foot-deep excavation at its tallest point. A tunnel would be approximately 1,100 feet long through the hillside. After the tunnel, or open-cut, the topography flattens out and an open-cut would be continued to construct a nature-like fishway approximately 2,400 feet long, where the fishway would rejoin the Chehalis River.

Figure 18 shows the approximate construction footprint required to provide a nature-like fishway as construction phase upstream fish passage on the eastern side of the Chehalis River. The elevation profile provided shows that 3,000 feet of either open-cut construction or a tunnel would be required through the hillside, at depths between 100 and 200 feet, to extend the construction phase upstream fish passage channel past the flood retention structure construction. A nature-like fishway on the eastern (right bank) side of the construction area would also need to avoid the water diversion tunnel.

As displayed in Figure 17 and Figure 18, these potential bypass routes for a construction phase passage facility are both lengthy and expensive. The nature-like fishway could be constructed only through use of a tunnel, or by performing open-cut construction several hundred feet deep, which will be economically impractical for a construction phase upstream fish passage facility. In addition, nature-like fishways will require additional measures to prevent severe flooding of the fishway and provide site safety at the bypass channel. Further, the amount of cut needed for construction of this technology is greater than the cut required for the permanent flood retention structure.

The nature-like fishway technology was removed from consideration because of its inability to meet the environmental and cultural impact and cost effectiveness feasibility criteria. The cut required for open-cut construction of this technology is approximately 400 feet at its deepest point and a length of about 3,000 feet. The footprint of this excavation rivals that of the permanent flood retention structure. The impact of clearing such a large area of vegetation and the substantial changes to the topography caused by a 3000-foot-long, 400-foot-deep excavation render this technology infeasible in terms of environmental and cultural impact for a construction phase technology. In addition, the alternative is infeasible from a cost effectiveness perspective because the cost associated with the extensive volume of excavated material due to the open-cut construction through the hillside would rival that of the permanent facility, violating the cost effectiveness feasibility criteria. Construction of a tunnel would also violate this criteria because tunnel construction would require use of a tunnel boring machine for the same distance of approximately 3,000 feet. The width of the tunnel would need to be greater than that of the diversion tunnel to accommodate upstream fish passage velocity and depth criteria at higher flows, increasing construction cost. In addition, ambient lighting and electrical power would also need to be routed through this tunnel. The cost of this tunnel and its associated elements would rival that of the permanent facility, rendering it infeasible based on the cost effectiveness feasibility criterion.

Figure 17. Nature-Like Fishway and Fish Ladder Potential Construction Footprint, Western Alignment

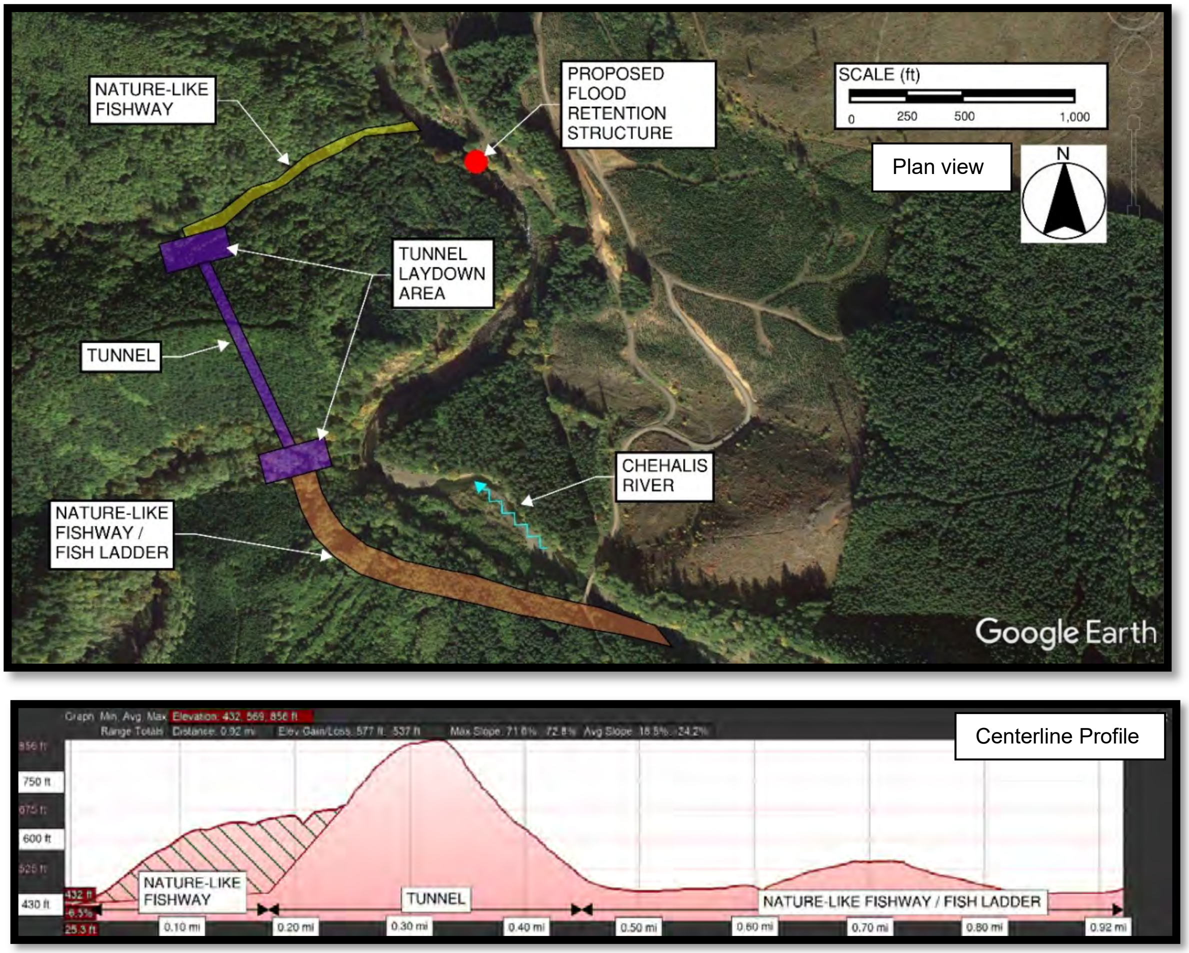
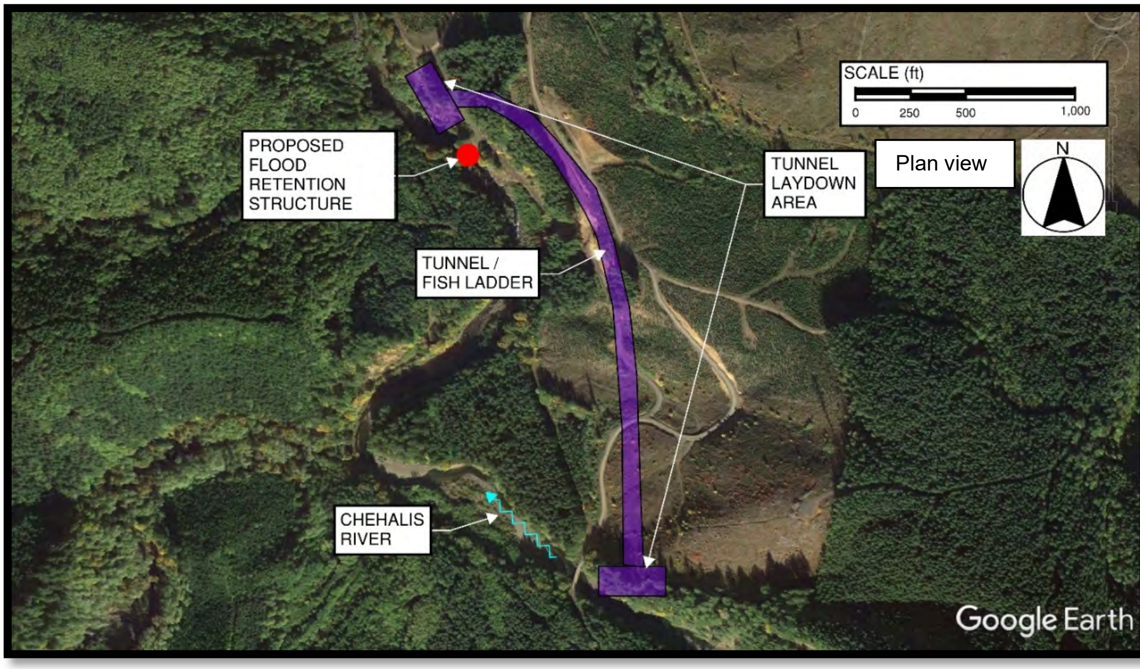


Figure 18. Nature-Like Fishway and Fish Ladder Potential Construction Footprint, Eastern Alignment



4.2.2 Fish Ladders

Research was conducted for several of the fish passage technologies to determine if there was data available for the passage rates of species beyond adult salmonids. Research of Pacific Northwest fish ladders shows no documented evidence of passage rates for resident and juvenile fish, though several references identified visual observations of these fish in the ladders (HDR 2021b). Low bottom swimmers such as resident fish find it difficult to pass through longer fish ladders because of the higher velocities requiring different criteria to accommodate the wide variety of expected fish species and life stages. If a ladder was designed for a broader range of species and life stages, identification of appropriate design criteria would require additional research. For example, one limiting factor requiring vertical slot ladder design analysis is the maximum slot velocity. If the slot velocity is reduced to accommodate weaker swimmers and the hydraulic differential per pool is reduced to 0.4 feet (~5 inches), the conceptual ladder would be 1,100 to 1,200 feet long to accommodate an approximately 40-foot hydraulic differential between the fishway entrance and exit. The 40-foot hydraulic differential value was estimated from bathymetry data as a surrogate for water surface elevation (EL 405 ft to EL 447 ft NAVD88).

A construction phase fish ladder would also need to bypass the construction site, using the same routes as outlined above in Figure 17 and Figure 18 for the nature-like fishway technology. A conceptual fish ladder would require navigational channel sections linking the ladder segments, entrance, and exit together, and extending the fish passage far enough upstream to bypass the flood retention structure construction activities. Those navigational channel sections could be sloped, nature-like fishway sections or simple constructed channels. Figure 17 and Figure 18 show potential fish ladder alignments on the west and east sides of the river.

To determine whether or not the Maintenance and Reliability criterion is met, the water supply needs of the fish ladders and lamprey ramp for the permanent CHTR facility (HDR 2018b)_are listed in Table 4-1. At this stage of design, it is assumed that the same water supply would be required for a construction phase fish ladder as for a permanent fish ladder.

Table 4-1. Permanent Facility Fish Ladder Conceptual Design Water Supply

Water Supply Need	Flow Requirement (cfs)
Adult fish ladder	25
Adult fish ladder AWS	0-200
Juvenile fish ladder	18
Juvenile fish ladder AWS	0-50
Lamprey ramp	3.6
Total required for ladder	46.6 – 296.6

Water supplied to the CHTR facility is gravity-fed from the temporary reservoir upstream of the flood retention structure when it is available[2]; however, the construction phase facility does not provide the same large impoundment of water to pull from upstream. The fish passage design flows, as discussed in Section 2.1, range from 16 cfs to approximately 2,200 cfs. As a result, at the low fish passage design flow of 16 cfs, a fish ladder as an upstream passage technology would be inoperable because of insufficient water supply to support adult and juvenile ladders as well as the lamprey ramp. This technology application does not meet the water supply criteria because the amount of water required is greater than the lower range of target design flows for fish passage.

The fish ladder was removed from consideration because of its inability to meet the environmental and cultural impact, cost effectiveness, and water supply criteria. As stated in

[2] The CHTR facility is fed both by gravity when sufficient water is impounded and from a pump station below the flood retention structure the rest of the time the CHTR is operating (HDR 2018b).

Section 4.2.1, this technology requires cut of about 400 feet at its deepest point for a length of about 3,000 feet through the hillside on either the right or left bank of the Chehalis River. The footprint of this excavation rivals that of the permanent flood retention structure. The impact of clearing such a large area of vegetation and the substantial changes to the topography caused by a 3000-foot-long, 400-foot-deep excavation render this technology infeasible in terms of environmental and cultural impact for a construction phase technology. In addition, the alternative is infeasible from a cost effectiveness perspective because the cost associated with the extensive volume of excavated material due to the open-cut construction through the hillside would rival that of the permanent facility, violating the cost effectiveness feasibility criteria. Thirdly, the alternative is infeasible from a water supply perspective because the required water for fish ladder operation (46.6 cfs) is higher than the available river flow at the low fish passage design river flow (16 cfs). Therefore there would be insufficient flow to meet the function of the technology.

The possibility of a short fish ladder in conjunction with a construction phase trap and transport technology was also investigated and is further discussed in Section 4.2.5.

4.2.3 Fish Passes

Fish passes (e.g., elevators, lifts, and locks) are typically used to transport fish over an established flood retention structure. At the FRE project site, a construction phase fish elevator, lift, or lock would need to bypass the construction site by ascending an adjacent hillslope on the western or eastern bank of the Chehalis River using similar routes as the nature-like fishway and fish ladder technologies described in Sections 4.2.1 and 4.2.2. These types of fish passes would also likely be combined with a natural gravity channel.

Prior to transport, fish would be collected in a similar manner as other trap and transport facility type technologies with similar required guidance, attraction, water control, fish ladder, and holding gallery components.

Figure 19 shows an example configuration of a fish pass system incorporated with a nature-like fishway/fish ladder on the western bank of the Chehalis River. Figure 20 shows an example of a similar configuration on the eastern bank.

Figure 19. Fish Elevator/Lift/Lock to Nature-like Fishway/Fish Ladder Potential Construction Footprint, Western Alignment

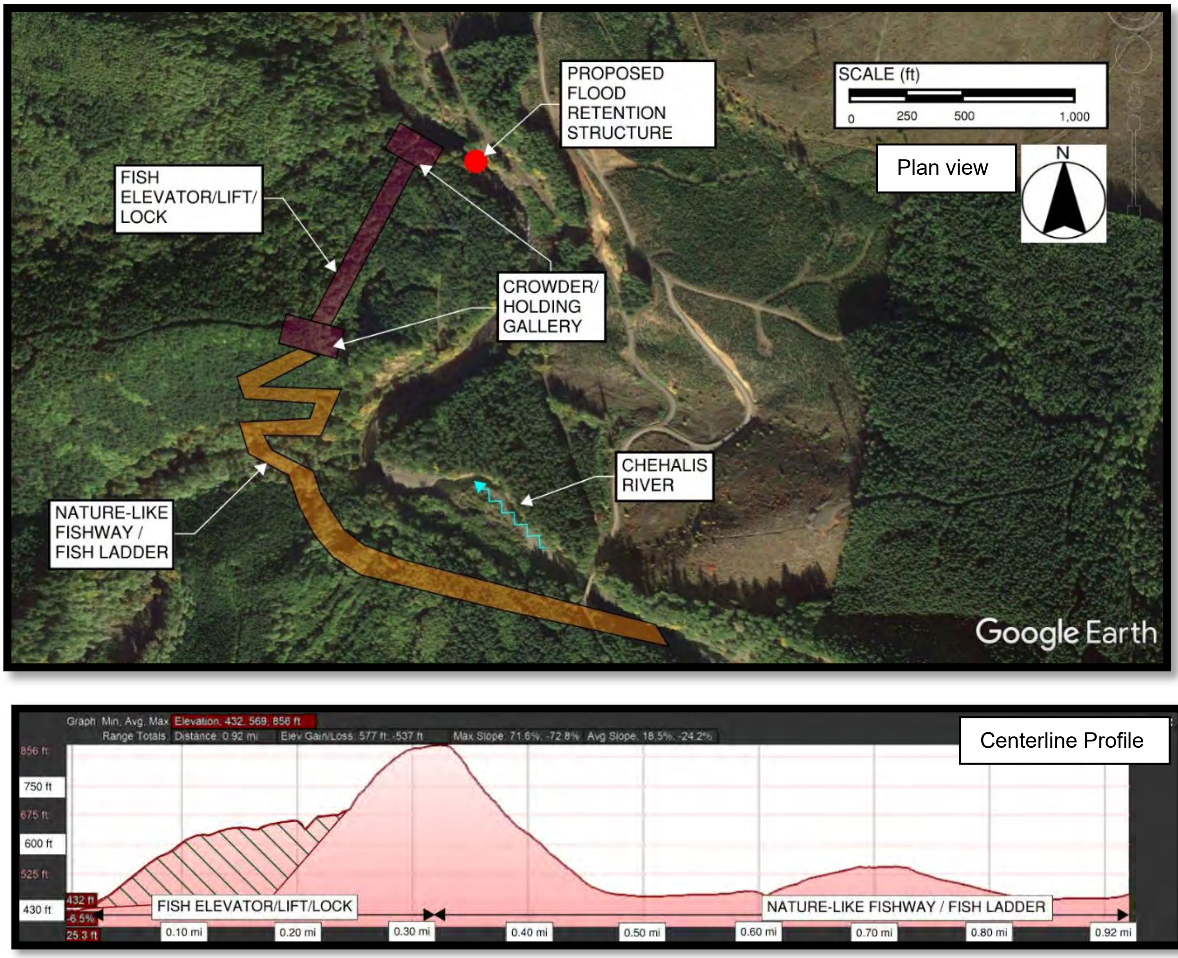
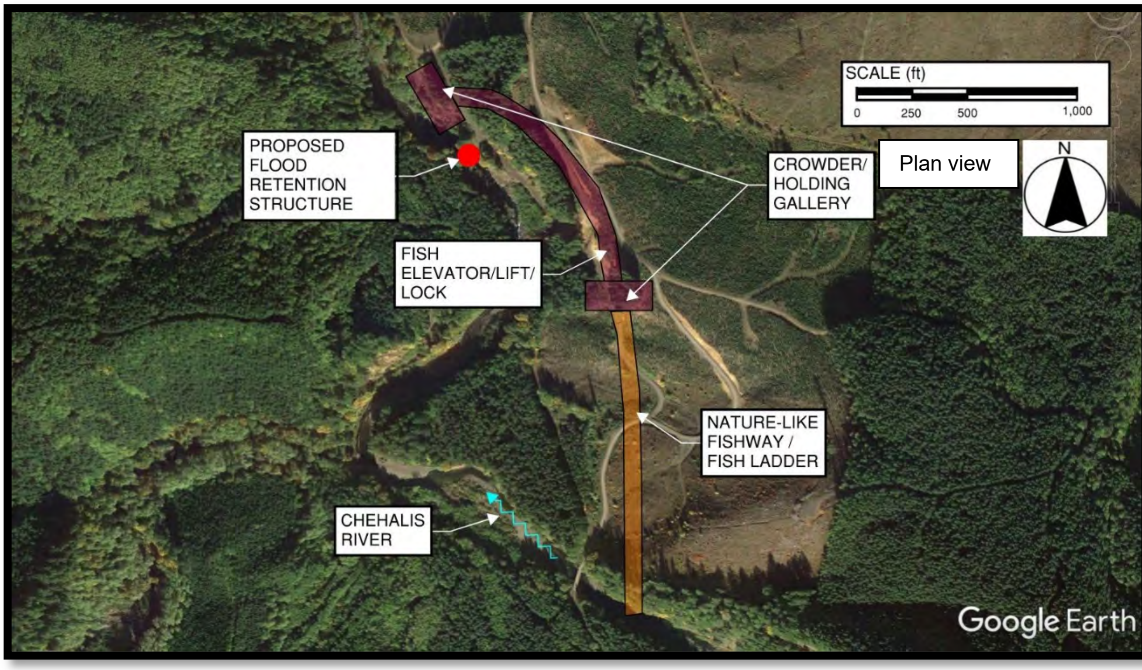


Figure 20. Fish Elevator/Lift/Lock to Nature-like Fishway/Fish Ladder Potential Construction Footprint, Eastern Alignment



A fish lift system would require construction of hoists, concrete foundations, rails, structural members, ramps, pumps, and piping. The elevator, or trolley, would also require a life support system and means to offload fish in case of mechanical failure when in route.

A fish lock system would also require extensive space and infrastructure to be built and construction of a lock chamber, concrete foundations, structural members, gates, pumps, and piping. A fish lock system alone would not be able to transport fish to the upstream release location; therefore, a fish ladder or nature-like fishway would need to be constructed with similar impacts as described in previous sections.

The fish pass was removed from consideration because of its inability to meet the environmental and cultural impact and cost effectiveness criteria. As described, this technology would need to bypass the construction site by ascending approximately 400 feet at the highest point on an adjacent hillslope on the western bank or eastern bank of the Chehalis River using similar routes as the nature-like fishway and fish ladder technologies described above in Sections 4.2.1 and 4.2.2. These routes require an extensive footprint and significant excavation of the hillside to accommodate the required infrastructure. The area of vegetation removal and change to the topography rivals that of the permanent flood retention structure. Thus, this technology is considered infeasible in terms of environmental and cultural impact. Additionally, costs associated with the technological elements and the extensive excavation associated with the open-cut construction through the hillside would rival that of the permanent flood retention facility, making this technology infeasible from a cost effectiveness perspective

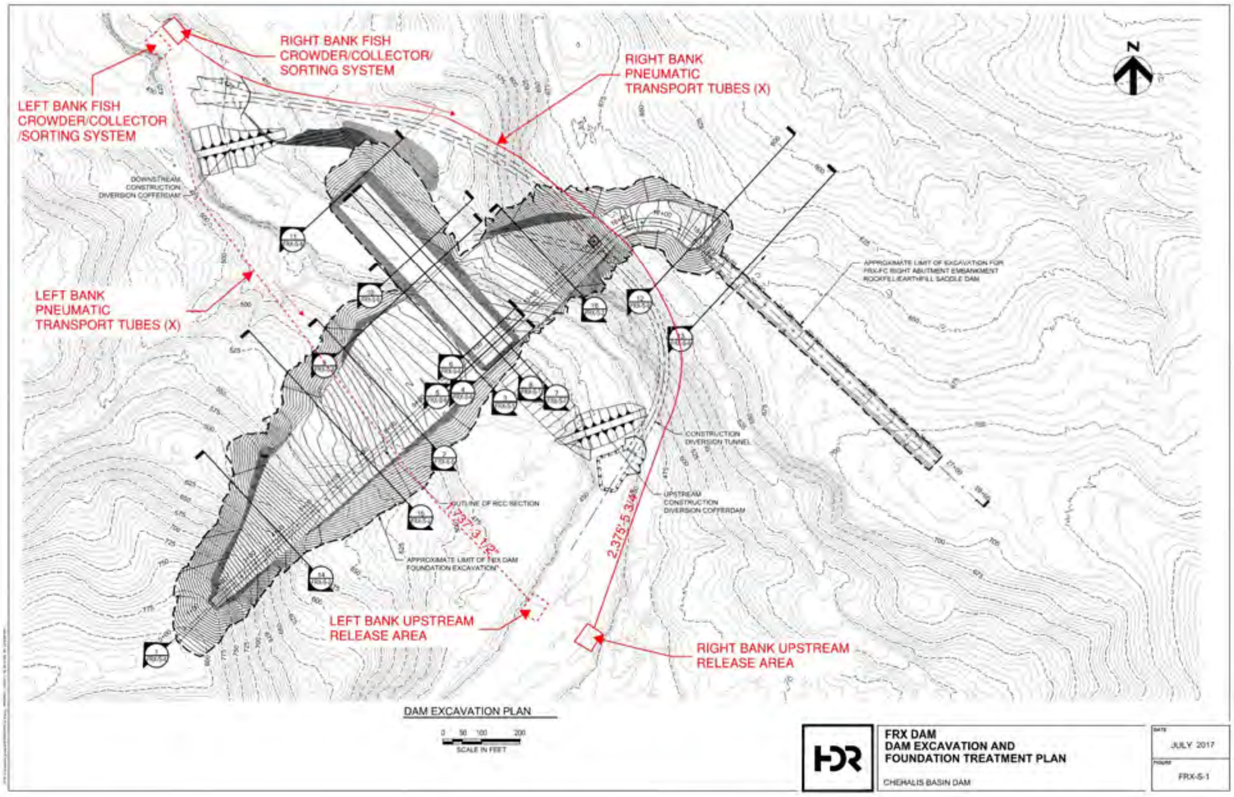
While this technology is not be feasible for a primary passage method, a fish elevator, lift, or lock may be employed as part of a trap and transport system to carry fish to a sorting facility.

4.2.4 Pneumatic Fish Transport Tube System (Whooshh)

A pneumatic fish transport tube system (Whooshh) implemented at the FRE project site could be located on either the eastern or western bank of the river. Figure 21 depicts the approximate extents of the potential Whooshh systems on either bank. Each system would consist of a downstream fish crowder/collector/sorting system, a series of pneumatic transport tubes, and an upstream release area. The flexible pneumatic transport tubes would go up and over the flood retention structure construction area, following the natural topography. The left or right bank options allow the transport system to be moved and placed on either bank depending on construction sequence timing to prevent the transport system from impeding construction activities.

Different tube diameters are required to transport different fish sizes; therefore, a system accommodating several species of upstream migrating fish would require a multiple tube system. The upstream release location for this passage technology differs from the previously discussed technologies. Because space requirements for the tube transport system release location differ from the requirements for the nature-like fishway or fish ladder, the release location for this technology was chosen as the most downstream possible location to minimize travel distance and required tube length. Based on river bathymetry, the hydraulic differential is approximately 30 feet between the downstream and upstream capture and release points (EL 405 ft to EL 436 ft NAVD 88). The tubes for the right bank system would span approximately 2,500 feet and ascend a height of approximately 250 feet before descending approximately 210 feet to the release point. The tubes for the left bank system would span approximately 2,000 feet and ascend a height of approximately 100 feet before descending approximately 60 feet to the release point.

Figure 21. Pneumatic Fish Transport Tube System (Whooshh) Schematic with Flood Retention Structure Excavation and Foundation Plan

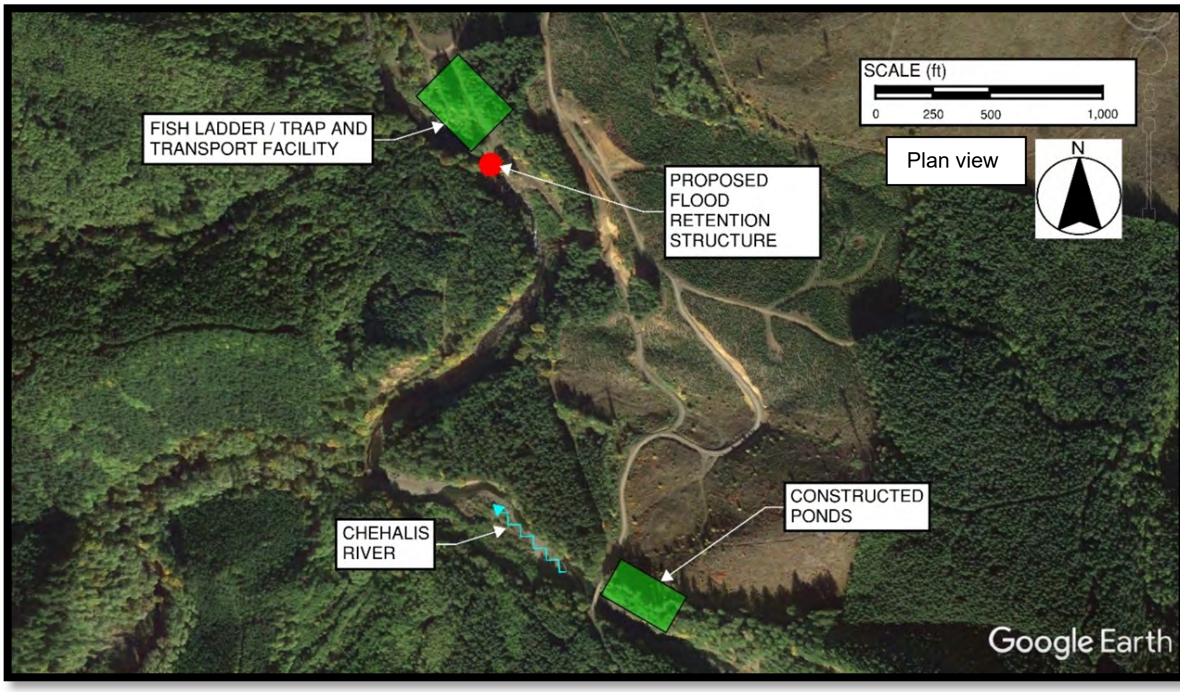


As an experimental technology, the Whooshh system is unable to transport certain species and life stages of fish. The volitional entry into the pneumatic fish transport system requires that fish species are highly motivated to migrate upstream and pass over a false weir into the scanner and sorting module. Pacific Lamprey, juvenile fish, and many of the other target resident fish species are also unable to be transported by the Whooshh system given that tube diameters are not yet compatible with small-bodied fish. Thus, the Whooshh technology was removed from consideration due to its inability to meet the anticipated fish passage performance and survival feasibility requirement of providing passage for all fish and fish life stages believed to be present in the system.

4.2.5 Trap and Transport

As stated in Section 3.1.5, trap and transport technologies are generally composed of five main components that include a barrier or guidance structure; fish entrance; collection, sorting, and holding facility; vehicle with a transport vessel; and designated release location or locations. Similar to fish ladders, documented fish passage rates for resident and juvenile fish using upstream trap and transport technology were not identified in the brief data research conducted for this TM, though there are many qualitative observations of these fish at facilities using this technology (HDR 2021b). Figure 22 shows the approximate construction footprint that for the construction phase upstream fish passage using an upstream trap and transport facility. The system would collect fish downstream of the flood retention structure and transport all fish to a sorting facility. A short road would also be constructed to connect the facility to the nearby existing road to the north. Trucks would transport the fish upstream of the construction zone and release them to continue upstream. Specific release points would be identified during the design development phase if this technology was selected for further development.

Figure 22. Trap and Transport Facility Potential Construction Footprint



As displayed in Figure 22, the upstream trap and transport technology exhibits the smallest and most economical construction footprint. Historically, upstream trap and transport facilities in the Pacific Northwest have been designed for adult-sized salmonids. Designing the facility for smaller, resident and juvenile fish would be an experimental undertaking, but is anticipated to be possible through careful consideration of fish swimming behavior and selection of trap and haul components.

Trap and transport technology could be implemented on the right bank of the river, consisting of a short channel connecting to a crowder and hopper. Alternatively, while a fish ladder functioning as the primary technology does not meet feasibility criteria as explained in Section 3.1.2, fish ladders are on occasion used in combination with a trap and transport system. Fish would swim up a short ladder downstream of the flood retention structure before entering the fish hopper and lift system described in this section, similar to the permanent facility design, to be trucked upstream to the release site.

The water supply needs of the fish ladders and lamprey ramp for the permanent CHTR facility (HDR 2018b) are listed in Table 4-2. At this stage of design, it is assumed that the same water supply would be required for a construction phase facility.

Table 4-2. Permanent Facility Conceptual Design Water Supply

Water Supply Need	Flow Requirement (cfs)
Adult fish ladder	25
Adult fish ladder AWS	0-200
Juvenile fish ladder	18
Juvenile fish ladder AWS	0-50
Lamprey ramp	3.6
Lift, hopper, holding, sorting facility	10
Total required for ladder and trap and transport combination	56.6 – 306.6
Total required for trap and transport on the bank	10 – 260

AWS = auxiliary water supply

Water supplied to the CHTR facility is gravity-fed from the reservoir upstream of the flood retention structure for portions of its operation; however, the construction phase facility does not provide an impoundment of water upstream to pull from. The fish passage design flows, as discussed in Section 2.2.1, range from 16 cfs to approximately 2,200 cfs. As a result, at the low fish passage design flow of 16 cfs, a fish ladder as an upstream passage technology would not be able to operate due to the water supply needs in the adult and juvenile ladders as well as the lamprey ramp. This application of the technology does not meet the water supply criteria because the amount of water required is greater than the lower range of target design flows for fish passage.

However, use of the trap and transport system directly on the bank would meet the water supply criteria as a fish ladder is not necessary. The low fish passage design flow of 16 cfs can accommodate the approximately 10 cfs needed to operate the hopper, lift system, and holding and sorting facilities (HDR 2018b). As flows increase in the river, additional water could be used as the AWS for the collection facility, until approximately 220 cfs is used for the fishway entrance at the high design flow of 2,200 cfs.

This technology meets all the feasibility criteria defined:

- **Anticipated Fish Passage Performance and Survival** – Though actual passage performance for resident and juvenile fish would be an experimental undertaking, all target species and life stages have been observed using this technology in other applications, thereby meeting this criteria.

- **Cost Effectiveness** – The cost of construction of this facility will be substantially less than the permanent flood retention facility as the site footprint is limited, the excavation is comparatively shallow, and the infrastructure is simple in nature and limited in amount.
- **Environmental and Cultural Impact** – The environmental impact of this technology will be substantially less than the permanent flood retention structure facility as the footprint of the required infrastructure is limited and compact.
- **Water Supply** – The low fish passage design river flow (16 cfs) is sufficient to accommodate the water required for function of the technology (10 cfs). River flow is sufficient during the full range of design flows to accommodate operation of the facility.
- **Maintenance and Reliability** – The simplicity of the system and the minimal infrastructure subject to damage from debris and sediment during high river flows reduces the risk of the facility being inoperable for long periods of time. The risk of damage to the facility is low and maintenance required to return the facility to operability is relatively short. As such, the environmental conditions affecting the technology and O&M required for this facility are not anticipated to leave the facility inoperable for appreciable periods of time.

4.3 Feasibility of Barrier Technologies

Barrier technologies are used to minimize attraction and prevent the migration of upstream migrating fish into areas where there is no suitable upstream passage (NMFS 2011). In addition, barrier technologies are also used to guide fish into fish passage facilities. Feasibility of barrier technologies is investigated as part of this TM because the diversion tunnel is unsuitable for upstream fish passage and each of the passage technologies examined in the previous section achieves better passage performance when used in conjunction with an upstream barrier.

4.3.1 Velocity Barrier

Preliminary calculations for two locations at the FRE project site indicate that a velocity barrier can be designed to meet most of the NMFS Anadromous Salmonid Passage Facility Design Guidelines (2011) for the 95 percent and 5 percent exceedance flows. The NMFS criteria for 2 feet of maximum head over the weir crest is surpassed by the 5 percent exceedance flows at the two potential velocity barrier locations and will require NMFS approval on a site-specific basis.

A velocity barrier allows flow and debris to pass freely over a weir, is not likely to impinge fish (NMFS 2011), and is able to serve as an effective barrier for the target fish species and life stages. Inclusion of a bypass in the velocity barrier could allow downstream passage at low river flows. A bypass would likely involve a weir with a notch in the velocity barrier; a bypass pipe in the velocity barrier; or an open channel and fyke combination.

Following storm events debris such as large branches and trees as well as cobbles and larger rock may be deposited on the velocity barrier apron and crest. Removal of large debris and rock from the velocity barrier is anticipated to be achieved by mobile crane or excavator located on the river bank. Removal of smaller debris and sediment is expected to occur by hand by maintenance personnel during low river flow conditions with the use of tie-offs, safety wire, or other safe access methods.

This barrier technology meets all the feasibility criteria. This technology has the best anticipated survival of the barrier technologies examined for all species and life stages as it is less likely to impinge fish and is expected to return to full functionality the most quickly after a high flow event. As with the other barrier technologies, the velocity barrier meets the cost effectiveness and environmental and cultural impact feasibility criteria as it is substantially less cost and environmental footprint than the permanent flood retention facility. The ability to add a low-flow channel to the velocity barrier allows the technology to provide sufficient flow at the low fish passage design river flow, meeting the water supply. Additionally, the velocity barrier is the most reliable of the examined barrier technologies as it allows debris and sediment to pass downstream without impeding passage and with the least need for human intervention and maintenance.

4.3.2 Jump Barrier

A jump barrier (or vertical drop structure) is required to have a minimum 5-foot-deep pool for fish leaping at the jump barrier flow to land in to prevent injury (NMFS 2011). Preliminary calculations for the 95 percent exceedance flow depths for the FRE project site do not meet this required 5-foot minimum tailwater depth. These depths are 0.6 feet at Location 1 near the project site, and 1.3 feet at Location 2 at the low fish passage design flow. Although deeper pools can be constructed at these locations to meet the minimum depth requirement, these constructed pools would require regular maintenance to preserve the minimum depth as they fill with sediment and debris. This maintenance may not be possible during certain times of the year (e.g., when river flow is too high to put machines in the river) and would require additional fish exclusion and removal efforts to achieve.

When the constructed pools fill with sediment but are unable to be maintained, the facility is considered inoperable due to its inability to meet pool depth criteria. The inability of staff to perform required maintenance for extended periods of time, rendering the facility functionally inoperable, classifies this technology as infeasible relative to the Maintenance and Reliability criterion. A jump barrier was removed from consideration as a feasible barrier technology due to its inability to meet the Maintenance and Reliability feasibility criterion.

4.3.3 Picket Barrier

Because the likelihood of impinging downstream moving fish using picket barriers is high, these types of barriers cannot be used in waters containing species listed under the Endangered Species Act (ESA), unless they are continually monitored by personnel on site, and have a sufficient operational plan and facility design in place to provide timely removal of impinged or stranded fish prior to injury (NMFS 2011). While the Chehalis River does not have any salmonids federally listed under the ESA (Ecology 2016), the risk likelihood of impinging downstream moving fish remains for the construction phase fish passage target fish.

In addition, picket barriers must be continually monitored for debris accumulations, and debris must be removed before it concentrates flow and violates the criteria and guidelines established in the NMFS Anadromous Salmonid Passage Facility Design Guidelines (2011). Picket barriers also usually require removal during high flow events to prevent damage to the structure. Winter flows, flood events, and the debris load that come down the Chehalis River are anticipated to be large enough to damage a picket barrier, rendering it non-functional or a detriment to fish health.

Thus, picket barriers were removed from consideration as a viable barrier technology due to their inability to meet the anticipated fish passage performance and survival and reliability criterion.

4.3.4 Barrier Net

Barrier nets are typically only effective in low water velocity and light debris load conditions. The Chehalis River exhibits flashy conditions with high flows and high debris loads. If barrier nets were used in all flow conditions they would frequently be destroyed, washed downstream, and heavily damaged. Replacement and repair following such events would require long delays until river flows reduced enough to safely install replacements and lengthy delays while replacement material was obtained and installed. These conditions would leave the construction phase fish passage facility without an exclusionary barrier for long periods of time, multiple times each year. Thus, barrier nets were removed from consideration due to their inability to meet the Maintenance and Reliability feasibility criterion.

4.4 Recommended Technologies

Table 4-3 provides a summary of the discussion in Sections 4.2 and 4.3. After comparing all technologies to the feasibility criteria, the only viable technology is the upstream trap and transport facility. Additionally, the only viable barrier technology is the velocity barrier. Each of the other passage and barrier technologies exhibit a fatal flaw that would make them infeasible.

Table 4-3. Summary of Technology Evaluation Against Feasibility Criteria

Technology	Reason for Removal
Passage Technology	
Nature-like Fishways	Does not meet environmental and cultural impact criteria due to substantive effect on environment and does not meet cost effectiveness criteria due to substantive cost
Fish Ladders	Does not meet environmental and cultural impact criteria due to substantive effect on environment; does not meet cost effectiveness criteria due to substantive cost; does not meet water supply criteria due to amount of water required for facility operation
Fish Passes	Does not meet environmental and cultural impact criteria due to substantive effect on environment and does not meet cost effectiveness criteria due to the range of facilities that would be required for construction phase technology and likely never used again
Pneumatic Fish Transport Tube System	Does not meet anticipated fish passage performance and survival criteria due to inability to pass resident species, juvenile fish, and Pacific Lamprey
Trap and Transport	Not removed from consideration
Barrier Technology	
Velocity Barrier	Not removed from consideration
Jump Barrier	Does not meet Maintenance and Reliability criterion due to the frequency in which this technology is anticipated to be inoperable
Picket Barrier	Does not meet anticipated fish passage performance and survival criteria due to inability to meet agency criteria for use and reliability due to the frequency in which this technology is expected to be inoperable because of high flows
Barrier Net	Does not meet Maintenance and Reliability criterion due to the frequency in which this technology will be inoperable because of ineffectiveness at high flows and debris loads

The recommendation of the velocity barrier technology is consistent with the technical memorandum (HDR 2021) regarding the District's correction of the assumption in the Draft SEPA EIS that a picket barrier would be used as part of the construction phase fish passage facility (Ecology 2020). In this TM as well as HDR 2021, it is noted that a velocity barrier is anticipated to prevent upstream movement of aquatic species with better effectiveness, is not rendered less effective due to damage from debris and sediment, and has less potential for harm to aquatic species compared with a picket barrier. The greater feasibility and performance of the velocity barrier was the basis for the District's request that Ecology revise the survival and performance rates assumed in the SEPA EIS for the construction phase fish passage facility to match that of the permanent CHTR structure (HDR 2021).

5.0 Alternatives Analysis

An alternative analysis was performed using the preferred upstream fish passage technology identified in the previous section. First, conceptual design alternatives for a trap and transport facility with velocity barrier immediately downstream of the diversion tunnel outlet were developed using the design criteria in Section 2.0. Formulation of the alternatives is described in Section 5.1. Next, a range of potential conceptual design alternatives for upstream trap and transport meeting these design criteria, identified as the preferred technologies in Section 4.0, were developed for comparison using evaluation factors. The identification and development of evaluation factors included removal of those that did not differentiate alternatives. Next, three alternatives were developed to a conceptual level. Alternatives were then scored based on how well they meet the intent of the evaluation factors. Discussion and conclusions resulting from this exercise are summarized in the following sections.

5.1 Alternative Formulation

To develop alternatives using the trap and transport and velocity barrier technologies, numerous options were considered and previous work regarding fish passage during construction was reviewed. Alternative formulation focused on location, specifically the challenging topography of the project area, as well as complexity and the interplay between construction phase and permanent project elements. Each facility follows the trap and transport design criteria described in the trap and transport technology section above. The following sections describe trap and transport alternatives, evaluation factors, and the alternative comparison.

5.1.1 Trap and Transport Design Criteria

For design of the recommended upstream trap and transport technology, a variety of facilities are required such as trapping and holding facilities, a fishway with an associated fishway entrance, lamprey passage facilities, and a pump station to supply the required water. The criteria associated with these facilities are noted in Section 0 through 5.1.1.4 and were taken from a previous report (HDR 2018b). These design criteria were followed to perform alternative evaluation.

5.1.1.1 Trapping and Holding Criteria

The criteria for fish trapping and holding facilities are provided in Table 5-1 and Table 5-2.

Table 5-1. Trapping and Holding Criteria

Criteria	Value	Reference
Holding duration – holding gallery	24 hours, maximum	NOAA Fisheries (2011)
Holding duration – hopper and transport tank	24 hours, maximum 1/2 hour, maximum during peak run rates	NOAA Fisheries (2011)
Temperature	50°F	NOAA Fisheries (2011)
Dissolved oxygen	6 to 7 parts per million	NOAA Fisheries (2011)
Water supply, holding, fry	0.0075 gallons per minute (gpm) per fish	Piper et al. 1982
Water supply, holding, smolts	0.13 gpm per fish	Piper et al. 1982
Water supply, holding, adults	0.67 gpm per fish	NOAA Fisheries (2011)
Adult jump provisions	Required	NOAA Fisheries (2011)
Segregation of fish	Capability required	Not applicable
General	Decrease poundage of fish held by 5% for every degree over 50ºF	

Table 5-2. Fish Size, Holding Volume, and Long-Term Holding Flow Criteria

Species	Average Assumed Weight/Fish (pounds)	Long-Term Holding: Flow/fish (gpm)	Holding Volume (cubic feet/pounds)
Spring-Run Chinook Salmon	23	1	0.25
Fall-run Chinook Salmon	23	1	0.25
Coho Salmon	9.5	0.5	0.25
Winter-Run Steelhead Trout	9	2.0	0.25
Summer-Run Steelhead Trout	8	2.0	0.25
Coastal Cutthroat Trout	1	Unknown	0.25
Lamprey	Unknown		
Resident species	Unknown		

Notes: Holding volume and long-term holding flow requirements per NOAA Fisheries (2011)
Long-term flow requirements are for emergency situations where fish must be held for more than 72 hours Adult fish sizes per Bell (1991).

Fish holding volume requirements do not change based on the amount of time held. However, flow requirements are contingent upon holding time, and fish held longer than 72 hours require more flow than fish held less than 72 hours. The Subcommittee did not address fish holding periods during emergencies (e.g., a situation where washed out roads prevent fish transportation activities). Fish holding during emergency situations where holding may be required for more than 72 hours will be addressed in the next phase of design development. Flow requirements for long-term holding are provided in Table 5-2 for reference in future design development discussions.

Volume and flow needed for the holding gallery, fish hoppers, and transport tanks were determined using the trapping and holding criteria presented in Table 5-3 and the peak daily and hourly number of fish as determined in Section 5.1.1. The number of fish used to size these design elements is as follows:

- Holding gallery
  - Flow: Peak daily number of fish
  - Volume: Peak daily number of fish
- Hopper
  - Flow: Half the peak hourly number of fish
  - Volume: Half the peak hourly number of fish
- Transport tank
  - Flow: Not applicable
  - Volume: Half the peak hourly number of fish

The hoppers hold half the peak hourly count of fish to limit the size of the hoppers. Fish hoppers would be emptied frequently during peak short-term runs (e.g., every 20 minutes). However, during most of the trapping period, low numbers of fish will enter the low volume, low velocity entrance each day, so the hopper would be emptied less frequently (e.g., every few hours). While the hopper will hold fish for up to 24 hours, the hopper would be operated such that no more than half the peak hourly count of fish is held at any time. Receptacles for life support systems would be provided on the outside wall of the hopper vessel (e.g., oxygen tanks). Use of such equipment would be evaluated based on need during the commissioning and demonstration period.

Calculations determining the size of these elements are provided in Table 5-3 and Table 5-4.

Table 5-3. Adult Holding Gallery Sizing

Criteria	No. of Fish	Pounds of Fish	Cubic Feet Required	Flow (gpm)
Spring-Run Chinook Salmon	135	3,105	776.25	--
Coho Salmon	1,290	12,255	3,063.75	--
Winter-Run Steelhead	563	5,067	1,266.75	--
Subtotal	--	--	5,107	--
Factor of Safety	--	20%	1,022	--
Total	**1,988**	**20,427**	**6,130**	**1,332**

Notes: Holding gallery sized for 1 day of peak-day run.

Table 5-4. Hopper and Transport Tank Sizing

Criteria	No. of Fish	Pounds of Fish	Cubic Feet Required	Flow (gpm)
Adult hopper and transport tank	200	2,043	511	134
Juvenile/resident hopper and transport tank	Same as adult hopper and transport tank			

Notes: Juvenile/resident hopper and transport tank sized to match adult hopper and transport tank.

5.1.1.2 Fishway Criteria

Designs of upstream fish passage facilities at dams are developed based on criteria and guidelines developed to successfully pass adult salmonids. The fishway is comprised of two major components: the fishway entrance(s) and the fish ladder. Table 5-5 lists the primary design criteria for the fishway entrance(s) and fish ladder, respectively.

Table 5-5. Fishway Entrance Criteria

Criteria	Value	Reference
Location	Easily located by fish	NOAA Fisheries (2011), WDFW (2009)
Width	4 feet, minimum	NOAA Fisheries (2011)
Depth	6 feet, minimum	NOAA Fisheries (2011)
Head differential, adults	1 – 1.5 feet	NOAA Fisheries (2011), WDFW (2009)
Head differential, juveniles	0.13 inches	NOAA Fisheries (2011)
Attraction flow	5% – 10% of the maximum of the 5% exceedance flows for the migration period of each species	NOAA Fisheries (2011)
AWS energy dissipation factor	16 foot-pounds/second/cubic foot	NOAA Fisheries (2011)
AWS diffuser velocity, vertical	1 foot/second, maximum	NOAA Fisheries (2011)
AWS diffuser velocity, horizontal	0.5 foot/second, maximum	NOAA Fisheries (2011)
AWS diffuser bar spacing	1.75 millimeter, maximum (juvenile criteria)	NOAA Fisheries (2011)
Fish darting speed	27 feet per second, maximum	Bell (1991), pg. 6.3 (steelhead)
Fish darting duration	10 seconds, maximum	Bell (1991), pg. 6.2
Depth required for jumping	2 feet, minimum	USFS (2001), Adult Salmonid Migration Blockage Table (adapted)

5.1.1.3 Lamprey Passage Criteria

Throughout the preliminary design of the CHTR, the best available science relating to the lamprey passage at dams and in fishways was discussed, used to inform fish passage facility requirements, and incorporated into the design. This included information contained in the scientific literature, lessons learned from experimental facilities at USACE dams on the Columbia River, and interviews with researchers who specialize in studying lamprey behavior and navigational capabilities. The following resources outline the experimental facilities and best practices used in the CHTR design for adult lamprey:

- Best Management Practices to Minimize Adverse Effects to Pacific Lamprey (USFWS 2010)
- Adult Pacific Lamprey Passage: Data Synthesis and Fishway Improvement Prioritization Tools (Keefer et al. 2012)
- Pacific Lamprey and NRCS: Conservation, Management and Guidelines for Instream and Riparian Activities (USDA 2011)
- Pacific Lamprey Protection Guidelines for USDA Natural Resources Conservation Service Instream and Riparian Activities (USDA 2010)

- Lamprey Passage in the Willamette Basin: Considerations, Challenges, and Examples (USFWS 2011)
- Adult Pacific Lamprey: Known passage challenges and opportunities for improvement (Keefer et al. 2014)
- Evaluation of Adult Pacific Lamprey Fish Passage at Snake River Dams (Stevens et al. 2015)

Based on information contained in these resources, the lamprey passage design criteria listed in Table 5-6 will be used for the preliminary design of lamprey passage components of the construction phase upstream fish passage facility.

Table 5-6. Lamprey Passage Design Criteria

Criteria	Value	Reference
Flow velocity	6 feet per second, maximum	USDA (2010)
Ramp width	1.0 feet minimum	USACE (2015)
Distance between resting pools	20 feet maximum	USACE (2015)
Water depth in ramp	3 inches, minimum	USACE (2015)
Wetted surface finish	Smooth	USACE (2015)

5.1.1.4 Pump Station Intake Criteria

Construction phase upstream fish passage facility alternatives include the use of pumped flow to supply flows to multiple facility components. The intake for pump stations is designed in accordance with the Hydraulic Institute's (2018) pump intake design guidelines and NMFS 2011 salmonid passage facility design guidelines. The pump station intake will be screened according to NMFS 2011 guidelines, which include the values shown in Table 5-7.

Table 5-7. Intake Screen Design Criteria

Criteria	Value
Screen bar spacing	1.75 millimeter
Approach velocity	0.40 fps, maximum
Screen cleaning	Active

5.1.2 Description of Alternatives

Previous analysis conducted during preliminary design of the permanent fish passage facility identified two possible locations for a construction phase trap and transport facility. Both locations were on the right bank of the river and chosen based on the presence of small floodplains that could accommodate potential construction phase facilities and construction laydown. Further, consideration was given to minimizing complexity of the project by comparing construction phase and permanent facility elements to determine where project challenges could be mitigated. Three alternatives for a construction phase upstream trap and transport system using a velocity barrier were evaluated:

- Alternative 1: Trap and Transport Facility at Location 1
- Alternative 2: Trap and Transport Facility at Location 2
- Alternative 3: Trap and Transport Facility at Location 1 using Permanent Facility Elements

These alternatives encompass two different locations at the FRE project site (Figure 23). Location 1 is approximately 1,200 feet downstream of the proposed Chehalis flood retention structure. Location 2 is approximately 1,300 feet downstream of Location 1 (approximately 2,500 downstream of the proposed flood retention structure). The upstream release area for all of the alternatives is yet to be determined, but is shown for conceptual purposes as approximately 950 feet upstream from the proposed flood retention structure. Specific release locations will be determined during future design development phases.

Figure 23. Potential Locations for Construction Phase Upstream Trap and Transport Systems using a Velocity Barrier at the FRE Project Site

The construction phase trap and transport facility for each alternative will include six main components:

- Velocity barrier
- Water supply
- Fish entrance
- Collection, holding, and sorting facilities
- Vehicle with a transport vessel (tank of water)
- Designated release location

Components that are the same or similar among the three alternatives are described in this section. Components that vary among alternatives and additional detail for each of the three alternatives are described in Section 5.3.

Velocity Barrier

A velocity barrier meeting design criteria and guidance listed in NMFS 2011 will be utilized as an exclusion barrier. The velocity barrier for each alternative will consist of a weir and concrete apron as described in Section 3.2.1. There will be a bypass to allow downstream passage. This bypass will involve a weir with a notch in the velocity barrier; a bypass pipe in the velocity barrier; or an open channel and fyke combination. The bypass design will meet criteria in Sections 11.9.3 and 11.9.4 of the NMFS (2011) Anadromous Salmonid Passage Facility Design.

At higher flows where fish can pass downstream directly over the velocity barrier, it is expected that it will be necessary to close off this bypass to avoid effects of higher flows with sediment and debris loads. Details will be provided during future design development phases.

Water Supply

Water supply for each alternative will consist of a set of tee screens located upstream of each velocity barrier. The screens will be submerged as water is backwatered behind the velocity barrier. There will be a pump system providing water to the collection, holding, and sorting facilities, prior to flowing out the fishway entrance. When necessary, water will also be provided to the AWS system through the screened intake and pump system.

Under the low fish passage design flow of 16 cfs upstream of the velocity barrier, the river will be a backwater pool. Approximately 10 cfs will be used by the pumps to operate the trap and transport facility. As stated under the velocity barrier component description, a bypass for the velocity barrier will be reduced to approximately 6 cfs as stream flow for a short distance of less than 20 feet. Downstream of the bypass, flow will be returned from the trap and transport facility to the river, returning the river flow to 16 cfs.

There is no regulatory minimum flow in the Chehalis Headwaters (where the project site is located), as stated in Supplement IV to the Chehalis Watershed Management Plan (Chehalis Basin Partnership 2004). As a result, the bypass for the velocity barrier will be designed such that criteria will be met under the low flow of 6 cfs through the bypass.

One other option would be to place the screens and pump system downstream of the trap and transport facility. Under this scenario, at the low fish passage design flow of 16 cfs, all instream water would flow through the velocity barrier bypass. Downstream of the trap and transport facility, screens would take 10 cfs from the river, pump it through the trap and transport facility, and release it upstream in the fishway entrance to rejoin the instream flow. This recirculation system provides a minimum 16 cfs in the river upstream of the fishway and downstream of the pumps, with 26 cfs in the river between the fishway and the pumps. This option is less attractive because it would likely require channel grading or a grade structure downstream to impound the water to gain the required submergence of the screens. Under the first option, the velocity barrier would be used to impound the water and therefore cause less impact to the stream and would be less expensive.

Once permanent construction of the flood retention structure is completed, the tee screens will be removed and reused for water supply for the permanent facility. The structural support system for the construction phase tee screens will be removed and the site restored to pre-project conditions.

Fish Entrance

The fish entrance will be located on the right bank of the Chehalis River for each alternative. It will meet the criteria specified by accepted fisheries design guidelines (NMFS 2011; WDFW 2000a). Water for this entrance will be provided by water emanating from the fish collection facility, as well as water used for downstream fish passage. As flows in the river increase, an AWS will also be provided at the fish entrance for attraction.

Collection, Holding, and Sorting Facilities

All alternatives will have collection, holding, and sorting facilities. The collection facility in each alternative will be located on the right bank of the Chehalis River adjacent to the velocity barrier and utilize a fish hopper and lift system. The fish hopper and lift system will use flumes to transport fish to the holding facility, which will also be connected via a gravity flume to the sorting facility. The sorting facility will be located at a height far enough above ground that a truck could drive underneath to collect the fish.

Vehicle with a Transport Vessel

A vehicle (or vehicles as required in peak times) will be needed to transport fish from the sorting facility to the upstream release site. The truck will drive under the sorting facility, which will open and transfer fish below to the truck. The truck will then immediately drive upstream to the release site. Existing roads will be used, but it is anticipated some additional roads will need to be constructed.

Designated Release Locations

The upstream release locations are the same for all alternatives. Trucks will arrive at the release point, release fish in the designated location, and return to the sorting facility as necessary.

The release area is yet to be determined. As design progresses, the release locations will be determined in collaboration with stakeholders such as WDFW, NMFS, and other agencies.

There will be multiple locations for fish release due to different species, life stage migration, or other considerations. Release points will utilize existing roads or add extensions of these existing roads to access the river or stream identified for release; hardened infrastructure is not anticipated to be constructed. See Section 6.2.8 for additional discussion of release locations.

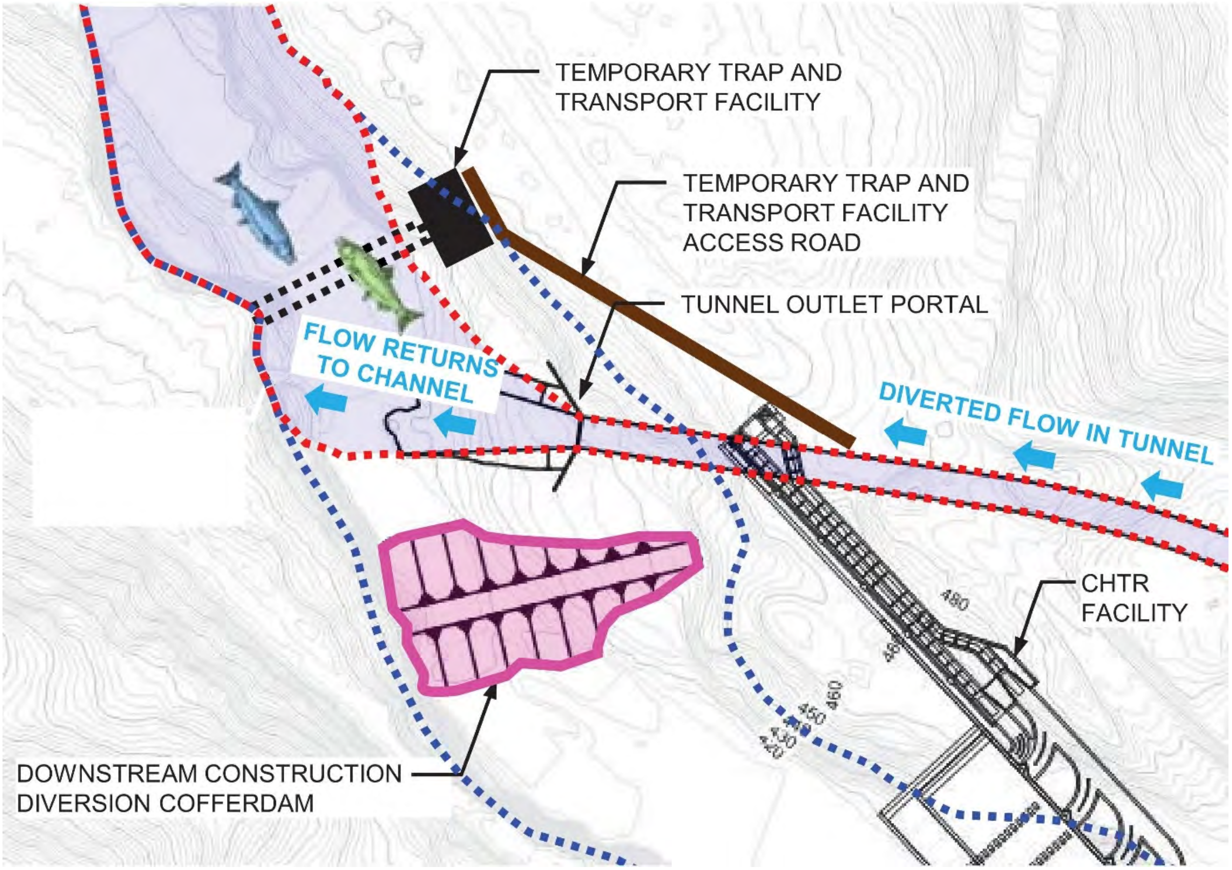
5.1.2.1 Alternative 1

Alternative 1 consists of a construction phase trap and transport facility at Location 1 with a velocity barrier (Figure 24). The facilities built as part of Alternative 1, such as the collection, holding, and sorting facilities, will all be temporary and require associated temporary grading of the site during their construction. Implementation of Alternative 1 would also require a new temporary access road in and out of the construction phase trap and transport facility. After construction of the flood retention structure is completed, the construction phase fish passage facility will be removed completely.

Preliminary calculations for the velocity barrier at Location 1 indicate there is 0.1 feet of head over the weir for the 95 percent exceedance flow and 3.8 feet of head for the 5 percent exceedance flow. The head over the weir crest for the 5 percent exceedance flow is greater than the 2-foot maximum specified by NMFS guidelines and will thus need to be approved by NMFS on a site-specific basis. The velocity barrier creates an upstream impoundment that backwaters to the downstream construction diversion cofferdam at all fish passage flows. This also causes backwatering of the diversion tunnel outlet, with an extent of about 200-550 feet into the tunnel. Refinements to this design at Location 1 will need to be made to limit backwatering effects and addressed during future design development phases[3].

[3] Hydraulic modeling of the backwater effects of the velocity barrier on the tunnel outlet are being performed on the recommended alternative for the 10% design. The location of the velocity barrier will be refined during the 10% design and future design development based on hydraulic modeling. A discussion of the hydraulic modeling and the refined velocity barrier location will be included in the final version of this technical memorandum.

Figure 24. Alternative 1—Construction Phase Trap and Transport Facility with Velocity Barrier at Location 1

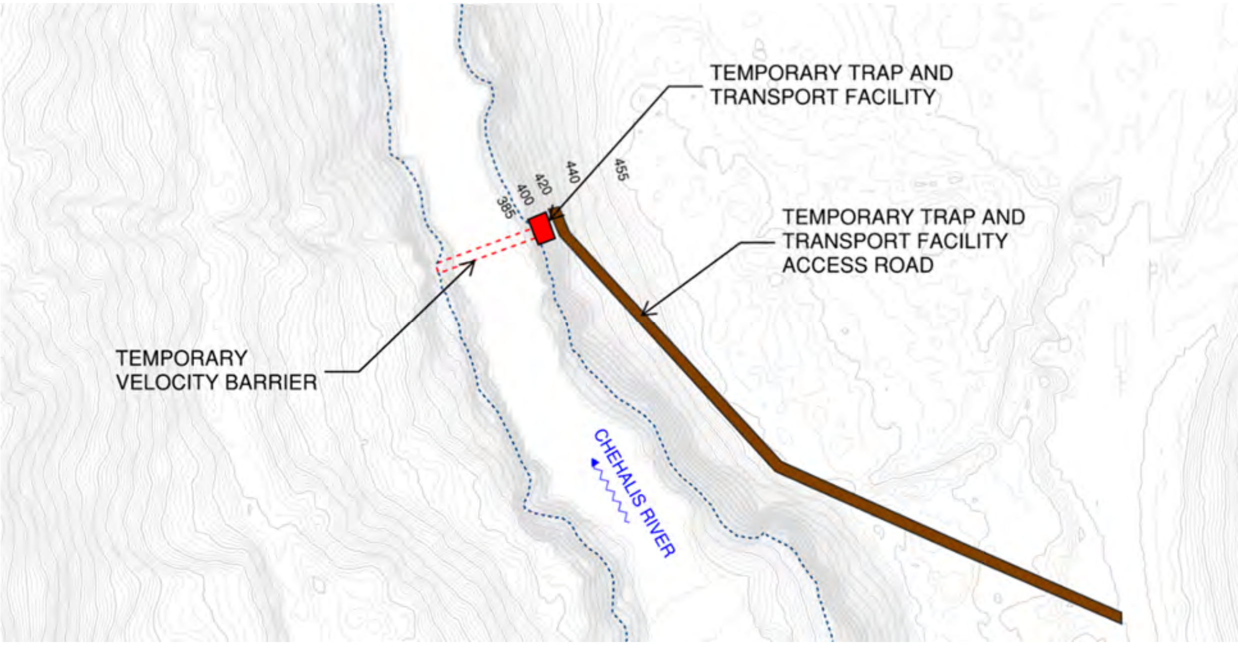


5.1.2.2 Alternative 2

Alternative 2 consists of a construction phase trap and transport facility approximately ¼ mile downstream of the diversion tunnel outlet at Location 2 with a velocity barrier (Figure 25). Similar to Alternative 1, the facilities built as part of Alternative 2, such as the collection, holding, and sorting facilities, will all be temporary and require associated temporary grading of the site during their construction. Implementation of Alternative 2 would also require a new temporary access road in and out of the construction phase trap and transport facility. After construction of the flood retention structure is completed, the construction phase fish passage facility will be removed completely.

Preliminary calculations for the velocity barrier at Location 2 indicate there is 0.2 feet of head over the weir for the 95 percent exceedance flow and 5.7 feet of head for the 5 percent exceedance flow. The head over the weir crest for the 5 percent exceedance flow at this location is greater than at Location 1 and the 2-foot maximum specified by NMFS guidelines. Thus, this design will need to be approved by NMFS on a site-specific basis. The velocity barrier at Location 2 creates an upstream impoundment that backwaters approximately 750 feet upstream of the velocity barrier at the 95 percent exceedance flow and approximately 1,250 feet upstream at the 5 percent exceedance flow. This 5 percent exceedance flow backwater pool extends to approximately 180 feet downstream of the diversion tunnel outlet and does not inundate the tunnel outlet.

Figure 25. Alternative 2—Construction Phase Trap and Transport Facility with Velocity Barrier at Location 2



5.1.2.3 Alternative 3

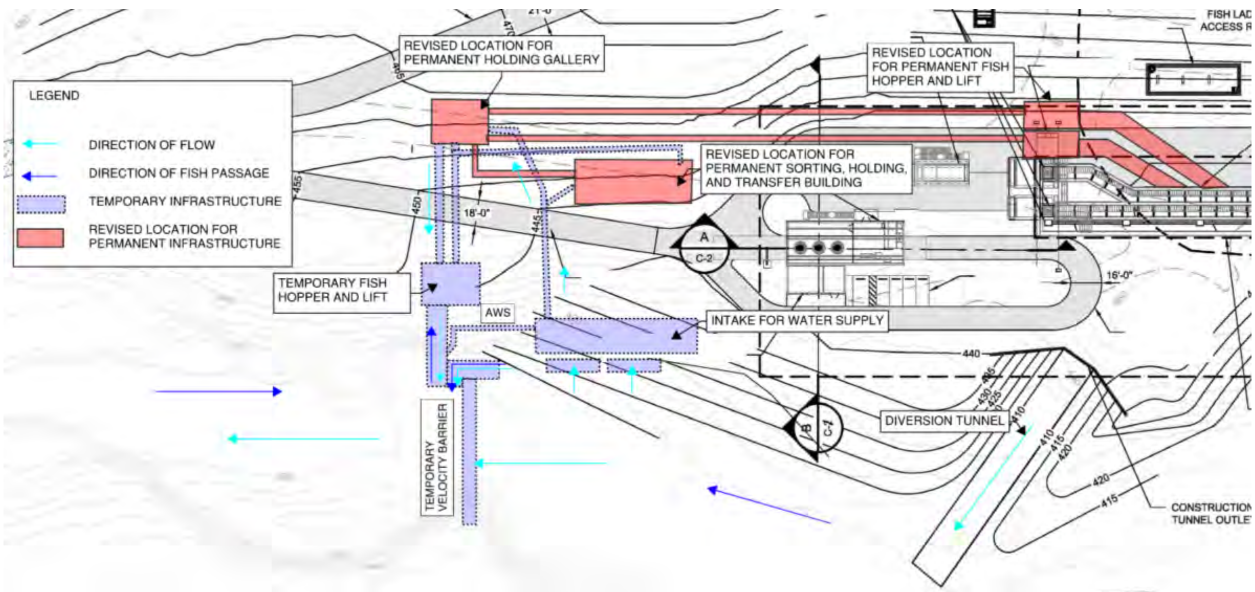
Similar to Alternative 1, Alternative 3 utilizes a trap and transport facility at Location 1 with a velocity barrier. The construction phase fish hopper and lift, velocity barrier, and water supply intake are consistent with Alternative 1, using the same design and location. The primary difference between Alternative 1 and Alternative 3 is that several elements of the construction phase fish passage facility would remain and be incorporated into the permanent CHTR facility as part of Alternative 3.

Elements such as access roads, the holding gallery, and the sorting facility will be constructed to provide construction phase upstream fish passage and later integrated into the permanent CHTR facility. As shown in Figure 26, several elements of the CHTR design, will be reconfigured and shifted west to be used for both construction phase and permanent fish passage. Access roads and parking will be reconfigured to accommodate these shifted facilities.

Alternative 3 shares a significant footprint with the proposed CHTR facility, at the toe of an identified landslide (Shannon & Wilson 2016). Shannon & Wilson (2016) note that more substantial retrogressive-type failures for this landslide are unlikely. Nonetheless, Shannon & Wilson (2016) recommend implementing mitigation measures such as monitoring the landslide for movement and installing deep drains, structural reinforcements, and stability berms. Alternative 3 would include implementation of these mitigation measures.

Not all of the CHTR fish passage facilities would be constructed for construction phase fish passage Alternative 3. The stilling basin, adult and juvenile fish ladders, as well as permanent fish hoppers and lifts would remain on their original construction schedule. After construction of the flood retention structure is completed, the permanent elements of the facility would remain in place for use as part of the permanent fish passage facility. The construction phase fish lift and hopper facility would be removed.

Figure 26. Alternative 3 Detail Figure



5.2 Alternative Evaluation

5.2.1 Evaluation Factors Not Providing Differentiation Between Alternatives

Multiple alternative evaluation factors were considered for use in comparing upstream passage. Many were not included as evaluation factors because all the alternatives presented met the evaluation criteria to the same level and therefore were not differentiated by these factors. The removed factors and reason for removal are specified in Table 5-8.

Table 5-8. Summary of Evaluation Factors Not Providing Differentiation

Evaluation Factor	Reason for Removal
Meet federal and state fish passage criteria	Each proposed alternative must meet federal and state fish protection and screening criteria to be acceptable and qualify for potential environmental permitting during implementation. None of the alternatives will be able to better meet the criteria and therefore this was not selected as a potential differentiator among alternatives.
Reliability	Each alternative implements the same upstream passage technology and barrier technology; as a result, none provides more reliable passage than another.
Public safety	Each alternative will comply with all state and federal safety requirements. As a result, safety will not be a differentiating factor between the alternatives.
Permitting	Each alternative implements the same upstream passage technology and barrier technology; as a result, none provides a more permittable alternative than another.

5.2.2 Alternative Evaluation Factors

All alternatives presented in Section 5.1 meet the feasibility criteria summarized in Section 4.1. Evaluation factors used to compare the alternatives for an upstream trap and transport system with a velocity barrier include:

- **Fish Passage Performance** – Provide safe fish passage for all target species and life stages throughout the range of anticipated flows where fish require upstream passage through the project site.
- **Compatibility with Construction Activity** – Minimize the potential for impacts to construction of the permanent infrastructure associated with the flood retention structure.
- **Minimization of Relative Capital Costs** – Minimize total construction cost of the construction phase and permanent facilities.
- **Simplicity of Operation and Maintenance** – Minimize O&M level of effort and complexity.

5.2.2.1 Fish Passage Performance

The intent of this evaluation factor is to measure how well each alternative is expected to provide safe and effective upstream fish passage for all target species and life stages throughout their anticipated migration periods. It considers the ability of fish passage pathways to remain free of failure, occlusion, or disruption and meet agency criteria. For example, an alternative that meets all agency criteria, and is therefore safer for fish passage, will have higher suitability than one that requires a variance from recommended criteria.

5.2.2.2 Compatibility with Construction Activity

The intent of this evaluation factor is to consider the impact of each alternative on construction activities associated with the flood retention structure. Construction of the flood retention structure is anticipated to last approximately 3 to 5 years; throughout this time, construction phase upstream fish passage must remain viable while mitigating impacts to the facility construction footprint. For example, an alternative that avoids all impacts to the facility construction will have higher suitability than one that conflicts with, causes delays to, or otherwise affects construction of the flood retention structure.

5.2.2.3 Simplicity of Operation and Maintenance

The intent of this evaluation factor is to estimate the level of effort and complexity required for O&M of a proposed facility. This is based on the skill level and level of effort required for facility operation, as well as the anticipated frequency of maintenance required. For example, an alternative that must be maintained once per month on a regular basis will have higher suitability than one that must be maintained once per week.

5.2.2.4 Minimization of Relative Capital Costs

Capital cost is the fixed, one-time expense, of construction of the entire fish passage facility – including both construction phase and permanent elements. Costs are qualitative and comparative; no detailed cost estimating has been performed at this stage of design. A lower capital cost is preferred, and therefore, an alternative with a lower anticipated capital cost will have higher suitability than a more expensive alternative. For example, an alternative that reuses construction phase upstream fish passage infrastructure in permanent fish passage facilities will incur an overall lesser capital cost and rate higher than one that requires construction of an entirely separate construction phase upstream fish passage facility from the permanent fish passage facility.

5.3 Comparison of Alternatives

A qualitative rating scale was used to evaluate each alternative for the criteria listed above. A qualitative comparison is commensurate with the conceptual level of design. More quantitative analysis would require further design development which is planned to be undertaken prior to project permitting. Each alternative was ranked as low, medium, or high suitability using the evaluation factors in the following sections. In the evaluation all criteria were assumed to be of relatively equal importance. Results are summarized in Table 5-9.

5.3.1 Fish Passage Performance

As discussed in Sections 5.1.2.1 and 5.1.2.2, preliminary calculations for the velocity barrier at Locations 1 and 2 indicate there is 3.8 feet and 5.7 feet of head over the weir for the 5 percent exceedance flow respectively. Both of these values exceed the 2-foot maximum specified by NMFS guidelines and will require site-specific approval. Because Location 1 requires a smaller variance from NMFS criteria, Alternatives 1 and 3 were assigned a higher suitability ranking for fish passage performance.

Also discussed in Sections 5.1.2.1 and 5.1.2.2, the velocity barrier creates backwater effects at both Locations 1 and 2. At Location 1, the velocity barrier creates an upstream impoundment that backwaters to the downstream construction diversion cofferdam at all fish passage flows. This also causes backwatering of the diversion tunnel outlet, with an extent of about 200-550 feet into the tunnel. Refinements at Location 1 will need to be made during future design development phases to limit backwater effects. At Location 2, the velocity barrier creates an upstream impoundment that backwaters approximately 750 feet upstream of the velocity barrier at the 95 percent exceedance flow and approximately 1,250 feet upstream at the 5 percent exceedance flow. This 5 percent exceedance flow backwater pool extends to approximately 180 feet downstream of the diversion tunnel outlet and does not inundate the tunnel outlet. Because refinements to the alternatives design at Location 1 will be made to limit backwater effects for Alternatives 1 and 3, the current backwater implications were not used to assign suitability rankings for fish passage performance for the alternatives.

5.3.2 Compatibility with Construction Activity

Alternative 2 is located furthest away from the permanent facility construction site (approximately 2,500 feet downstream). Its remote location makes it unlikely to affect construction activities. Thus, Alternative 2 was ranked as high suitability in terms of compatibility with construction activity.

Alternatives 1 and 3 are located in close proximity to the permanent facility construction site. Therefore, the potential for these alternatives to interfere with construction activity is higher and both Alternatives 1 and 3 were ranked as medium suitability.

Alternative 3 requires the use of constructed permanent elements that could make coordination of construction and phasing between the construction phase and permanent upstream fish passage elements challenging. At this stage of design, the compatibility of Alternative 3 construction with the phasing of the permanent facility has not been evaluated. To determine the true construction suitability of Alternative 3 further investigation during future design would be required. At this time, Alternative 3 remains ranked as medium suitability until further investigation has been performed.

5.3.3 Simplicity of Operation and Maintenance

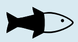
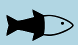
All three alternatives have facilities located at the base of a steep bank on the river, which would be difficult to access for O&M purposes. Alternative 2 is located on a steeper bank than the other alternatives and further away from the permanent facility construction site, making it less suitable for O&M access. For this reason, Alternative 2 was given a low suitability ranking. Alternatives 1 and 3 are in close proximity to the construction site, which would have both readily available equipment and access points to the river, making these alternatives more suitable for O&M. In addition, Alternative 3 consists of permanent facilities rather than construction phase facilities. The permanent facilities within this alternative would require less maintenance than a construction phase counterpart, giving it a higher suitability than the other alternatives in terms of O&M. Alternative 2 was ranked as medium suitability and Alternative 3 as high suitability.

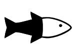
5.3.4 Minimization of Relative Capital Costs

Capital costs for each alternative are assessed on a total basis, inclusive of the construction phase upstream fish passage facilities and all permanent facilities constructed with the flood retention structure. The remote location in Alternative 2 directly affects its total costs, as the steep bank would make construction more challenging by requiring more hillside stabilization and grading than in the other alternatives. Additionally, the collection point in Alternative 2 is further from the release site than the other alternatives by about 0.4 mile, which could increase the number of trucks and associated expenses needed for transport at peak fish passage times. O&M at the remote Alternative 2 site would also be more time consuming and costly due to access (further described in 5.3.3). Alternative 2 was ranked as low suitability compared to the other alternatives.

Alternatives 1 and 3 are both in the same approximate location, so it is not a differentiator between alternatives. However, under Alternative 1, separate construction phase and permanent fish holding and sorting facilities would be constructed, while for Alternative 3 fish holding and sorting facilities constructed for the construction phase fish passage facility would also be used for the permanent facility. Alternative 3 would have lower capital costs as fewer facilities would be constructed overall. Alternative 1 was ranked as medium suitability, and Alternative 3 as high suitability compared to the other alternatives.

Table 5-9. Evaluation Matrix

Evaluation Factor	Alternative 1: Trap and Transport Facility at Location 1	Alternative 2: Trap and Transport Facility at Location 2	Alternative 3: Trap and Transport Facility at Location 1 using Permanent Facility Elements
Fish Passage Performance	 • Requires a smaller variance on velocity barrier head differential	 • Requires a larger variance on velocity barrier head differential	 • Requires a smaller variance on velocity barrier head differential
Compatibility with Construction Activity	 • Located within close proximity to permanent construction footprint • Backwater from velocity barrier inundates diversion tunnel outlet	 • Located away from permanent construction footprint • Backwater from velocity barrier does not impact construction footprint	 • Requires use of constructed permanent elements; further investigation into construction phasing is required to determine the compatibility of continuous construction phase facility use with the permanent facility construction phasing
Simplicity of O&M	 • Facility is nearer to construction site, allowing easier and simpler access for O&M	 • Facility is further away from construction site, making access for O&M more difficult	 • Facility is nearer to construction site, allowing easier and simpler access for O&M • Required O&M of permanent upstream fish passage elements will be simpler and less frequent than O&M of construction phase project elements
Minimization of Relative Capital Costs	 • Requires construction of temporary facilities and access roads in an area with steep topography near the project construction site	 • Requires construction of temporary facilities and access roads in an area with very steep topography further from project the construction site	 • Requires use of constructed permanent elements, thereby eliminating need and cost for some temporary upstream fish passage elements

 = Low Suitability;  = Medium Suitability;  = High Suitability

5.4 Recommended Alternative

Each of the three alternatives presented in Section 5.1.2 are viable options for providing construction phase upstream fish passage. **Alternative 3 –Trap and Transport Facility at Location 1 Using Permanent Facility Elements** is recommended to be the construction phase fish passage design included as part of the flood retention structure project. Alternative 3 meets the suitability criteria better than the other alternatives. Compared to Alternatives 1 and 2, fish passage performance would be more reliable, with improved overall cost effectiveness because fewer temporary project elements would be built and then removed under Alternative 3. O&M would also be simpler and require less effort due to its location nearer to the construction site and more reliable given that operations are dependent on permeant features and equipment rather than on temporary project elements. However, this alternative would need to be vetted further against the construction needs and footprint of the permanent facility to ensure that the permanent infrastructure is not displaced by the space required by various potential phases of the project.

The project team met with the District on December 16, 2021, and was asked to develop a 10 percent design alternative of the recommended alternative identified above.

6.0 10% Design of the Preferred Alternative

The recommended alternative, Alternative 3 – Trap and Transport Facility at Location 1 Using Permanent Facility Elements, was developed to a 10 percent design level following the December 16, 2021 District meeting. This alternative will be referred to in the remainder of this document as the construction phase fish passage facility or facility. The permanent fish passage facility and its elements, also referred to in previous reports as the CHTR facility, will be referred to as either the permanent fish passage facility or the permanent facility. The development of the design to a 10 percent level includes preliminary design of the elements and development of water supply criteria, the theory of operation for the facility, and construction sequencing. Preliminary hydraulic calculations were performed for the fishway and water supply design, and a preliminary hydraulic modeling effort was undertaken to aid in the design of the velocity barrier and determine potential impact to the diversion tunnel capacity and FRE construction cofferdam.

6.1 Design Criteria

The design of the facility is based on the criteria described in Sections 2.0 and 5.1.1 as well as that described in this section.

6.1.1 Adult and Juvenile / Resident Fishway Entrances

Designs of upstream fish passage facilities at dams are developed based on criteria and guidelines developed to successfully pass adult salmonids. The primary design criteria for the fishway entrances are summarized in Table 6-1.

Table 6-1. Fishway Entrance Hydraulic Criteria

Design Criteria	Value	Source
Hydraulic differential (adult)	0.5 – 2.0 feet	NMFS 2011
Hydraulic differential (juvenile fish 40 to 60 mm)	0.13 foot	NMFS 2011
Hydraulic differential (juvenile/resident fish 80 to 100 mm)	0.33 foot	NMFS 2011
Width	4 feet	NMFS 2011
Depth	6 feet	NMFS 2011

6.1.2 Adult and Juvenile Fishway Holding Pools

NMFS requires a minimum inflow for holding pools per holding criteria but allows variability in the width and depth, instead providing guidance for these values. Holding pools are sized based on volume per pound of fish and holding time; with limited space at the fishway location, the pools will be sized according to site constraints and fish will be collected as necessary to satisfy volume requirements. River flow at the low fish passage design flow constrains how much water is available to operate the adult and juvenile fishway holding galleries. The minimum design depth of the fishways "are different than the minimums (due to the) site conditions" (Section 4.5.3.3 NMFS 2011). The minimum depth of 3.0 feet is used to allow the safe passage of the larger adult salmonids and is a site-specific criteria. This criteria is smaller than the NMFS 2011 guideline but based on past projects is generally accepted as a sufficient depth for adult salmonid passage in transport channels. The criteria used for the fishways are summarized in Table 6-2.

Table 6-2. Fishway Holding Pools Hydraulic Criteria

Design Criteria	Value	Source
Water supply, holding, (adult/juveniles)	0.67 gpm / fish	NMFS 2011
Width (juveniles)	4 feet min	NMFS 2011
Width (adults)	8 feet min	Site Specific / NMFS 2011
Depth	3 feet minimum	Site specific selection

6.1.3 Auxiliary Water Supply

The attraction flow criteria for the fishway entrance is 10 percent of the high fish passage design flow (NMFS 2011). With a high fish passage design flow of 2,200 cfs, the required attraction flow is 220 cfs. The attraction flow includes the flow from the adult and juvenile fishways, lamprey ramp, and the auxiliary water supply (AWS) provided to the adult and juvenile fishways. As described in Section 6.1.2, flow will be provided for the fishway holding pools in order to meet the criteria specified in Table 6-2. Once the required attraction flow is larger than the flow supplied via the fishways, AWS flow will be provided to achieve the design attraction flow up to the maximum value of 220 cfs. AWS design criteria are the same as those listed in Table 2-12 of the CHTR Report (HDR 2018b).

6.1.4 Gravity and Pumped Water Supply

Gravity and pumped water is supplied via intakes located in the Chehalis River. The intake locations and a description of the pumped and gravity fed flows are provided in Section 6.2.10. The intake design criteria are described in Section 5.1.1.4.

Flow in the water supply pipes is pressurized for both gravity and pumped flow conditions. Water supply pipes are designed to achieve the minimum cross-sectional area required to meet the flow demand of the pipe and prevent excessive erosion of the pipe material. Pipes are designed for target velocities of 6-8 fps.

The sizing for the pressure water supply pipes was based on the head loss through the system and the maximum velocity in the pipe. As with the gravity pipes, velocities are 6-8 fps or less to prevent excessive erosion of the pipe material.

Trashracks will be used to exclude large debris from the vicinity of the intake screens. Trashracks are commonly used upstream of screening facilities. Table 2-8 in Appendix G of the Combined Dam and Fish Passage Report (HDR 2017) lists the design criteria for trashracks.

6.1.5 Transport Pipes

Criteria for adult and juvenile resident transport pipes is provided in the bypass pipe channel criteria presented in Section 11.9 of NMFS (2011). The criteria used for the transport pipes is summarized in Table 6-3.

Table 6-3. Transport Pipes Design Criteria

Design Criteria	Value	Source
Diameter	1.5 feet minimum	NMFS 2011
Depth	40% of width	NMFS 2011
Velocity	6 – 12 fps	NMFS 2011

6.1.6 Velocity Barrier

Criteria for the velocity barrier comes from the NMFS 2011 document and is described in Table 6-4.

Table 6-4. Velocity Barrier Design Criteria

Design Criteria	Value	Source
Apron elevation above high fish passage design flow, minimum	1 foot	NMFS 2011
Apron slope, minimum	16:1	NMFS 2011
Apron length, minimum	16 feet	NMFS 2011
Weir height above apron, minimum	3.5 feet	NMFS 2011

6.1.7 Velocity Barrier Low Flow Channel

To develop the 10% preliminary design, a low flow channel was implemented in the velocity barrier in order to pass fish traveling downstream at the lowest fish passage flows. The channel was designed using bypass channel criteria presented in Section 11.9 of NMFS (2011). The criteria used for the velocity barrier low flow channel is summarized in Table 6-5.

The criteria for the low flow channel will be further developed and refined in collaboration with project participants as design progresses.

Table 6-5. Construction Phase Velocity Barrier Low Flow Channel Design Criteria

Design Criteria	Value	Source
Channel width	1.5 feet minimum	NMFS 2011
Minimum channel depth	40% of width	NMFS 2011
Velocity	6 – 12 fps	NMFS 2011
Maximum outfall velocity	25 fps	NMFS 2011

6.1.8 Fish Lift, Holding Gallery, and Sorting Building

The fish lifts, transport pipes, hoppers, holding gallery, and sorting building criteria were described in the CHTR Preliminary Design Report for the permanent facility (HDR 2018b). The design indicated that 10 cfs is required for operation of the holding gallery, sorting building, and flumes. The fish lift, holding gallery, and sorting building must meet the same criteria as their permanent counterparts because they are both passing the same types and number of fish. The facility will be operating year-round as compared to the permanent facility which is only expected to operate for approximately one month every seven years during flood control events.

This should not affect the design criteria needed for the facility as the permanent facility was designed to meet peak capacity.

6.1.9 Diversion Tunnel

Preliminary design of the diversion tunnel was conducted as part of the Combined Dam and Fish Passage Conceptual Design Report (HDR 2016). The diversion tunnel was designed with a 20-foot width and was determined to be a practical size that could be cost effectively advanced using drill and blast techniques and conventional mining equipment. Other diversion tunnel criteria are provided in the Combined Dam and Fish Passage Conceptual Design Report (HDR 2016).

6.1.10 Summary of Flows

Based on the design criteria described in Section 6.1 and the elements described in Section 6.2 the water supply needs are summarized in Table 6-6. Section 6.3 provides more detail regarding operation of the facility.

Table 6-6. Summary of Water Supply Flows

Design Element	Flow (cfs)
AWS	0 – 201
Adult fishway holding pool	3
Juvenile fishway holding pool	3
Lamprey ramp	3
Adult transport pipe	6
Juvenile transport pipe	6
Sorting and holding buildings	10
Velocity barrier low flow channel	6 – 50

6.2 Design elements

The elements of the construction phase fish passage facility were identified in Section 5.1.2.3 and are described in Table 6-7.

Table 6-7. Primary Design Element Descriptions

Design Element		Primary Function
Fishway	Entrance	Attract fish to the facility
	Holding Pools	Hold fish after they enter the fishway before the fish lift system is operated; includes crowders to crowd fish into hoppers
	Fish Lift System	Lift the fish from the holding pools using a gantry crane and hopper so that they can be directed to either the juvenile/resident transfer facility or to the adult sorting facility via transport pipes
	Transport Pipes	Transport fish from the hopper to either the juvenile/resident transfer facility or the adult sorting facility
Juvenile/Resident Transfer Station		Hold juvenile and resident fish to prepare them for water-to-water transfer into the transport trucks
Sorting Facility	Adult Holding Gallery	Hold adult target species before they are sorted in the sorting building
	Sorting Building	Sort adults by species for transport to their upstream release location and prepare them for water-to-water transfer into the transport trucks
Transportation		Transport all target species via truck to predesignated upstream release points based on species
Velocity Barrier		Prevent upstream fish passage during construction while allowing downstream passage

The design includes both elements that are solely associated with the facility, and also elements that will remain as part of the permanent fish passage facility. The following features were located and sized to the 10 percent design level. The permanent fish passage facility has been developed to a preliminary design level (HDR 2018b); as a result, design criteria and design of common elements between the two facilities were used in development of the construction phase fish passage facility. This includes the sizing of features such as the holding gallery, sorting building, and electrical buildings.

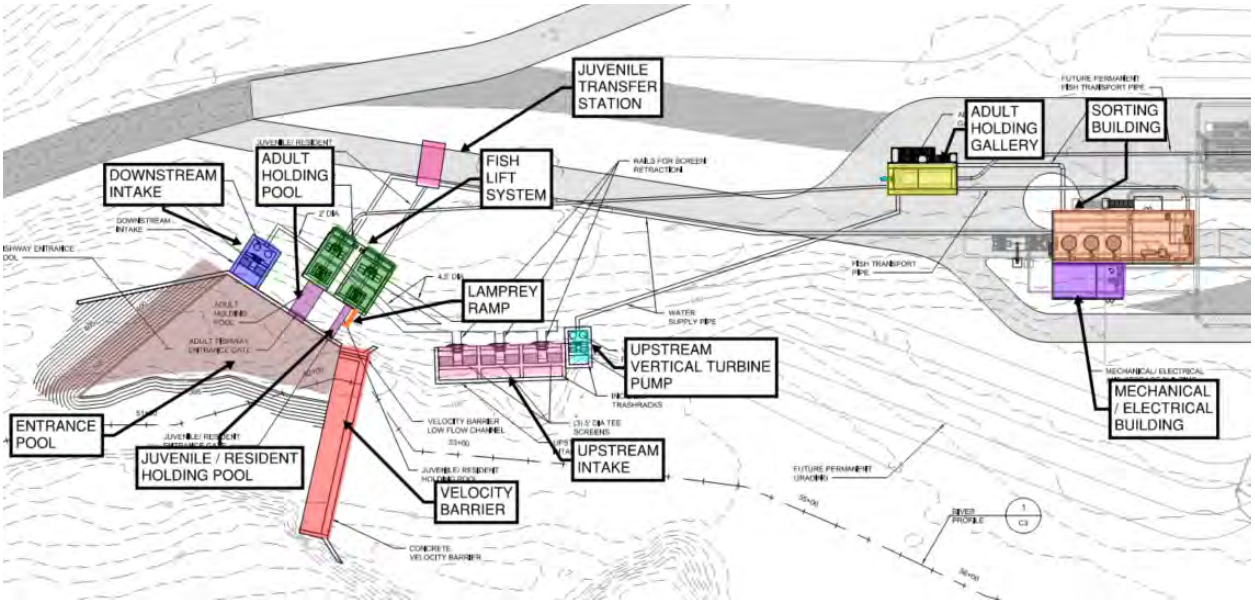
6.2.1 General Layout

The facility consists of multiple design elements including a velocity barrier, adult and juvenile fishways, gravity transport pipes, sorting building, and holding/transfer galleries and pools.

The velocity barrier is a concrete channel-spanning structure located downstream of the diversion tunnel outlet. There are intakes upstream and downstream of the barrier.

The adult and juvenile fishways include a fishway entrance, adjustable entrance gate, fishway holding pools, and fish lift used to collect and transport fish from the river to their respective sorting and holding buildings via transport pipes. The layout of the facility is shown in Figure 27. The facility is shown in greater detail in the drawings in Attachment A.

Figure 27. Collect, Handle, Transfer, and Release Features for Construction Phase Fish Passage



In other projects, occasionally trap and transport facilities are used in conjunction with a short fish ladder. Trap and transport technology without a fish ladder was used for this facility because the trap and transport technology components require less flow than fish ladders, an important consideration in this river system where water is limited during low flow events. In addition, the facility will require a much smaller footprint than if a fish ladder was used in combination with the facility, significantly decreasing the amount of cut required. A fish ladder also cannot accommodate the full hydraulic differential needed for upstream fish passage, so a lift system would be required with either technology. Accommodating the full hydraulic differential using a lift system alone rather than using a combination of lift and fish ladder simplifies the design.

Multiple factors, listed below, were considered when locating the various facility elements.

- The velocity barrier will be located at a distance far enough downstream from the diversion tunnel outlet that fish traveling downstream will have sufficient time to reorient themselves after exiting the diversion tunnel to cross the velocity barrier.
- The fishways will be located in a relatively flat bank area to reduce cut and accommodate laydown area.
- The permanent sorting building will be kept in the same location to keep permanent elements grouped together in the same vicinity for operational efficiency.
- The adult holding gallery will be accessible to both the construction phase and the permanent facilities and located close to the permanent facility.

Further information regarding the design of each element is described in the following sections.

6.2.2 Fishway Entrances

Both the adult and juvenile fishway entrances are located downstream of the velocity barrier. An entrance pool will be excavated to elevation 391.5, which will provide 6 feet of depth at the low fish passage design flow per design criteria (Table 6-1). A gate on each of the adult and juvenile fishway entrances adjusts according to river flow to maintain the required head differential for fish attraction (Table 6-1). This gate will be sized as development of the facility continues.

6.2.3 Fishway Holding Pools

Once fish swim through the appropriate fishway entrance, they pass through a fyke and enter a fishway holding pool. A crowder panel will periodically encourage fish to move from the holding pool to the hopper.

The adult fishway holding pool is about 8 feet wide based on site-specific criteria to limit the cut required at the site while maintaining an appropriate width. The juvenile and resident holding pool is about 4 feet wide based on criteria from NMFS (2011).

At the lowest design flow of 16 cfs, the depth in each of the adult and juvenile/resident fishway holding galleries is 3 feet. This depth rises as the adult and juvenile fishway entrance gates are adjusted with river flow to meet minimum depth criteria of 5 feet within the holding pools at most flows.

The flow required is about 3 cfs for each fishway holding pool and 3 cfs for the lamprey ramp. The flow pumped to the elements above the bank including the upstream holding gallery, sorting building, and juvenile/resident transfer station is drained to the fishway holding galleries. An AWS is required starting at approximately river flow 190 cfs. At this flow, diffusers in each of the fish hopper sumps provide the additional flow required for adult and juvenile attraction.

See Section 6.2.10 for further explanation of the intake designs and Section 6.3 for fishway operation information.

Similar to the permanent fish passage facility design, resident fish may require accommodation through a separate low volume, low velocity entrance (HDR 2018b); based on swim speeds the species will be able to continue migrating upstream via the juvenile holding pool, which will have low velocities. A lamprey ramp is provided for lamprey passage and collection. The design is similar to the lamprey ramp in the permanent facility. The lamprey ramp is located adjacent to the east wall of the juvenile fishway. It is a free-standing steel structure mounted to a continuous concrete foundation. Like the permanent lamprey ramp, it is bolted together every few feet. It extends from the entrance in the east wall of the juvenile fishway to the lamprey hopper near the juvenile fish lift. The lamprey ramp has resting boxes along the full length of the ramp (HDR 2018b).

6.2.3.1 Changes to Permanent Facility

There are no changes to the permanent facility due to the design of the fishway holding pools.

6.2.4 Fishway Fish Lift System and Transport Pipes

The fish lift system is located at the fishway holding pool exits and lamprey ramp exit and is northwest of the permanent fish lift system. This location was chosen as it does not interfere with the staging area during construction, and it allows the fishways to be shorter in length while still locating the fish lift outside 10-year flood inundation area (EL 419.6 NAVD88, see Table 6-10).

The fish lift system consists of a gantry crane, an adult fish hopper and trapping mechanism, a juvenile/resident fish hopper and trapping mechanism, and a lamprey tank and trapping mechanism. Water is supplied to the hopper by an upwell and diffuser system upstream of the hopper sumps. The design and criteria of the hopper, including sizing, is provided in the CHTR Report (HDR 2018b).

As previously described, a crowder encourages fish to move into the adult or juvenile hoppers from the holding pools. Gates close and the gantry crane lifts the full hopper 60 to 80 feet vertically to a fish transport pipe. During fish transport, water is pumped into the transport pipes via the downstream intake; at other times, these pipes are only minimally supplied with water.

The adult fish transport pipe is sloped down toward the adult holding gallery. The juveniles/resident fish transport pipe is sloped down toward the juvenile/resident transfer station, where a holding tank resides. All fish transport pipes are designed at an approximately 3 percent slope to discourage fish from milling and encourage them to exit the pipes while maintaining appropriate pipe width, velocity, and depth per design criteria. A fish transport pipe was chosen over the traditional flume as a pipe will require fewer support towers and can free-span between support towers. Further, a pipe is contained so fish cannot jump out and are protected from predators.

The water for the fishway system will be supplied by a 24-inch-diameter steel pipe running from the pump station downstream of the velocity barrier and a 24-inch-diameter steel pipe running from the sorting building. Once AWS is required, water will be supplied by two 4-foot-6-inch-diameter steel pipes from the upstream intake. The water will be used to fill the hoppers and tanks as well as supply the required flow to the fishway holding pools. Any excess flow will be discharged to the fishway holding pools and back into the Chehalis River. The fish transport pipelines will continue to be supplied by the downstream intake. The expected water surface elevation at the hopper when it discharges into the adult fish transport pipe is EL 480.0 NAVD88, and EL 463.0 NAVD88 for the juvenile and resident fish transport pipe. As the design develops, these water surface elevations and hydraulic profiles will be refined.

Further information on the fish lift system can be found in Section 3.1.2 of the CHTR report (HDR 2018b).

6.2.4.1 Changes to Permanent Facility

There are no changes to the permanent facility due to the design of the fish lift system.

6.2.5 Sorting Facility

The sorting facility is comprised of the adult holding gallery and the sorting building. These components hold the fish during peak times and sort them by species before they are transported to their predesignated upstream release location.

6.2.5.1 Adult Holding Gallery

The adult holding gallery near the permanent facility is provided for adult salmonids and steelhead. It is part of the sorting facility and is located southeast of the fish lifts. The holding gallery is located northwest of the permanent holding gallery location shown in the CHTR report. The intent of this change is to allow the holding gallery to be used for both the permanent and construction phase fish passage facilities. The construction access roads were shifted slightly to the northeast and the permanent access road area was extended partially to accommodate this change.

Adult salmonids and steelhead are transported to the holding gallery via a transport pipe as described in Section 6.2.4. The fish transport pipelines for the facility are about 200 feet longer than those shown in the CHTR Report (HDR 2018b). Using the holding gallery for both the permanent and construction phase facilities will result in a 170-foot length increase in the transport pipes from the holding gallery to the sorting building than those in the CTHR Report (HDR 2018b).

The holding gallery is an elevated concrete structure, sized to hold the estimated peak daily fish run for up to 24 hours. Components of the holding gallery include an automated crowder panel and false weir.

Water is supplied to the holding gallery via a 24-inch-diameter steel pipe that runs from the pumped intake upstream of the velocity barrier. The water will be used for any necessary processes in the holding gallery. The flow from the holding gallery will then be routed via another 24-inch-diameter steel pipe to the sorting building. The operating water surface elevation in the holding gallery is expected to be EL 468.0 NAVD88.

Further information on the holding gallery design can be found in Section 3.1.3.1 of the CHTR (HDR 2018b).

6.2.5.2 Sorting Building

The sorting building is located southeast and downstream of the holding gallery. The location of the sorting building is unchanged from the CHTR Report (HDR 2018b). It is an elevated building that contains flumes, tanks, tables, and other equipment necessary for the manual sorting and handling of adult salmonids and steelhead. The building is elevated to allow fish transport trucks to drive directly under the holding tanks for water-to-water transfer of fish.

The operating water surface elevation of the sorting building is expected to be EL 461.25 NAVD88. The water supply comes from the holding gallery, as described in Section 6.2.4. The water is then routed via a 24-inch-diameter steel pipe to the fish lift system.

Further information on the sorting building can be found in Section 3.1.3.2 of the CHTR.

6.2.5.3 Changes to Permanent Facility

The holding gallery will be moved about 150 feet to the northwest from the original permanent facility design. This is to allow the holding gallery to be used for both the construction phase and permanent facilities.

6.2.6 Juvenile and Resident Transfer Station

The transfer station is provided for residents and juveniles. It is located north of the sorting facility and directly east from the fish lift system. Once the juvenile and resident hopper is full, the fish lift system will be operated and juveniles and residents that enter transport pipes will travel approximately 50 feet to reach the transfer station. The building is elevated to allow fish transport trucks to drive directly under the holding tanks for water-to-water transfer of fish.

Water is provided to this building via the holding gallery and sorting facility; after water exits these buildings, it supplies the transfer station and then is drained to the adult fishway.

6.2.6.1 Changes to Permanent Facility

To implement this structure, additional grading may need to occur. During future design development, an appropriate balance between gantry crane height associated with the juvenile and resident fish lift and transfer station foundation elevation will be determined to allow the transport of fish between the two elements.

6.2.7 Transportation

All collected target species are transported upstream of the construction site, by truck, in transport tanks designed specifically for fish health and safety during transport. Transfer of collected target species to the transport trucks takes place via water-to-water transfer from overhead holding tanks located in the sorting building and in the juvenile and resident transfer station.

The transport trucks move the adult salmonids and steelhead, juvenile and resident fish, and lamprey upstream to predesignated points of release. Further discussion on the points of release is below in Section 6.2.8.

During peak run times, as many as 2 truck trips per hour may occur. This was estimated based on the peak hourly count of salmonids estimated as 400 adults, and a transport tank size of 200 fish (HDR 2018b). Truck trip estimates reflect peak salmonid and steelhead abundance. Peak abundance is unlikely to be seen every year. Abundance estimates for juvenile and resident populations are not known. Therefore, the truck trip values above do not include any additional trips that may be needed for the transport of juvenile and resident species. The number of truck trips will be refined in future stages of design development.

Further information on the transportation can be found in Section 3.1.4 of the CHTR (HDR 2018b).

6.2.7.1 Changes to Permanent Facility

There are no changes to the permanent facility due to the design of the transportation trucks.

6.2.8 Release Location

The fish release location details have not yet been developed for the construction phase or permanent facilities. The fish release details will be developed later in the engineering design and environmental permitting process after further discussion with key stakeholders. Potential release locations will comply with state and federal agency fish passage guidelines (NMFS 2011, WDFW 2000b). These guidelines include releasing fish:

- A sufficient distance upstream of the FRE structure to minimize potential for fall back;
- Along the shoreline with sufficient flow to guide the fish to move upstream (generally less than 4 fps);
- With a drop from the transport vehicle that is less than 5.9 ft (1.8 m), with an impact velocity less than 24.9 fps (7.6 m/s);
- Into receiving waters greater than 3.0 feet (0.9 m) deep.

There are multiple salmonid species targeted for transport. These target species migrate at different times of year and spawn in different habitats. Because of this, it is likely that species-specific release locations will be necessary to maximize ascent to spawning habitats for all species.

Data from other projects in the Pacific Northwest have suggested that releasing tributary spawners, such as Coho Salmon, steelhead, and Cutthroat Trout within the influence of tributary flow can reduce tendency for fall back and delay (Kock et al. 2016; McHenry et al. 2018). Similar affects can be attained by releasing Chinook Salmon upstream of the reservoir closer to riverine spawning area (Naughton et al. 2018). Species-specific release locations will also be considered when determining fish release locations.

Fish release locations will be developed in the future in consultation with WDFW based on existing data, review suitability of each habitat, and accessibility as part of Hydraulic Project Approval (HPA) development.

6.2.8.1 Changes to Permanent Facility

There are no changes to the permanent facility due to the construction phase facility design of the release locations. The release locations will be decided during a later phase of design.

6.2.9 Velocity Barrier

A general description of the velocity barrier is provided in Section 3.2.1 and elsewhere throughout this document. This section provides specific design details of the velocity barrier.

The 10% design of the velocity barrier locates the downstream end of the apron at an elevation of 404.6, 1 foot above the high fish passage design flow. The apron is at a slope of 16:1 and has a length of 16 feet, terminating at a weir base elevation of 405.6. The weir crest is 3.5 feet above the top of the weir base at elevation 409.1. Water surface elevations upstream and downstream of the velocity barrier at key flow events are provided in a later table, Table 6-10.

The velocity barrier also incorporates a low flow channel along the right bank. The purpose of the low flow channel is for ease of downstream passage for outmigrating fish at the lowest flows. The low flow channel is trapezoidal in shape to accommodate width and depth requirements for the bypass at a range of flow events (NMFS 2011).

At the lowest fish passage design flow, approximately 6 cfs will be routed down this channel. The channel is 1.5 feet in width at the base, meeting minimum width criteria for a bypass flow of 6 cfs. The depth at the low fish passage design flow of 16 cfs is 0.7 foot, exceeding the criteria that the depth should be a minimum of 40 percent of the width of the channel (NMFS 2011). The low flow channel was designed for a minimum slope of 1.1 percent to produce a velocity of 6 fps at the low fish passage design flow. Using a minimum slope allows a higher normal depth within the channel while still meeting minimum velocity criteria (NMFS 2011).

The inlet invert of the low flow channel is at EL 404.8 NAVD88. The outlet invert of the low flow channel is at the apron elevation of 1 foot above the high fish passage design flow at EL 404.6 NAVD88. This results in a drop from the channel to the river water surface of about 7 feet at the low fish passage river flow. The outlet velocity is about 22 fps at the point of impact, which is lower than the maximum outlet velocity of 25 fps (NMFS 2011).

Flow is routed down the low flow channel until approximately river flow of 250 cfs. At about the 250 cfs river flow event, 50 cfs of flow passes through the low flow channel. NMFS criteria does not detail the required width for 50 cfs within a bypass channel; using interpolation within the guidelines and site specific conditions, at this preliminary level of design the low flow channel is designed for a top width of 3.5 feet for the 50 cfs bypass. As a result, the side slopes of the trapezoidal channel are designed as 1H:3V to meet the appropriate depth requirement at both the low and high flow condition for the channel. Above a river flow of 250 cfs, the gate for the low flow channel will close and all flow routed over the velocity barrier weir crest. In the fully closed position, the gate crest is at the same elevation as the weir crest of EL 409.1. Stoplogs will be used on top of the gate from EL 409.1 to 420.5 to prevent flood flows from entering the low flow channel.

The design of the low flow channel and gate will be further developed as design progresses to determine the correct shape, width, slope, and transition point to close the low flow channel gate.

The velocity barrier abutments are designed to the height of the upstream cofferdam design height: the 2-year flow event water surface elevation with 3 feet of freeboard. Per hydraulic results (Table 6-10) the 2-year flow event water surface elevation is approximately 417.5; the abutments will be designed to an elevation of 420.5.

A plan view of the velocity barrier along with two section views are included for clarity (Figure 28 to Figure 30).

Figure 28. Velocity Barrier Plan View

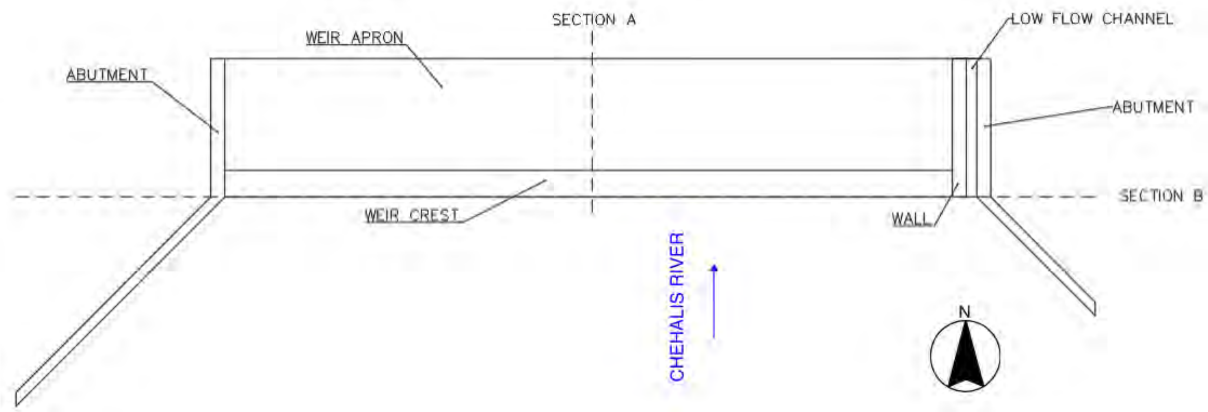


Figure 29. Velocity Barrier Section, from Right Bank looking into River

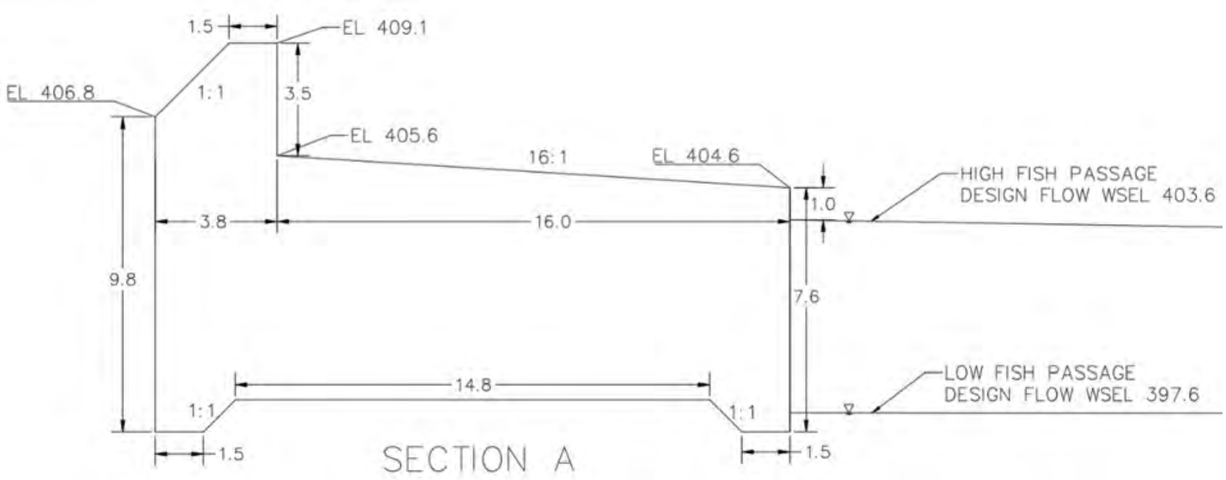
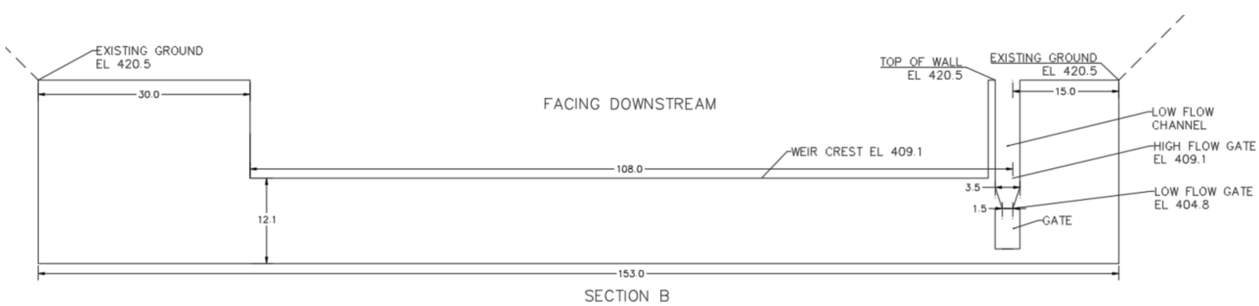


Figure 30. Velocity Barrier Section, from Upstream looking Downstream



6.2.9.1 Changes to Permanent Facility

There are no changes to the permanent facility due to the construction phase facility design of the velocity barrier.

6.2.10 Water Supply

Water is supplied to most elements via gravity and pumped intakes. Water is collected at two separate locations. One intake is located downstream of the velocity barrier within the entrance pool. At lower flows, water collected at this location is pumped to the adult and juvenile fishways and transport pipes, acting as a recirculation system. Once flows increase and AWS is required, water supply to the fishways is provided via the upstream intake and the downstream intake ceases sending flow to the fishways, while continuing to send flow to the transport pipes.

The other intake is upstream of the velocity barrier, utilizing the impoundment of water generated by the barrier. The upstream intake supplies water to two parts of the facility. At all times during operation of the facility, flow is pumped from the upstream intake to supply the holding gallery and sorting building. At higher flows, once AWS is required, the upstream intake starts pumping flow to the adult and juvenile fishways and use gravity to provide attraction flow as well.

The two intakes allow the system to continue to run even when the water surface elevation of the Chehalis River is lower than the crest of the velocity barrier, during the period when flow travels downstream through the velocity barrier low flow channel. See Section 6.3 for more detailed information regarding system operation.

Table 6-8 identifies the water supply demands and Table 6-9 identifies the water source and supply method at different flows for each design element that must be supplied with water.

Table 6-8. Water Supply Demands

Design element	Required flow (cfs)
AWS	0 – 201
Fishway channels / lamprey ramp	9
Transport pipes	0 – 6
Sorting facility	10

Table 6-9. Water Supply Sources

Design element	River flow (cfs)	Water source	Supply method	Amount (cfs)
AWS	16 – 190	None	N/A	0
	190 – 2,200	Upstream of velocity barrier	Gravity	0.1 – 201
	2,200+	None	N/A	0
Fishway channels/ lamprey ramp	16 – 190	Downstream of velocity barrier	Pumped (recirculated)	9
	190 – 2,200	Upstream of velocity barrier	Gravity	9
	2,200+	None	N/A	0
Transport pipes	0 – 2,200	Downstream of velocity barrier	Pumped	0 – 6
	2,200+	None	N/A	0
Sorting facility	0 – 15,000+	Upstream of velocity barrier	Pumped	10

Each intake will provide fish screens meeting NMFS and WDFW screening criteria for juvenile fish. The current concept shows a series of rotating cylindrical tee screens, but other technologies such as vertical flat-plate or inclined flat-plate screening systems will be evaluated during future design development to improve performance at low flow conditions, reduce cut, and improve cost effectiveness.

An inclined coarse trashrack will be placed upstream of the fish screens to prevent large debris from damaging the fish screens. The trashracks on the upstream side of the velocity barrier will not be equipped with automatic trashrack rakers due to the high sweeping velocities in that region. The trashrack downstream of the velocity barrier will have an automatic screen cleaner due to the anticipated flow patterns in the river and expected debris.

No potable water or sewer is provided at the facility.

The pipelines and intakes will be disassembled, salvaged, and removed from the site following construction. The post-construction disposition of the pipelines will be determined during a later phase of design.

6.2.10.1 Upstream Intake

The upstream intake consists of two parts. Water is screened and then runs to either one vertical turbine pump and one backup vertical turbine pump located in a concrete intake or to a gravity pipeline. The vertical turbine pump provides water to the sorting facility and is screened using one 24-inch-diameter tee screen. The pump station is designed to Hydraulic Institute (2018) standards.

A 24-inch-diameter pipe runs from the upstream intake to supply the holding gallery with water. From the holding gallery, water is provided to the sorting building via a 24-inch-diameter pipe that is buried underneath the access road. At the sorting building, the pipe branches to feed multiple water needs of the sorting facility. Downstream of the sorting building, the 24-inch-diameter pipe then runs toward the juvenile and resident transfer station to supply water as needed. After that, the water drains to the adult fishway to supplement the water supply.

At higher flows, the gravity pipeline provides water to the fishways, including AWS flow. The water is screened using three 60-inch-diameter tee screens that discharge into a 6-foot-diameter steel pipe manifold. The number and type of screens and pumps at the upstream intake will be refined during future design phases.

The 6-foot-diameter steel manifold then divides into two 4-foot-6-inch-diameter steel pipes that discharge at the fishway sumps.

6.2.10.2 Downstream Intake

Water supply for the transport pipes, and at higher flows the adult fishway, juvenile fishway, and lamprey ramp, is provided by a pump station and intake located downstream of the velocity barrier. The intake draws water from the river through one cylindrical tee screen. Water from the adult fishway, juvenile fishway, and lamprey ramp is returned directly to the same pool in the river that the intake draws from, creating a recirculation cycle. The recirculation cycle allows the fishways to operate during low river flows.

The downstream intake consists of one 24-inch-diameter tee screen. The current concept shows a cylindrical tee screen, but other technologies can be evaluated to improve performance at low flow conditions, reduce cut, and improve cost effectiveness.

The downstream pump station currently contains one submersible pump and one backup submersible pump. As with the upstream pump station, the number of pumps will be refined in future phases of design development and the station will be designed to Hydraulic Institute (2018) standards.

Water for the adult and juvenile fishway sumps, lamprey ramp, and transport pipes is supplied by a common 24-inch-diameter steel pipe that runs parallel to the fishways. Pipes tee off the 24-inch supply pipe to supply the sumps, lamprey ramp, and transport pipes.

6.2.10.3 Changes to Permanent Facility

There are no changes to the permanent facility due to the construction phase facility design of the water supply systems. However, the fish screens for the upper and lower intakes could potentially be removed and reused in the permanent fish passage facility intake. This will be considered during future phases of design development.

6.2.11 Mechanical / Electrical and Storage Building

A prefabricated or concrete masonry unit building is located adjacent to the sorting building to house mechanical and electrical equipment and provide storage for equipment and materials. The building is in the same location as the permanent facility. The building will be utilized for both the facility and the permanent facility.

480 volt, 3 phase power must be brought in to the site for the permanent facility (District 2019). This power will be brought to the site prior to or concurrent with construction of the construction phase fish passage facility. In the case of an outage, backup power will be provided via a diesel-powered generator. The generator will power systems critical to fish survival, including the downstream intake pump to supply water to the fish hopper and the sorting facility.

Further information on the mechanical/electrical and storage building can be found in Section 3.1.6 of the CHTR (HDR 2018b).

6.2.11.1 Changes to Permanent Facility

There are no changes to the permanent facility due to the construction phase facility design of the mechanical building.

6.3 Theory of Operation

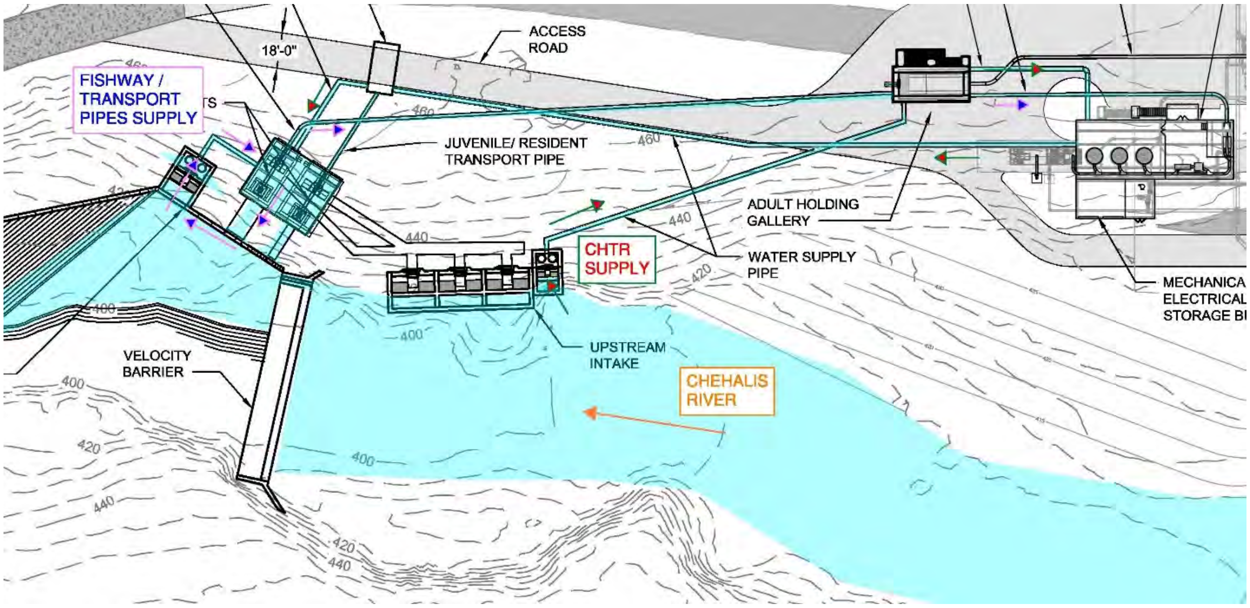
6.3.1 Water Supply and Discharge

The facility elements will be exposed to a wide range of Chehalis River flows. The variability requires detailed consideration of water supply needs for a range of river flow events. Calculations and modeling were performed to evaluate how the facility will operate from the low fish passage design flow event of 16 cfs to the 100-year, 15,000 cfs flood.

6.3.1.1 Flow Events not Requiring AWS

At the low fish passage design flow of 16 cfs, water is limited within the river. According to the design of the permanent facility, 10 cfs is required to operate the holding and sorting buildings (HDR 2018b). The upstream intake pumps the 10 cfs for the sorting buildings out of the river and up to the buildings. The remaining 6 cfs in the Chehalis River goes through the low flow channel in the velocity barrier to provide downstream passage. The pumped water supplies the holding gallery, sorting building, and juvenile transfer station. Water draining from these areas flows into the hopper sumps in the adult fishway, supplementing the flow in the fishway. The water flows down the holding pool to rejoin the river at the entrance pool, restoring the river flow to 16 cfs. A recirculation system is used to generate the remaining flow required for the fishways. According to criteria, 0.67 gpm, or 0.0015 cfs, is required per fish in the fishway holding pools. Based on peak-day data provided in the CHTR report, the required flow for the adult fishway holding pool is about 3 cfs (HDR 2018b). The juvenile/resident fishway holding pool is sized for the same peak-day data and requires 3 cfs. Water from the downstream intake is pumped to the sumps in the adult and juvenile fishways to provide the required flow for the fishway holding pools and lamprey ramp before returning to the river: a total of 9 cfs, with an additional 10 cfs draining from the sorting and transfer buildings on the bluff through the adult holding pool. Figure 31 shows the water supply for each element.

Figure 31. Water Supply for Flow Events not Requiring AWS



In addition, flows of about 6 cfs are required for each of the adult transport pipe and the juvenile and resident transport pipe periodically. Once either the adult or juvenile hoppers are full, a valve is turned and the water supply to the adult or juvenile fishway holding pool is shut off. A total of 6 cfs is pumped to the transport pipe from the downstream intake using the recirculation system. Once the hopper is emptied and fish have exited the transport pipe, the valve is turned again and flow resumes to the adult or juvenile fishway holding pool.

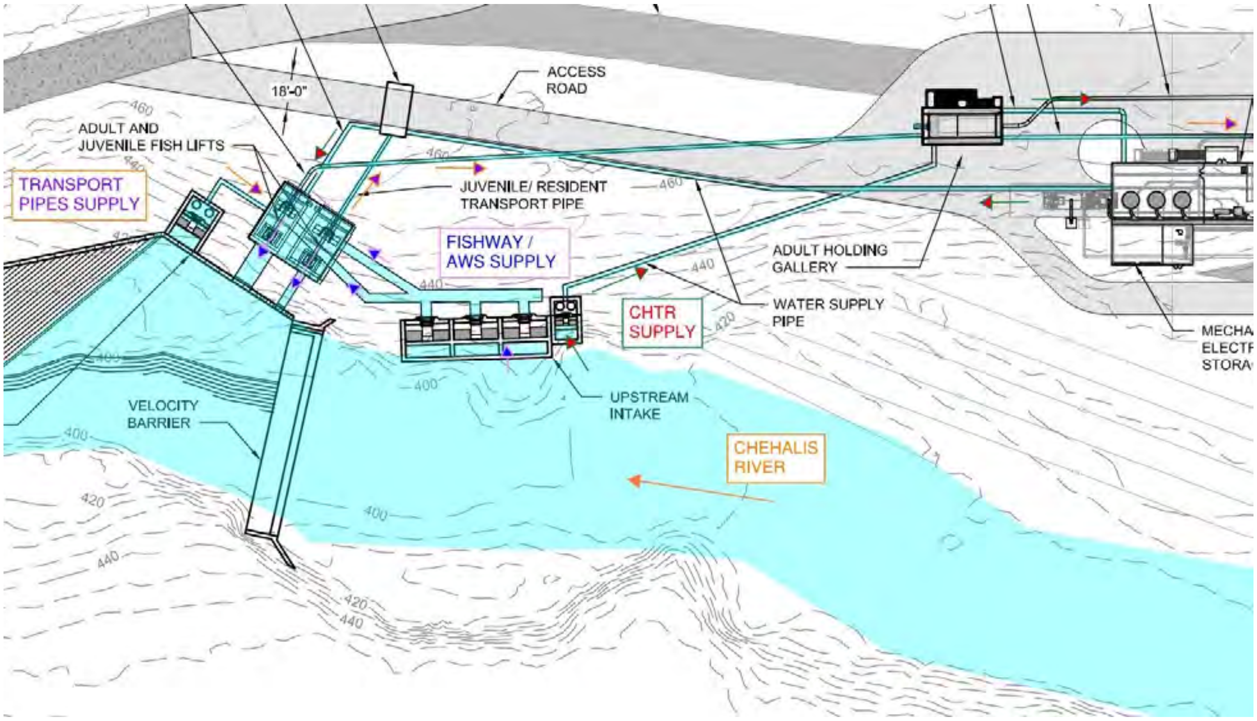
Once flows are beyond about 250 cfs in the river, river flow is transitioned from passing down the low flow channel to passing over the velocity barrier weir crest. During this process the gate in the low flow channel is shut.

6.3.1.2 Flow Events Requiring AWS

As river flows increase, the downstream screens continue to supply 9 to 12 cfs to the fishway holding pools and transport pipes until additional attraction flow is required. Once this occurs, the upstream screens begin to supply both flow to the fishway and lamprey ramp, and auxiliary water flow to the fishway sumps. Changing the water supply source reduces the amount of pumping by utilizing gravity flow from the backwater pool upstream of the velocity barrier once higher flow events have raised the water surface elevation in the pool to provide sufficient driving head.

Pumped flow is still required to supply the transport pipes when the hoppers are emptied. When this occurs, flow is pumped from the downstream intake to the transport pipes, eliminating the need for additional piping from the upstream intake and allowing the upstream intake to continue to supply solely gravity-fed water to the fishways. A figure detailing water supply for each element is in Figure 32.

Figure 32. Water Supply for Flow Events Requiring AWS



The depths, velocities, and WSELs for several different flow events are summarized in Table 6-10. The table illustrates the change in water supply and fish passage operation as river flow increases. A range of flow events was investigated, from the 16 cfs low fish passage design flow up to the 100-year flood event. Fish passage need only be provided between the 16 and 2,200 cfs flow events. Fish collection will not occur at greater flow events than the 2,200 cfs event.

Table 6-10. Hydraulic Results

Design Characteristic	River Flows						
	Low Fish Passage Design Flow (16 cfs)	AWS Flow Begins (190 cfs)	Low Flow Channel Closed; Water Passes over Velocity Barrier Crest (250 cfs)	High Fish Passage Design Flow (2,200 cfs)	2-Year Flood Event (7,300 cfs*)	10-Year Flood Event (10,300 cfs*)	100-Year Flood Event (15,000 cfs*)
WSEL upstream of velocity barrier (ft)	406.1	409.7	409.9	412.8	417.5	419.6	422.3
WSEL downstream of velocity barrier (ft)	397.6	398.6	398.7	403.6	411.4	414.1	417.2
Downstream passage via bypass channel or over barrier	Bypass	Bypass	Over Barrier	Over Barrier	Over Barrier	Over Barrier	Over Barrier
Depth on velocity barrier weir crest (ft)	N/A	0.6	0.8	3.6	8.4	10.4	13.2
Adult fishway flow, pumped (AWS not required) or gravity (AWS required) (cfs)	3	3	3	3	Not Operating	Not Operating	Not Operating
Juvenile fishway flow, pumped (AWS not required) or gravity (AWS required) (cfs)	3	3	3	3	Not Operating	Not Operating	Not Operating
Lamprey ramp flow, pumped (AWS not required) or gravity (AWS required) (cfs)	3	3	3	3	Not Operating	Not Operating	Not Operating
Transport pipe flow, pumped periodically at separate time than fishway flow (cfs)	6	6	6	6	Not Operating	Not Operating	Not Operating
Holding gallery and sorting building, pumped flow (cfs)	10	10	10	10	10	10	10
AWS flow, gravity (cfs)	0	0.1	6	201	Not Operating	Not Operating	Not Operating
Total attraction flow (cfs)	19	19.1	25	220	n/a	n/a	n/a
Upstream intake pumped flow (cfs)	10	10	10	10	10	10	10
Upstream intake gravity flow (cfs)	N/A	9.1	15	210	Not Operating	Not Operating	Not Operating
Downstream intake pumped flow (cfs)	9 – 12	0 – 6	0 – 6	0 – 6	Not Operating	Not Operating	Not Operating

*Fish collection will not occur during this event

6.3.2 Process Diagram

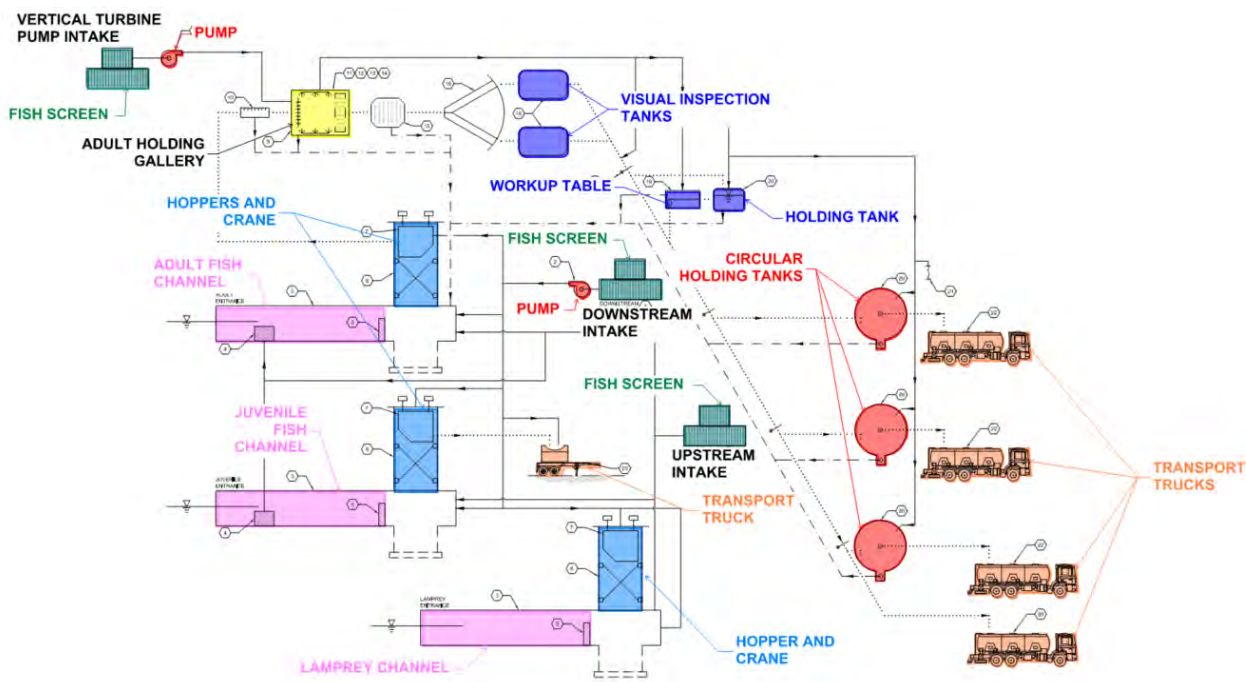
The facility system is shown in the process schematic below (Figure 33), and on sheet M1 in Attachment A. Aquatic species enter the system through either the adult, juvenile, or lamprey channels (shown in pink) and continue to the hopper and trapping mechanism (shown in light blue) at the end of the fishway holding pools. Once fish are in the hopper, a gantry crane lifts the hopper so that it aligns with the fish transport pipe. Adults travel through the pipe to the adult holding gallery (shown in yellow) and then onto the sorting building (shown in dark blue). At the sorting building, fish are directed either to the workup table, holding tank, or circular holding tanks (shown in red). Fish are transferred from the circular holding tanks to transfer trucks (shown in orange).

Juveniles and residents travel through a separate transport pipe to the juvenile and resident transfer station where they are directly deposited into transfer trucks via water-to-water transfer.

Lamprey collection and transfer has not been detailed, but will be developed during future design phases.

Once in transfer trucks the species are transported to predesignated upstream release locations.

Figure 33. Process Diagram



6.3.3 Downstream Conveyance

The diversion tunnel was sized prior to development of the facility based on a practical size that could be cost effectively advanced using drill and blast techniques and conventional mining equipment (HDR 2016). Design of the tunnel occurred prior to this memo. As such, the tunnel did not account for potential backwater at the tunnel outlet created by the velocity barrier. As part of the development of the construction phase fish passage design, hydraulic modeling was conducted to determine if the diversion tunnel capacity would be impacted by the velocity barrier. This information was used to help locate velocity barrier to reduce potential impact to the tunnel capacity.

Hydraulic modeling utilized HEC-RAS model of the Chehalis River originally developed by Watershed Science and Engineering in 2013 for the Chehalis River Basin Flood Authority as a basis. This model was updated in 2017 by HDR for the FRE design and updated again for this construction phase fish passage facility effort. The velocity barrier and FRE construction cofferdams were added to the 2013 HEC-RAS model and the model run. The location of the velocity barrier shown in Figure 27 and in Attachment A has been refined consistent with a 10% level of design. The velocity barrier creates a backwater pool that reaches the outlet of the diversion tunnel beginning at river flow of approximately 500 cfs. Backwater from the velocity barrier does not affect the cofferdam elevations. As design progresses, the shape of the tunnel, the design of the bypass channel, and the location of the velocity barrier will be refined to ensure that the tunnel retains capacity for diversion of the 10-year flow event per design criteria.

6.3.4 Maintenance Schedule

Regular maintenance of the facility will be required. There are maintenance activities that occur regularly throughout periods of operation and activities that occur following each flood event.

The frequent and periodic maintenance activities outlined in Section 3.2.3 of the CHTR Report for the permanent facility (HDR 2018b) are applicable to the construction phase facility as well. However, the facility will operate continuously during its life span compared to the permanent facility which will operate for only a few weeks every few years. As such, periodic maintenance required to maintain the regular function will occur more frequently for the construction phase facility than for the permanent facility.

Additionally, maintenance will be required following each flood event to ensure the facility can continue to operate. Maintenance following each flood event is anticipated to include the following:

- Inspection of trashracks and fish screens for damage
- Removal of debris, including tree limbs and other large debris from trashracks and fish screens
- Removal of large branches and trees from velocity barrier

High flow events will pass debris from upstream of the velocity barrier over the weir and apron. As high flow events recede and occasionally during low flow periods it may be necessary to remove large branches and trees from the velocity barrier. Removal of large branches and trees may include the use of pole saws, boats, shore-based cranes and excavators, safety lines, and hand removal.

6.4 Construction Sequencing

The construction sequencing for the facility and permanent structures is described in the Proposed Flood Retention Dam Construction Schedule Supplemental Information TM (District 2019). The construction of the downstream intake will also occur during the first in-water work period. The upstream intake will be constructed during the second in-water work period. The facility will continue to function for the remainder of the construction window, until the FRE structure conduits and permanent facility described in the CHTR Report (HDR 2018b) are commissioned and fully operational. Fish passage via the conduits and permanent facility will begin prior to removal of the facility to ensure fish passage remains uninterrupted. Portions of the facility that are not part of the permanent facility will then be demolished.

The adult holding gallery and the sorting building are located in the staging area for the diversion tunnel. However, there is enough clearance around the buildings so that construction of the diversion tunnel will not be impeded. While some facility elements are located within the staging area (District 2019) there is room for staging areas to be expanded such that no reduction in staging area is required.

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2000a Draft Fishway Guidelines for Washington State.

2000b Draft Fish Protection Screen Guidelines for Washington State.

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Watershed Science & Engineering

2013 HEC-RAS model of the Chehalis Basin. Prepared for the Chehalis River Basin Flood Authority.

Attachment A. Preliminary Drawings

NOTES:

1. PERMANENT FISH PASSAGE FACILITY IS SHOWN IN FADED BACK LINETYPE FOR CLARITY AND TO SHOW THE INTERPLAY BETWEEN CONSTRUCTION PHASE AND PERMANENT FISH PASSAGE ELEMENTS.

PROJECT SITE PLAN

SCALE: 1"=50'

HDR

CHEHALIS CONSTRUCTION PHASE UPSTREAM FISH PASSAGE

PROJECT SITE PLAN

CHEHALIS BASIN

DATE 02/25/2022

FIGURE C1

HDR C:\pwworking\west01\d2448865\C1.dwg PRINTED: 2/25/2022 11:25:52 AM BY: JECAMPBE

ENLARGED SITE PLAN
SCALE: 1"=30'
1
C1

HDR

CHEHALIS CONSTRUCTION PHASE
UPSTREAM FISH PASSAGE

ENLARGED SITE PLAN

CHEHALIS BASIN

DATE	02/25/2022
FIGURE	C2

RIVER PROFILE
SCALE: HORZ. 1"=20' VERT. 1"=10'

1
C2

20 0 20 40
SCALE IN FEET

10 0 10 20
SCALE IN FEET

HDR

CHEHALIS CONSTRUCTION PHASE
UPSTREAM FISH PASSAGE

RIVER PROFILE

CHEHALIS BASIN

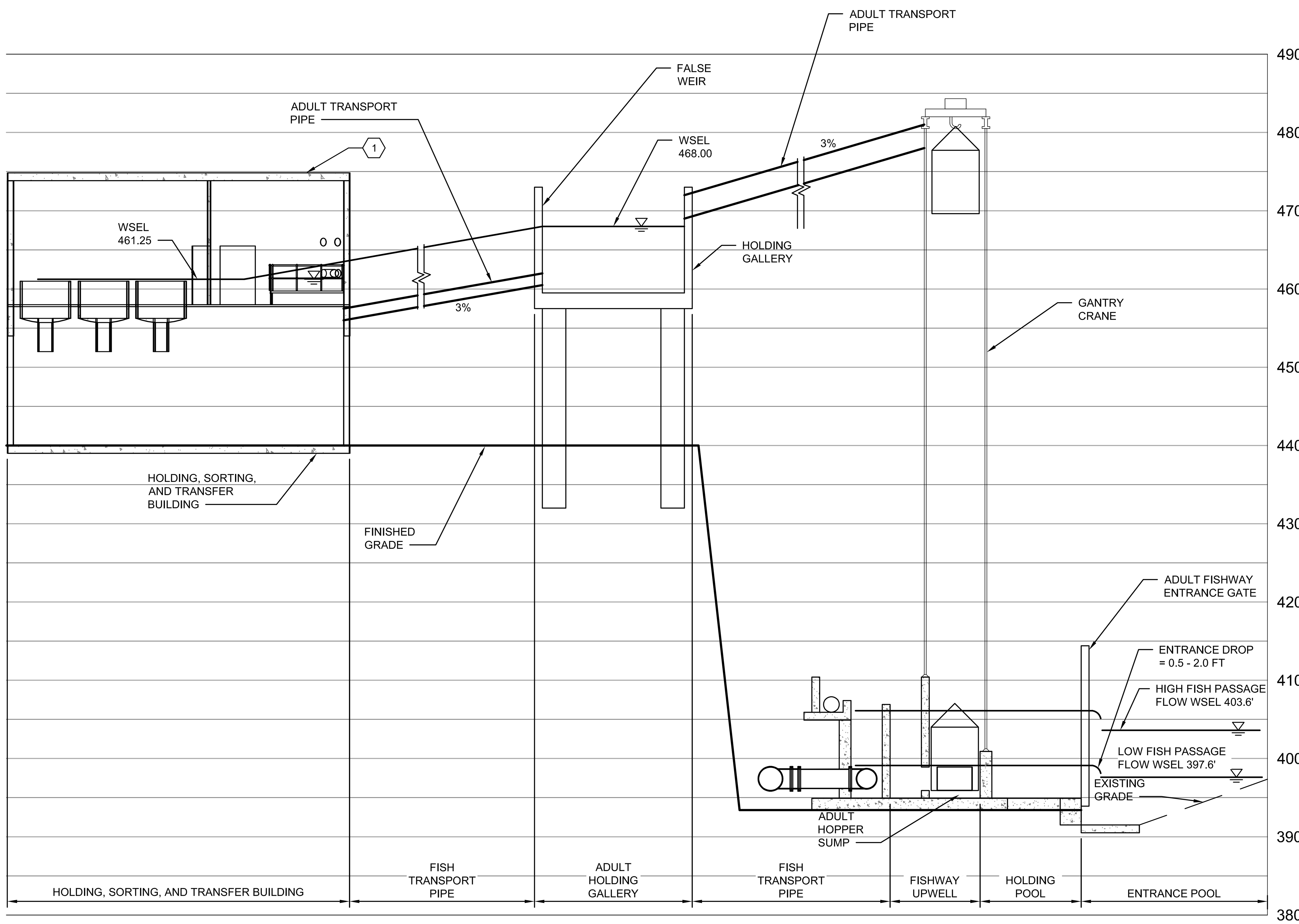
DATE
02/25/2022

FIGURE
C3

KEYED NOTES:

1. ADULT FISH LOADED INTO TRANSFER TANKS LOCATED ON TRANSPORT TRUCKS VIA WATER TO WATER TRANSFER FROM OVERHEAD HOLDING TANKS LOCATED IN THE SORTING BUILDING.

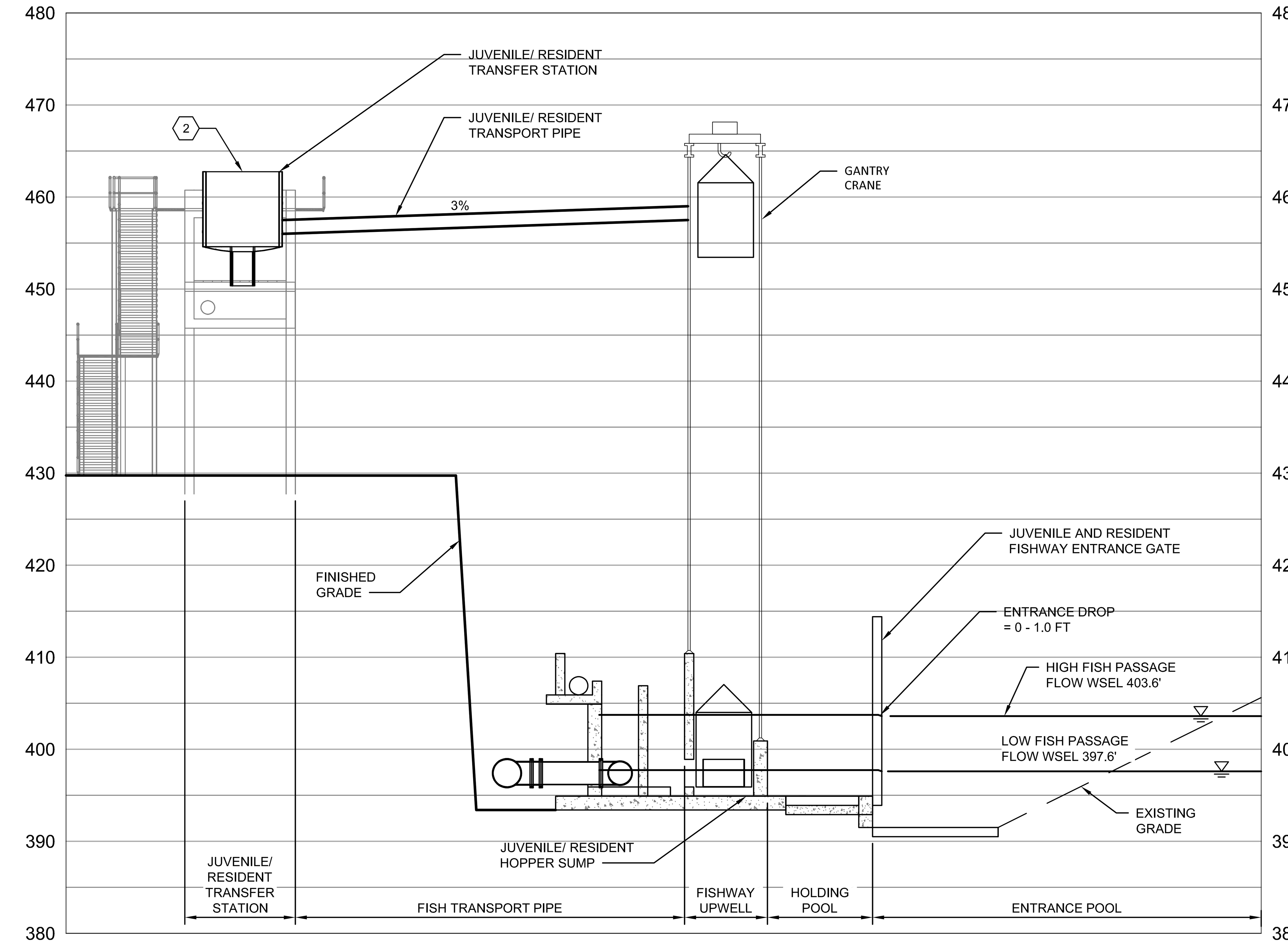
2. JUVENILE AND RESIDENT FISH LOADED INTO TRANSFER TANKS LOCATED ON TRANSPORT TRUCKS VIA WATER TO WATER TRANSFER FROM OVERHEAD TRANSFER STATION.



OPERATIONS PROFILE ADULT FISHWAY

SCALE: HORZ. NTS VERT. 1"=10'

1
-



OPERATIONS PROFILE JUVENLIE/ RESIDENT FISHWAY

SCALE: HORZ. NTS VERT. 1"=10'

2
-

10 0 10 20

SCALE IN FEET

HDR

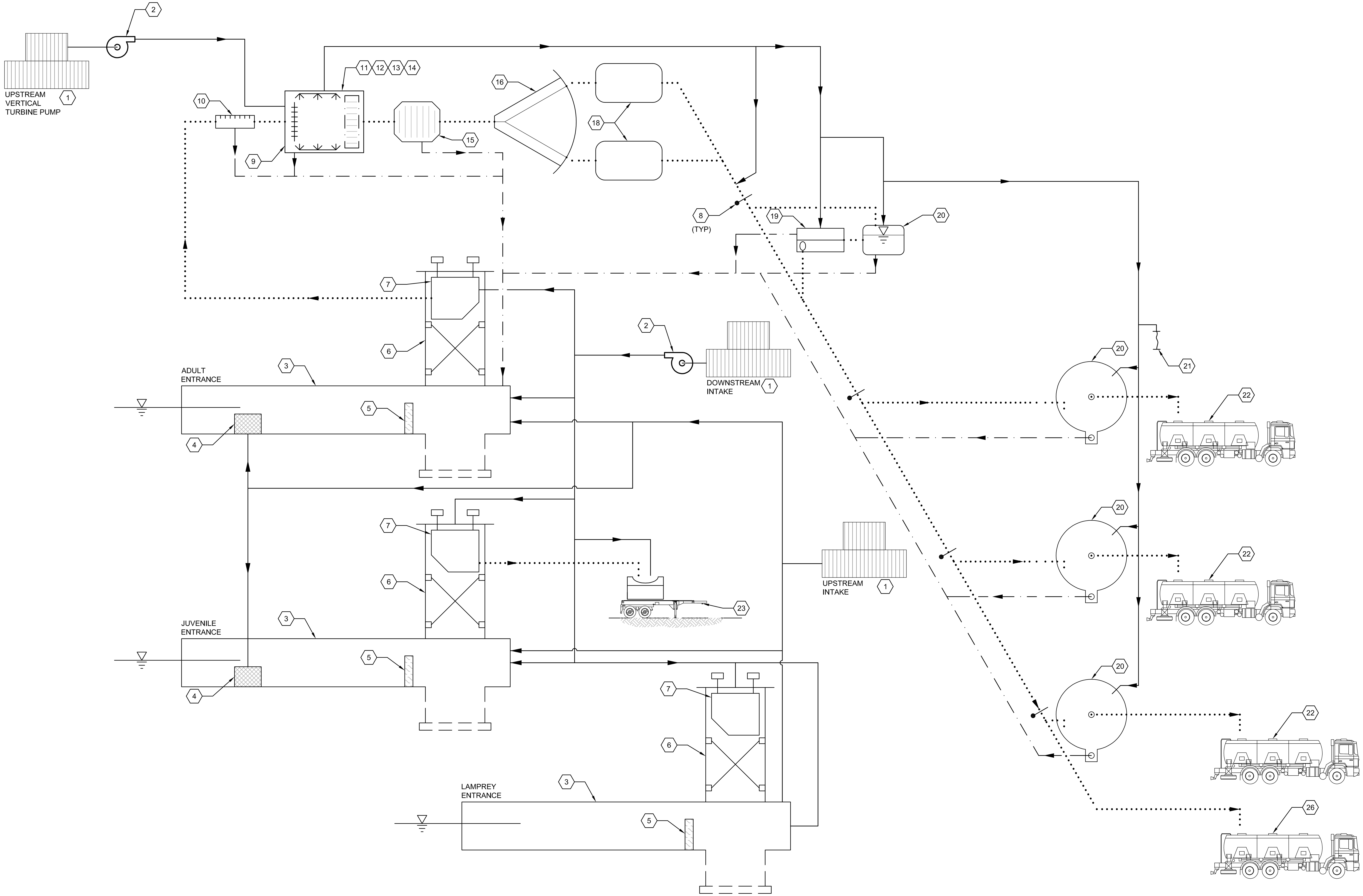
CHEHALIS CONSTRUCTION PHASE
UPSTREAM FISH PASSAGE

OPERATIONS PROFILES

CHEHALIS BASIN

DATE 02/25/2022

FIGURE C4



KEYED NOTES:

1. INTAKE SCREEN
2. PUMP
3. FISHWAY
4. AUXILIARY WATER SUPPLY
5. TRAP GATE
6. HOPPER LIFT TOWER
7. HOPPER BUCKET
8. DIVERTER GATE
9. HOLDING GALLERY
10. DEWATERING SCREEN
11. SPRINKLER SYSTEM
12. CROWDER
13. HOLDING GALLERY UPWELL
14. HOLDING GALLERY BRAIL
15. FALSE WEIR
16. AUTOMATIC DIVERTER GATE
17. VISUAL INSPECTION TANKS
18. WORKUP TABLE
19. HOLDING TANK
20. CIRCULAR HOLDING TANK
21. TRUCK FILL
22. ADULT TRANSPORT TRUCK
23. JUVENILE/ LAMPREY TRANSPORT TRUCK

LEGEND:

FISH DISTRIBUTION (FD)
DRAIN (DR)
WATER SUPPLY (WS)

CHEHALIS CONSTRUCTION PHASE
UPSTREAM FISH PASSAGE

PROCESS DIAGRAM

CHEHALIS BASIN

DATE
02/25/2022

FIGURE
M1

Appendix C
Vegetation Management Plan

Conceptual Vegetation Management Plan

Chehalis River Basin Flood Damage Reduction Project

Submitted by the Chehalis River Basin Flood Control Zone District

November 2020

Preface

Preface

This document contains a draft Conceptual Vegetation Management Plan (VMP) for the Chehalis River Basin Flood Damage Reduction Project (Project) proposed by the Chehalis River Basin Flood Control Zone District. The purpose of the Conceptual VMP is to provide avoidance and minimization components to the overall ecosystem mitigation approach for the Project. A primary objective of the conceptual VMP is to minimize the extent of tree clearing and vegetation removal in the Flood Retention Expandable (FRE) facility and temporary reservoir footprint to the extent practical, while balancing the need to reduce the amount of woody material that would be generated within the area during a flood event that triggers FRE operation.

This document expands upon the *Technical Memorandum on Proposed Flood Retention Facility Pre-Construction Vegetation Management Plan* submitted by Anchor QEA, LLC, in 2016. The Conceptual VMP includes a summary of existing vegetation conditions in the proposed FRE Facility and temporary reservoir area, mapping of inundation in the FRE temporary reservoir during major flood events and the anticipated vegetation community responses likely to result from construction and operation of the Project, a conceptual pre-construction and facility operations selective tree harvest plan, and a conceptual adaptive management plan. The Conceptual VMP will be used for future stakeholder and agency coordination efforts and serve as the basis for a more detailed Final VMP once project permitting commences.

Acronyms and Abbreviations

Anchor QEA	Anchor QEA, LLC
BMPs	Best management practices
cfs	cubic feet per second
CMZ	channel migration zone
Corps	U.S. Army Corps of Engineers
DAHP	Washington State Department of Archaeology and Historic Preservation
dbh	diameter at breast height
DSM	digital surface model
DTM	digital terrain model
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
FCZD	Chehalis River Basin Flood Control Zone District
FEMA	Federal Emergency Management Agency
FRE	Flood Retention Facility - Expandable
GIS	geographic information system
HDR	HDR Engineering, Inc.
I-5	Interstate 5
LCC	Lewis County Code
LiDAR	light detection and ranging
mxd	map exchange document
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OHWM	ordinary high water mark
Project	Chehalis River Basin Flood Damage Reduction Project
RCW	Revised Code of Washington
RMZ	riparian management zone
SMP	Shoreline Master Program

Acronyms and Abbreviations

USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
VMP	Vegetation Management Plan
WAC	Washington Administrative Code
WDNR	Washington Department of Natural Resources
WMZ	wetland management zone
WSEL	water surface elevation

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1.0 Introduction

1.1 Project Background

The Chehalis River Basin Flood Control Zone District (FCZD) is proposing to construct a flood retention facility near the town of Pe Ell and conduct airport levee improvements at the Chehalis-Centralia Airport in Lewis County, Washington (Project). The Project would reduce the extent and intensity of flooding from the Chehalis River and improve levee integrity at the Chehalis-Centralia Airport to reduce potential flood damage in the Chehalis-Centralia area.

Flooding has become more frequent in the Chehalis-Centralia area in recent years. The three most recent floods in 1996, 2007, and 2009 were the largest on record and caused extensive physical, emotional, and economic damage. The 2007 and 2009 floods occurred only 13 months apart, affording the community a short window of opportunity to restore the area between floods. These extreme floods caused the loss of homes, farms, and businesses, and floodwater inundation resulted in the closure of Interstate 5 (I-5) for several days. These floods also caused damage to and closure of the Chehalis-Centralia Airport. Most of the flood damage occurred in the cities of Chehalis and Centralia, where there is more intensive development in the floodplain. Peak flows from the 1996, 2007, and 2009 floods rank in the top five ever observed at stream gages in the Chehalis River near Grand Mound, the Newaukum River near Chehalis, and the South Fork Chehalis River.

1.2 Project Location

The flood retention facility would be located on Weyerhaeuser and Panesko Tree Farm property, south of State Road 6 in Lewis County. It would be constructed on the mainstem Chehalis River at approximately River Mile 108, about 1 mile south of (upstream of) Pe Ell. The facility would be located in Section 3, Township 12N, Range 5W at parcel number 016392004000. The watershed area upstream of the flood retention facility location is 68.9 square miles. Property within the flood retention facility and reservoir footprint would no longer be managed as commercial forestland.

At the Chehalis-Centralia Airport, the FCZD is proposing to raise the existing airport levee and part of NW Louisiana Avenue. The property is located in Section 30, Township 14N, Range 2W, and the parcel number is 005605080001. This construction would take place concurrently with flood retention facility construction but could be completed within 1 construction year.

1.3 Project Description

The proposed Flood Retention Expandable (FRE) facility would temporarily store floodwater during major floods and then release retained floodwater following the flood peak. Specific flow release operations would depend on inflow and the need to hold water to relieve downstream flooding. Major floods include events with river flows forecasted to reach 38,800 cubic feet per second (cfs) or more as measured at the Chehalis River Grand Mound gage located in Thurston County. Events of this magnitude have a 15% probability of occurrence in any one year, or a 7-year recurrence interval. Major floods also include those with a lower frequency of occurrence, such as 10-year, 100-year, and 500-year floods. Except during flood reduction operations, the Chehalis River would flow through the structure's low-level outlet works at its normal rate of flow and volume, and no water would be stored in the temporary reservoir. This mode of operation would allow fish to pass both upstream and downstream.

The FRE facility would operate when flood forecasts predict a major or greater flood. The FRE facility conduit gates would begin to close and start holding water approximately 48 hours before flows at the Grand Mound gage (USGS 12027500) were predicted to exceed 38,800 cfs due to heavy rainfall in the Willapa Hills. Once conduit gates begin to close, flows through the conduit gates would be reduced until reaching a flow of 300 cfs. A 300-cfs flow is a naturally occurring winter low flow on the Chehalis River. The outflow rate would be adjusted based on observed flows and revised predictions. The FRE facility would be operated to keep river outflow at a reduced rate until the peak flood passes the Grand Mound gage.

FRE facility operation would cause the temporary reservoir to fill. The size of the temporary reservoir depends on the peak of the flood flow and its duration, but in no case would it be greater than 808 acres and would have a maximum depth of 212 feet (measured at conduit invert elevation 408 feet). Peak flood flows for major or greater floods are predicted to last on the order of 2 to 3 days. Once the peak flood flow has passed, a three-stage reservoir evacuation operation would be implemented (see Section 4.0). The duration of temporary reservoir evacuation would depend on the magnitude of the flood event and the amount of water temporarily stored. For catastrophic floods on the order of 75,100 cfs, it is estimated that inundation would last approximately 36 days total from closing of conduit gates through final reservoir evacuation.

The proposed construction of the FRE facility would require removal of vegetation for construction, staging, and access in and around the FRE facilities footprint, as well as selective vegetation removal and tree harvest within the temporary reservoir area before the project is commissioned and available for operation.

Operation of the FRE facility would also require routine vegetation management in the temporary reservoir area to ensure that the FRE facility could be safely operated. Vegetation management would involve periodic selective tree harvest in the temporary reservoir. This would happen about every 7 to 10 years to keep larger trees from growing in areas that would be frequently flooded when the FRE facility is activated.

2.0 Regulatory Considerations

The Conceptual Vegetation Management Plan (VMP) is a component of the overall ecosystem effects mitigation approach for the Project. Vegetation communities in the Project area, and specifically streamside riparian vegetation, can help moderate local temperatures, intercept runoff and rainfall and uptake nutrients that may affect downstream water quality. Vegetation also provides habitat for wildlife. Functions provided by vegetation affect a variety of natural resources that are regulated at the federal, state, and local level. The VMP aims to avoid and minimize impacts to vegetation communities to the extent practical at the FRE facility and within the temporary reservoir area.

The following agencies and stakeholders may use the VMP to inform permit reviews, but do not have discretionary authority to approve or deny the VMP as part of their permit approval process. The exception is Washington State Department of Natural Resources (WDNR), who will need to issue a Forest Practices Permit per the Washington State Forest Practices Rules (Title 222 Washington Administrative Code [WAC]) in order for the FCZD to conduct selective and tree harvest and long-term vegetation management during Project construction and operations. WDNR would approve the VMP as part of the Forest Practices Permit issuance. This permit is discussed in detail in Section 2.3.3.1.

2.1 Federal

2.1.1 U.S. Army Corps of Engineers

2.1.1.1 Section 404 Clean Water Act Permit

Section 404 of the Clean Water Act requires discharges of dredged and fill material into waters of the U.S. be done only under the authorization of a permit. Because construction of the FRE facility would involve excavation and fill placement in the Chehalis River and adjoining wetlands that are Waters of the U.S., the Project would require a Section 404 permit from the Corps. The Corps is expected to review the VMP as part of their evaluation of impacts to Waters of the U.S., and measures to avoid and minimize such impacts.

2.1.2 U.S. Fish and Wildlife Service and National Marine Fisheries Service

2.1.2.1 Endangered Species Act and Magnuson-Stevens Fishery Conservation and Management Act

The Project could affect species listed under the Endangered Species Act (ESA) or designated critical habitats. The U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) would evaluate the effects on listed and proposed species and critical habitats and require specific conservation measures for unavoidable impacts.

The Magnuson-Stevens Fishery Conservation and Management Act requires federal action agencies to consult with NMFS on all actions, or proposed actions, authorized, funded, or undertaken by the agency that may adversely affect Essential Fish Habitat. USFWS and NMFS may review the VMP as part of their evaluation of potential impacts to listed species and habitats.

2.2 Tribal

The Corps, as federal lead agency, is conducting a review of the Project under the National Environmental Policy Act (NEPA). This includes consultation under Section 7 of the federal Endangered Species Act with the USFWS and NMFS and under Section 106 of the NHPA with tribes and DAHP.

Washington's salmon and steelhead fisheries are also managed cooperatively in a unique co-management relationship. Co-management of fisheries occurs through government-to-government cooperation, communications, and negotiations. One government is the State of Washington, and the other is Indian tribes whose rights were preserved in treaties signed with the federal government in the 1850s. The Tribes may review the VMP as part of government-to-government consultation relating to project effects on fisheries.

2.3 State

2.3.1 Washington Department of Ecology

2.3.1.1 Shoreline Conditional Use and Substantial Development Permit

Chehalis River, Crim Creek, and Rogers Creek are Shorelines of the State located in the Project Area. The FRE facility would be considered an in-water structure within Lewis County's Shoreline Master Program (SMP), which is a conditional use within the Rural Conservancy shoreline designation (Lewis County 2017). Tree harvest conducted within shoreline jurisdiction must be in compliance with the Lewis County SMP. Forest practices are a permitted use within the Rural Conservancy shoreline environment designation (Lewis County 2017). Ecology has final approval for these permits under the Shoreline Management Act (Chapter 90.58 Revised Code of Washington [RCW]). Ecology may review the VMP as part of their evaluation of potential impacts to shoreline ecological functions.

2.3.1.2 Section 401 Clean Water Act Water Quality Certification

Because a federal (Corps) permit would be required to construct the Project, a Section 401 Water Quality Certification from Ecology would be needed to document the state's review of the Project and its concurrence that the FCZD has demonstrated that the Project and associated activities will meet state water quality standards. This certification is intended to provide reasonable assurance that the FCZD's project would comply with state water quality standards and other requirements for protecting aquatic resources, and covers both construction and operation of the facility. Ecology is expected to review the VMP as part of their evaluation of potential impacts to wetlands and aquatic waterbodies regulated by Ecology under Section 401.

2.3.2 Washington Department of Fish and Wildlife

2.3.2.1 Hydraulic Project Approval

A hydraulic project approval is required because the Project would use, divert, obstruct, and change the natural flow and bed of Chehalis River and its tributaries, which are regulated as waters of the state. The Project would include work in and adjacent to waters of the state. WDFW may review the VMP as part of their evaluation of potential impacts to waters of the state.

2.3.3 Washington Department of Natural Resources

2.3.3.1 Forest Practices Permit

Selective tree harvest within the reservoir footprint during pre-construction and facility operations would be subject to Forest Practices Act Rules administered by the Washington Department of Natural Resources (WDNR) through the Forest Practices Application. In addition, activities for construction and operation of the FRE facility taking place on private or state forestland, including development of quarries and expanding, maintaining, or abandoning roads, would also be subject to Forest Practices Act Rules. These rules provide direction on how to implement the Forest Practices Act (Chapter 76.09 RCW) and Stewardship of Non-Industrial Forests and Woodlands (Chapter 76.13 RCW), and are designed to protect public resources such as water quality and fish habitat while maintaining a viable timber industry in Washington.

It is anticipated that selective tree harvest required for the Project would deviate from prescribed Forest Practices Act Rules, and therefore an Alternate Plan would need to be developed in order to acquire a Forest Practices Permit. WDNR may convene an Interdisciplinary Team to advise the applicant on how to successfully complete and implement an alternate plan to adequately maintain functions of riparian corridors and other sensitive areas. The Interdisciplinary Team is typically led by a Forest Practices Forester who serves as the representative of WDNR, and may include stakeholders such as Ecology field staff, representative(s) of the affected Native American Tribe(s), local or federal authorities that have jurisdiction, and other interested parties that may participate at the discretion of the applicant. WDNR will need to approve the VMP as part of their Forest Practices Permit issuance.

2.4 Local and Regional

2.4.1 Lewis County

2.4.1.1 Critical Areas Review

The Project would be within, abutting, or likely to affect critical areas regulated by Lewis County (i.e., wetlands, wetland buffers, and Fish and Wildlife Habitat Conservation Areas [FWHCAs]). Therefore, review of critical areas and associated permits will be required in accordance with Lewis County Code (LCC) Chapter 17.38. Lewis County may review the VMP as part of their evaluation of potential impacts to critical areas.

2.4.1.2 Shoreline Conditional Use and Shoreline Substantial Development Permit

The FRE facility would be considered an in-water structure within Lewis County's SMP, which is a conditional use within the Rural Conservancy shoreline environment designation. Development of the FRE facility and forest practices associated with Conceptual VMP implementation would require a Shoreline Substantial Development Permit. Lewis County issues these permits in accordance with the Lewis County SMP. Lewis County may review the VMP as part of their evaluation of potential impacts to shoreline ecological functions.

3.0 Existing Conditions

3.1 Existing Vegetation Mapping

3.1.1 Vegetation Mapping Methods

Existing vegetation communities were documented in the FRE temporary inundation study area, which encompasses the temporary reservoir pool from water surface elevation (WSEL) 425 up to WSEL 620 feet, the maximum WSEL for the 2007 event of record. Vegetation mapping used geographic information system (GIS) data and aerial photography available from public sources. A map exchange document (mxd) was set up in GIS with an empty feature class with defined domains for each land cover community that would be digitized. The mxd was populated with the following GIS reference files from previous studies and publicly available information: digital surface models (DSMs) showing the height of tree canopy (WDNR 2020a); digital terrain models (DTMs) representing the ground elevation (WDNR 2020b); streams, wetlands, and ditches mapped by Anchor QEA, LLC (Anchor QEA 2018); and logging road data (WDNR 2020c).

Using the reference data above as well as Google Earth aerial imagery from 1990 through 2018 (Google, LLC 2019), vegetation was characterized in the study area and digitized into distinct land cover classes using the vegetation communities identified in the Proposed Flood Retention Facility Pre-construction Vegetation Management Plan (Anchor QEA 2016), as amended with additional land use classifications such as open water, bare ground/roads, and logged lands to accurately capture current conditions in the study area. A reconnaissance-level site visit was conducted by FCZD biologists in June 2020 to qualitatively ground-truth the desktop mapping of the land cover types.

Table 1 summarizes land cover classifications, typical vegetation within each cover classification, and distinct characteristics that were used to map identified land cover types in the study area.

Table 1. Summary of Land Cover Classifications

Land Cover Classification	% Cover in Study Area	Typical Vegetation	Distinct Characteristics
Wetlands	1%	See Anchor QEA (2018)	Wetlands delineated by Anchor QEA 2018.
Open Water/Sand Bar	10%	Unvegetated	Mapped aquatic features (Anchor QEA 2018) and associated sand bars, rock features, etc.
Terrestrial Bare Ground/Roads	4%	Unvegetated	Lack of vegetation over multiple growing seasons; often associated with wide logging roads and equipment staging areas.
Herbaceous/Grass	1%	Reed canarygrass (*Phalaris arundinacea*), colonial bentgrass	Grasses and forbs present during growing season;

Land Cover Classification	% Cover in Study Area	Typical Vegetation	Distinct Characteristics
		(*Agrostis capillaris*), sword fern (*Polystichum munitum*), western lady fern (*Athyrium angustum*), piggyback plant (*Tolmiea menziesii*), creeping buttercup (*Ranunculus repens*)	often found adjacent to wetlands, riparian corridors, and recently disturbed areas.
Deciduous Riparian Shrubland	<1%	Various willows (*Salix* spp.), young red alder (*Alnus rubra*), red-osier dogwood (*Cornus alba*), vine maple (*Acer circinatum*), Indian plum (*Oemleria cerasiformis*), thimbleberry (*Rubus parviflorus*), salmonberry (*Rubus spectabilis*)	Dominated by deciduous shrub/saplings less than 6 meters (20 feet) tall (>75% cover).
Deciduous Riparian Forest with Some Conifers	17%	Red alder, Western red cedar (*Thuja plicata*), Western hemlock (*Tsuga heterophylla*), black cottonwood (*Populus balsamifera*), cascara (*Frangula purshiana*), willows, big leaf maple (*Acer macrophyllum*), red elderberry (*Sambucus racemosa*), snowberry (*Symphoricarpos albus*)	Dominated by deciduous tree species 6 meters (20 feet) tall or taller (>75% cover).
Mixed Coniferous/Deciduous Transitional Forest	29%	Douglas fir (*Pseudotsuga menziesii*), red alder, big leaf maple	Approximately equal distribution of deciduous and coniferous species (not clearly dominated by one or the other).
Coniferous Forest	28%	Douglas fir	Dominated by coniferous species (>75% cover).
Logged, replanted 0–5 years	7%	Sun-tolerant grasses and forbs, Douglas fir seedlings	Evidence of logging (i.e., clearcutting) on historic aerial imagery; replanting visible within last 5 years (2015–2020) or not replanted.
Logged, replanted 5–15+ years	3%	Douglas fir saplings	Evidence of logging on historic aerial imagery; replanting identified 5 or more years ago (prior to 2015).

3.1.1.1 Wetland and Open Water/Sand Bar

Wetlands and streams mapped in the *Wetland, Water, and Ordinary High Water Mark Delineation Report* (Anchor QEA 2018) were imported into GIS to create the Wetland and Open Water/Sand Bar land cover classifications, respectively.

The ordinary high water marks (OHWM) for Crim Creek, Roger Creek, and the Chehalis River were not delineated in their entirety during field visits conducted by Anchor QEA due to access limitations and the length of reaches within the project area. Instead, Anchor QEA conducted a desktop-based GIS analysis using light detection and ranging (LiDAR)-generated topography to interpret the OHWM elevation between each point that was gathered in the field. Minor adjustments were made to GIS-based stream mapping to more accurately reflect the spatial extent of streams visible on aerial photography.

3.1.1.2 Terrestrial Bare Ground/Roads

The Terrestrial Bare Ground/Roads land cover class includes wide logging roads and equipment staging areas. Historic aerial imagery was used to identify areas lacking vegetation for multiple growing seasons that were not associated with aquatic areas. To account for the surface area of logging roads obscured by dense vegetation and not visible on aerial imagery, a 7.5-foot buffer was applied to the centerline of mapped road features.

3.1.1.3 Herbaceous/Grass

The Herbaceous/Grass class accounts for upland areas dominated by grasses and forbs that are not wetlands. Herbaceous vegetation was distinguished from bare ground by comparing multiple years of aerial imagery to confirm the presence of vegetation during the growing season. Herbaceous vegetation was also commonly associated with areas recently disturbed by logging operations, and was found adjacent to areas categorized as Terrestrial Bare Ground. Species typically found in these areas include reed canarygrass (*Phalaris arundinacea*), colonial bentgrass (*Agrostis capillaris*), sword fern (*Polystichum munitum*), western lady fern (*Athyrium angustum*), piggyback plant (*Tolmiea menziesii*), and creeping buttercup (*Ranunculus repens*).

3.1.1.4 Deciduous Riparian Shrubland

The Deciduous Riparian Shrubland class was modeled after the Cowardin “Scrub-Shrub” class, which includes areas dominated by woody vegetation less than 6 meters (20 feet) tall, including true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions (Cowardin et al. 1979). This class was identified and mapped based on the prevalence of deciduous shrub species and proximity (generally within 200 feet) to mapped streams and aquatic areas. Species typically found in these areas include various willows (*Salix* spp.), red-osier dogwood (*Cornus alba*), vine maple (*Acer circinatum*), Indian plum (*Oemleria cerasiformis*), thimbleberry (*Rubus parviflorus*), salmonberry (*Rubus spectabilis*), and red alder (*Alnus rubra*) saplings.

3.1.1.5 Deciduous Riparian Forest with Some Conifers

The Deciduous Riparian Forest classification was established based on the Cowardin “Forested” class, which includes forested areas characterized by woody vegetation that is 6 meters (20 feet) or taller (Cowardin et al. 1979). Deciduous forest stands were differentiated from scrub-shrub communities using the DSM GIS layer to determine approximate tree height. Although the class is dominated by deciduous tree species (approximately >75% deciduous cover), scattered conifer trees were also commonly observed in these areas. Deciduous species were distinguished from conifers using multiple years of aerial imagery to identify seasonal differences in canopy cover. Species typically found in the Deciduous Riparian Forest class includes red alder, Western red cedar (*Thuja plicata*), Western hemlock (*Tsuga heterophylla*), black cottonwood (*Populus balsamifera*), cascara (*Frangula purshiana*), willows, big leaf maple (*Acer macrophyllum*), red elderberry (*Sambucus racemosa*), and snowberry (*Symphoricarpos albus*).

3.1.1.6 Mixed Coniferous/Deciduous Transitional Forest

Mixed Coniferous/Deciduous Transitional Forest represents areas with an approximately equal distribution of coniferous and deciduous tree species. Tree heights were estimated using the DSM layer, and the distribution of coniferous and deciduous species was determined using seasonal differences in canopy cover from historic aerial imagery. Species typically found in these areas include Douglas fir (*Pseudotsuga menziesii*), red alder, and big leaf maple.

3.1.1.7 Coniferous Forest

Areas dominated by coniferous tree species (>75% cover) were characterized as Coniferous Forest. The Coniferous Forest class is typically dominated by Douglas fir and often includes stands of various age classes managed for logging.

3.1.1.8 Recently Logged Areas

Areas with evidence of recent logging activity (i.e., clearcutting) were identified by comparing multiple years of aerial imagery. Recently logged areas with evidence of replanting within the last 5 years (2015 to present) or no evidence of replanting were characterized as “Logged, replanted 0-5 years.” Areas with evidence of replanting more than 5 years ago (prior to 2015) were characterized as “Logged, replanted 5-15+ years.” The 5-year threshold represents an approximation of time required for logged lands in the Pacific Northwest to transition from an early seral stage, in which grasses and forbs are predominant, to a shrub-sapling stage in which Douglas-fir seedlings accelerate in growth (Burns and Honkala 1990; Lam and Maguire 2011; USDA Forest Service 2012).

3.1.2 Existing Vegetation Mapping Results

An existing land cover map of the study area is presented in Appendix A.

4.0 FRE Temporary Reservoir Inundation Impacts

4.1 Inundation Mapping

4.1.1 Inundation Mapping Methods

The methods described below were used to generate the temporary reservoir inundation limits anticipated for the regulation of flood events by the proposed FRE facility. The inundation limits are the same as the vegetation study area, encompassing WSEL 425 to 620 feet.

Topography data were obtained from public light detection and ranging (LiDAR) databases. A series of digital terrain models (DTMs) provided by the Washington State Department of Natural Resource's LiDAR program were used to generate contour lines (datum: North American Vertical Datum of 1988 [NAVD88]). HDR Engineering, Inc. (HDR), used ArcGIS's "Mosaic to New Raster" tool to merge multiple DTMs into a single DTM that covers the entire project area. Once created, the new DTM was used to derive contours using the ArcGIS Contour tool. This tool was used to define the base contour, contour interval, and maximum vertices per contour. No unit conversion factor (Z factor) was used to generate the project contours. For the purpose of modeling, contours at a 5-foot contour interval were created with a base contour of zero.

The contour files were imported to AutoCAD 2018 and used to generate the inundation contour lines and show the aerial extent of these inundation limits. The following key WSEL contours were selected to illustrate the aerial (i.e., planform) extent of inundation during each of the three stages of temporary reservoir evacuation that would be implemented to evacuate the reservoir after a major flood event (i.e., events with river flows forecasted to reach 38,800 cfs or more) when the FRE facility is activated:

1. **Initial Reservoir Evacuation (Max. WSEL to WSEL 528 feet):** The maximum WSEL for each major flood event will vary depending on the intensity of the flood event. To evacuate the temporary reservoir after a major flood event, the partially closed reservoir outlet gates will open and increase outflow by 1,000 cfs each hour, from 300 cfs (minimum outflow during flood operations) to a maximum outflow of 5,000 to 6,500 cfs. This will cause evacuation of the temporary reservoir from its peak WSEL at the maximum pool, which will be limited to 10 feet per day (5 inches per hour) to reduce risk of landslides. During all major flood events, the 10-feet-per-day evacuation rate will continue until the pool elevation reaches 528 feet. Once the pool elevation reaches 528 feet, debris management operations will begin.

2. **Debris Management Evacuation (WSEL 528–500 feet):** During major flood events, debris from surrounding tributaries and hillsides may be swept into the reservoir. Debris management procedures will be used to ensure that large woody debris will not impact dam operations or cause damage to the FRE facility.

Debris management will begin once the pool elevation falls to 528 feet. At this time, evacuation rates will be slowed to 2 feet per day (1 inch per hour) for a 14-day period. During this period, crews operating from boats will move large debris to an existing log-sorting yard within the reservoir area previously operated previously by Weyerhaeuser. The slowed evacuation rate will continue until the pool elevation fall to 500 feet. Once the pool elevation reaches 500 feet, debris management operations will conclude.

3. **Final Reservoir Evacuation (WSEL 500–425 feet):** When the pool elevation falls to WSEL of 500 feet, evacuation rates will increase to 10 feet per day (5 inches per hour) once debris management operations are complete. Evacuation will continue at this rate until the pool elevation returns to 425 feet (empty reservoir). At this point, the reservoir will no longer be impounding water and the Chehalis River will return to a free-flowing state.

The State Environmental Policy Act Draft Environmental Impact Statement: Proposed Chehalis River Basin Flood Damage Reduction Project (EIS; Ecology 2020) analyzed three historical flood events and two theoretical events, the 10-year event and the 100-year event (see Table 2). To determine the predicted maximum reservoir pool WSELs resulting from FRE operations for each of these flood events, the regulated and unregulated flood hydrographs were obtained from the EIS and notations were added to the hydrograph plots to clarify key evacuation stages. Similar information was applied to the inundation limit map created in AutoCAD 2018. Additionally, the total inundation time above each of the three key reservoir evacuation elevations—maximum WSEL, WSEL 528 feet, and WSEL 500 feet—was determined from the time steps obtained from the flood hydrographs provided in the EIS.

4.1.2 Inundation Mapping Results

Table 2 shows the acreage and duration of inundation expected during the three stages of temporary reservoir drawdown for each major flood event evaluated. Inundation maps for historical and modeled flood events are presented in Appendix B. The figures show the Initial Reservoir Evacuation, Debris Management Evacuation, and Final Reservoir Evacuation areas in blue, yellow, and orange, respectively. Hydrographs for each major flood event are provided in Appendix C.

The terms used in Table 2 are defined as follows:

- **Area of inundation** refers to the area (in acres) of reservoir inundated during each stage of temporary reservoir drawdown. As described above, the Debris Management Evacuation and Final Reservoir Evacuation stages will have uniform operation during all major flood events; therefore, the acreage will be consistent during these operational milestones. The area inundated at the start of the Initial Reservoir Evacuation stage differs based on the severity of the flood event.
- **Duration of inundation** represents the maximum number of days of inundation during each stage of reservoir evacuation. The duration differs depending on the severity of the historical or

Table 2. Acreage and Duration of Inundation for Historical and Modeled Flood Events during Temporary Reservoir Evacuation Stages

Historical/Modeled Event	Initial Reservoir Evacuation (WSEL >528 feet)				Debris Management Evacuation (WSEL 528–500 feet)			Final Reservoir Evacuation (WSEL 500–425 feet)		
	Area of Inundation above WSEL 528 feet	Duration of Inundation above WSEL 528 feet	Total Reservoir Area[a]	Maximum WSEL[b]	Area of Inundation at WSEL 500–528 feet	Duration of Inundation at WSEL 520–500 feet[c]	Total Reservoir Area	Area of Inundation at WSEL 425–500 feet	Duration of Inundation at WSEL 500–425 feet[d]	Total Reservoir Area
10-year event	238 acres	Up to 5.9 days	519 acres	568 feet	122 acres	Up to 20.2 days	281 acres	159 acres	Up to 26.9 days	159 acres
100-year event	426 acres	Up to 10.7 days	707 acres	604 feet	122 acres	Up to 25.0 days	281 acres	159 acres	Up to 31.8 days	159 acres
1996 flood event	410 acres	Up to 9.8 days	691 acres	601 feet	122 acres	Up to 24.5 days	281 acres	159 acres	Up to 31.0 days	159 acres
2007 flood event	527 acres	Up to 11.1 days	808 acres	620 feet	122 acres	Up to 25.2 days	281 acres	159 acres	Up to 32.3 days	159 acres
2009 flood event	324 acres	Up to 7.8 days	605 acres	585 feet	122 acres	Up to 22.0 days	281 acres	159 acres	Up to 28.8 days	159 acres

[a] This value also represents the maximum area of inundation for the modelled flood event.

[b] This value also represents the maximum WSEL for the modelled flood event.

[c] Includes 14 days for debris-clearing activities starting when evacuation following flood peak falls to WSEL 528 feet.

[d] This value also represents the maximum number of days of flooding for the modelled flood event.

- modeled flood event. For the Debris Management Evacuation stage, this number includes 14 days for debris-clearing activities.
- **Maximum WSEL** gives the peak temporary reservoir pool WSEL for each flood event prior to the start of the Initial Reservoir Evacuation stage.

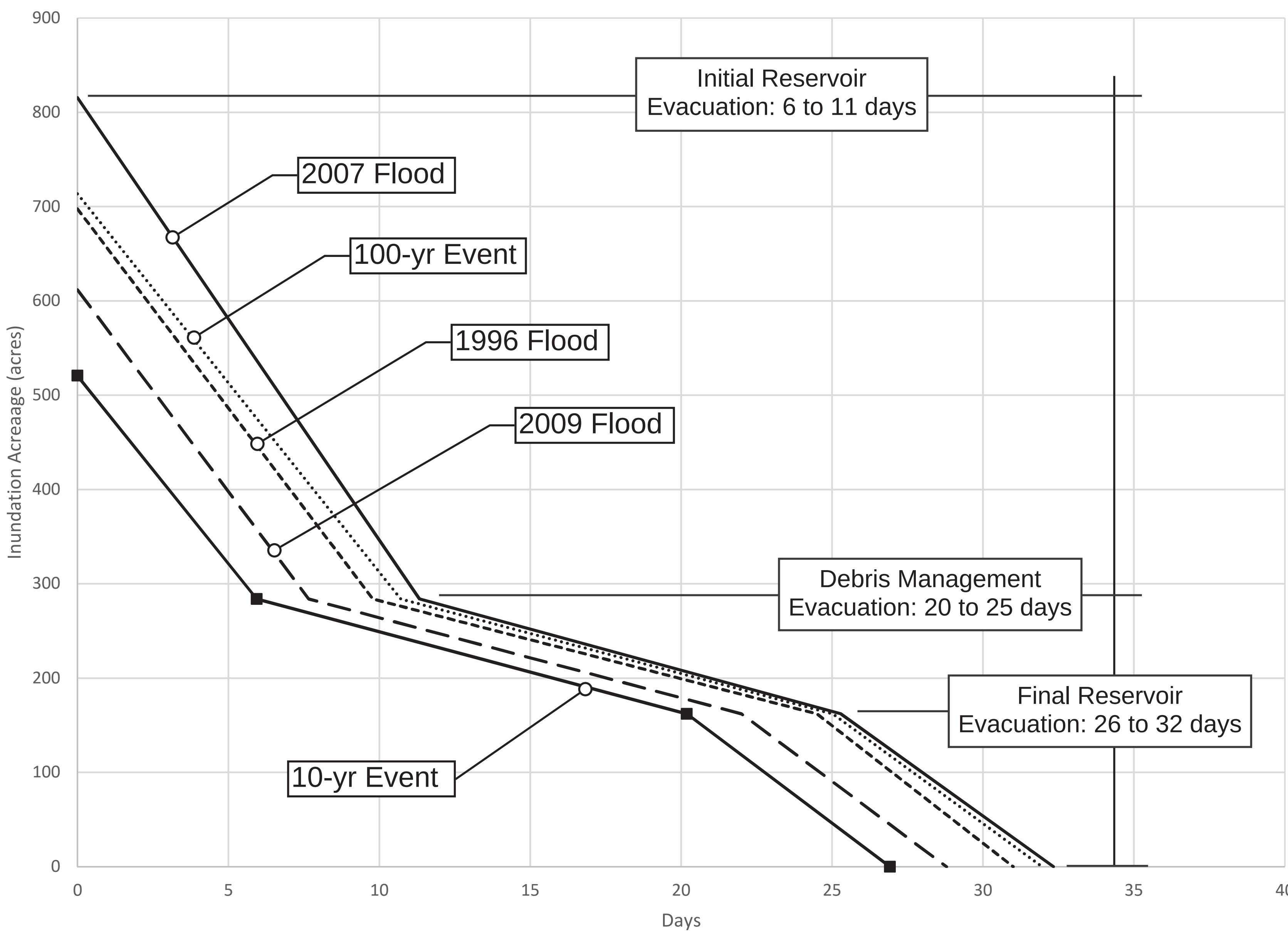
The results of the inundation mapping show that the maximum pool WSEL of the Initial Reservoir Evacuation area will range between 620 and 568 feet. The acreage of inundation above 528 feet (lower limit of the Initial Reservoir Evacuation area) will range between 238 and 527 acres, and the duration of inundation will range between 5.9 and 11.1 days. The Debris Management Evacuation area will have 122 acres of inundation between WSEL 528 and 500 feet, and will be inundated between 20.2 and 25.2 days. The Final Reservoir Evacuation area will have 159 acres of inundation between WSEL 500 and 425 feet. This area will be inundated at least 26 days under each flood event, and up to 32 days under the event of record (historic 2007 flood event).

Table 3 summarizes the range of acreage, inundation extent, and duration at each evacuation stage from the more frequent (10% chance) major flood event to the least frequent (<1% chance) major flood event. Figure 1 graphically depicts each evacuation stage for each flood event plotted as acreage of inundation over time. The standardized three-stage evacuation operations that will be implemented when the dam is activated during all major flood events provides a more accurate depiction of the duration and extent of inundation to evaluate impacts during operation of the dam. During any major flood event, nearly half of the reservoir or more will be inundated for only 6 to 11 days. Longer periods of inundation that will have greater potential effects on vegetation will commence at the Debris Management Evacuation stage.

Table 3. Inundation Zones Based on Temporary Reservoir Evacuation Stages

Temporary Reservoir Drawdown Stage	% Chance of being Flooded in a Year	Duration	WSEL Range	Total Reservoir Area
Initial Reservoir Evacuation	10%	Up to 5.9 days	568–528	238 acres
	<1%	Up to 11.1 days	620–528	527 acres
Debris Management Evacuation	10%	Up to 20.2 days	528–500	122 acres
	<1%	Up to 25.2 days	528–500	122 acres
Final Reservoir Evacuation	10%	Up to 26.9 days	500–425	159 acres
	<1%	Up to 32.3 days	500–425	159 acres

Figure 1. FRE Temporary Reservoir Inundation Acreage Over Time



4.2 Vegetation Responses to Flooding

4.2.1 General Flood Tolerance Themes

The likelihood of woody vegetation to survive a flood event is dependent on a variety of factors, including time of year, soil type, age and health of plants, frequency, duration and depth of inundation, and plant species. Flooding also causes mechanical destruction of vegetation through the direct impact of flood waters and the debris they transport, and through the erosion of substrate (Bendix 1998). It has also been noted that standing water is more harmful than moving flood water and that flood-tolerant plants are often injured by flooding in standing water (Kozlowski 1982, as cited in Kozlowski 1984).

Flooding also contributes to changes in the physical status of soil, as waterlogging causes large aggregates to break into smaller particles. As flood levels recede, the small particles are rearranged into a more dense structure, creating smaller soil-pore diameters, higher mechanical resistance to root penetration, low oxygen concentrations and the inhibition of resource use (Engelaar et al. 1993).

Flooding that occurs during the growing season is significantly more harmful to plant survival than flooding that occurs during the dormant season (Kozlowski 1984, 1997). The growing season for the project area was determined based on the period in which temperatures are above 28 degrees Fahrenheit in 5 out of 10 years using the long-term climatological data collected by the U.S. Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS) (2020a). Using the USDA NRCS Climate Analysis for Wetlands table for the nearest station (Centralia), the growing season was approximated to be typically between March 6 and November 23, or a total of 262 days.

The depth of flooding also introduces stresses to vegetation. Partially to fully submerged plants have partial to full loss of direct contact with atmospheric oxygen, which limits the ability for gas exchange to occur in leaves. Sunlight is also greatly reduced or extinguished, hampering photosynthesis (Parolin 2009). Trees that are submerged only partially during a flood event generally have greater survivability than fully submerged trees (Siebel et al. 1998; North Dakota State University 2000).

The types of soils found in the inundated area and their ability to drain or retain water also influences vegetation survival. Sandy soils drain much faster than predominantly clay-based soils, which hold water and remain wet for longer periods (Jull 2008). Soils in the study area are mapped by USDA NRCS as Winston loam (45.6%), Bunker loam (20.3%), Katula-Rock outcrop complex (10.9%), Aquic Xerofluvents (5.0%), and others (USDA NRCS 2019). In their natural state, nearly all soils found in the study area are classified as "well drained," meaning that water is removed from the soil readily but not rapidly (Soil Science Division Staff 2017).

The age and health of the plants also contribute to an individual plant's ability to survive a flood event. Young seedlings have been found to be more sensitive to flooding injury than older seedlings (Kozlowski 1997). Established, healthy trees and shrubs are also more tolerant of flooding than old, stressed, or young plants of the same species (Jull 2008).

4.2.2 Flood Tolerance of Plant Species in the FRE Temporary Reservoir

Flood-tolerant plants survive in anaerobic environments using various morphological and physiological adaptations, depending on the species and environmental conditions. Specifically, red alder exhibits adaptations that permit flood tolerance, including the formation of adventitious roots when subject to flooding (Batzli and Dawson 1997; Harrington 2006). Other studies recorded 100% survival of red alder seedlings when subjected to a 20-day flood and a 20-day recovery period (Harrington 1987).

In a controlled flooding experiment conducted by Minore in 1968, winter inundation did not significantly affect the survival or growth of western hemlock, red alder, Sitka spruce, lodgepole pine, or western redcedar, but even 1 week of winter inundation was detrimental to Douglas fir. In the same experiment, summer flooding survival rates for both western redcedar and lodgepole pine were significantly better than Douglas fir after 4 weeks of summer flooding. Minore (1968) concluded that short periods of winter flooding will likely not injure western hemlock, red alder, Sitka spruce, lodgepole pine, or western redcedar seedlings, but found that Douglas fir seedlings are very intolerant of flooding. It was also found that photosynthesis and transpiration of Douglas fir have been shown to decrease within 4 to 5 hours after flooding, indicating rapid stomatal closure (Zaerr 1983, as cited in Kozlowski and Pallardy 2002).

Based on a comprehensive literature review, existing vegetation species commonly found in the project area were sorted into three categories of anticipated flood tolerance:

- Low: 1–7 days of inundation
- Moderate: 8–14 days of inundation
- Medium-High: 6–30 days of inundation
- High: 15–30+ days of inundation

Table 4 summarizes the relative flood tolerance of common native woody plants found in the project area. Species with low anticipated flood tolerance, including Douglas fir, are likely to exhibit signs of flood stress after only a few days. Signs of flood stress in plants includes yellowing or browning of leaves, curled leaves, leaf wilt and drop, reduced size of new leaves, early fall color, branch dieback, formation of sprouts along stems or trunk, and gradual decline and death (Jull 2008). Stressed trees are also more susceptible to secondary organisms such as canker fungi and insects that bore into phloem and wood (Jull 2008).

Table 4. Relative Flood Tolerance of Common Native Woody Plants in the FRE Temporary Reservoir

Common Name	Scientific Name	Tilley et al. 2012	Walters et al. 1980	Withrow-Robinson et al. 2011	Whitlow and Harris 1979	Wenger 1984	USDA PLANTS Database[a]	Miscellaneous Sources
Red-osier dogwood	*Cornus alba*	High (10–30+ days)	Very tolerant (2+ growing seasons)	High tolerance	Very tolerant (>1 year)	N/A	High	N/A
Narrow leaf willow	*Salix exigua*	Medium-high (6-–30 days)	Very tolerant (all willows; 2+ growing seasons)	High tolerance (all willows)	Very tolerant (>1 year)	Moderately tolerant	High	94.9 days of maximum flooding at elevations where species was most common[b]
Hooker's willow	*Salix hookeriana*	N/A	Very tolerant (all willows; 2+ growing seasons)	High tolerance (all willows)	Very tolerant (>1 year)	Moderately tolerant	High	N/A
Pacific willow	*Salix lasiandra*	Medium-high (6–30 days)	Very tolerant (all willows; 2+ growing seasons)	High tolerance (all willows)	Very tolerant (>1 year)	Moderately tolerant	High	146.3 days of maximum flooding at elevations where species was most common[b]
Lodgepole pine	*Pinus contorta*	N/A	Intermediately tolerant (1–3 months during growing season)	N/A	Tolerant (1 growing season)	Moderately tolerant	Low	100% survival of seedlings inundated 1–4 weeks in winter; 100% survival after 4 weeks in summer; 50% survival after 8 weeks in summer;[c] tolerated submergence for 14 days[d]
Black cottonwood	*Populus balsamifera ssp. Trichocarpa*	Medium (6–10 days)	Tolerant (most of 1 growing season)	High tolerance	Tolerant (1 growing season)	Moderately tolerant	Medium	100% survival but varied growth response after 20-day flooding and 20-day recovery period[e]
Red elderberry	*Sambucus racemosa*	Medium (6–10 days)	N/A	High tolerance	Tolerant (1 growing season)	N/A	N/A	N/A
Hardhack	*Spiraea douglasii*	N/A	N/A	High tolerance	Tolerant (1 growing season)	N/A	High	Suffered no obvious injury after being inundated and covered in fine layer of silt during flood event[f]

Common Name	Scientific Name	Tilley et al. 2012	Walters et al. 1980	Withrow-Robinson et al. 2011	Whitlow and Harris 1979	Wenger 1984	USDA PLANTS Database[a]	Miscellaneous Sources
Western red cedar	*Thuja plicata*	N/A	Tolerant (most of 1 growing season)	High tolerance	Tolerant (1 growing season)	Weakly tolerant	N/A	100% survival of seedlings inundated 1–4 weeks in winter and 4 and 8 weeks in summer[c]
Sitka spruce	*Picea sitchensis*	N/A	Tolerant (most of 1 growing season)	N/A	Slightly tolerant (30 days)	Weakly tolerant	Low	100% survival of seedlings inundated 1–4 weeks in winter; 84% survival after 4 weeks in summer; 34% after 8 weeks in summer;[c] actively growing seedlings were alive after 22 days of root flooding[g]
Ponderosa pine	*Pinus ponderosa*	N/A	Intermediately tolerant (1–3 months during growing season)	Medium tolerance	Slightly tolerant (30 days)	Intolerant	N/A	N/A
Western hemlock	*Tsuga heterophylla*	N/A	Tolerant (most of 1 growing season)	N/A	Slightly tolerant (30 days)	Weakly tolerant	N/A	100% seedling survival after 1–4 weeks inundation in winter; 34% survival after 4 weeks in summer; 16% survival after 8 weeks in summer[c]
Big leaf maple	*Acer macrophyllum*	N/A	Intermediately tolerant (1–3 months during growing season)	Medium tolerance	Intolerant (no more than a few days)	Weakly tolerant	Medium	In repeated flood events in British Columbia, Canada, some maples succumbed, particularly if they were growing very actively[f]
Vine maple	*Acer circinatum*	N/A	Tolerant (most of 1 growing season)	Low tolerance	N/A	N/A	N/A	N/A
Red alder	*Alnus rubra*	Medium (6–10 days)	Very tolerant (2+ growing seasons)	High tolerance	Intolerant (no more than a few days)	Moderately tolerant	Low	Recovered after 50-day flood and 20-day recovery;[h] 100% seedling survival but varied growth response after 20-day flood and 20-day

Common Name	Scientific Name	Tilley et al. 2012	Walters et al. 1980	Withrow-Robinson et al. 2011	Whitlow and Harris 1979	Wenger 1984	USDA PLANTS Database[a]	Miscellaneous Sources
								recovery;[e] 100% seedling survival after 1–4 weeks in winter; 50% survival after 4 weeks in summer; 65% survival after 8 weeks in summer;[c] static flooding killed 2-year-old saplings after 4–6 days of flooding when water was above soil surface;[i] suffered "markedly" in flooded lowland forest after inundation; died in large numbers and regarded as one of the trees most susceptible to damage by flooding[f]
Indian plum	*Oemleria cerasiformis*	N/A	N/A	Low to Medium	N/A	N/A	Medium	N/A
Snowberry	*Symphoricarpos albus*	Medium (6–10 days)	Intermediately tolerant (1–3 months during growing season)	Medium tolerance	N/A	N/A	N/A	N/A
Thimbleberry	*Rubus parviflorus*	N/A	N/A	Low tolerance	N/A	N/A	Low	N/A
Salmonberry	*Rubus spectabilis*	N/A	N/A	High tolerance	N/A	N/A	Medium	N/A
Mock orange	*Philadelphus L.*	Unknown	N/A	Medium tolerance	Intolerant (no more than a few days)	N/A	N/A	N/A
Bitter cherry	*Prunus emarginata*	N/A	Intermediately tolerant (1–3 months during growing season)	N/A	Intolerant (no more than a few days)	N/A	N/A	N/A

Common Name	Scientific Name	Tilley et al. 2012	Walters et al. 1980	Withrow-Robinson et al. 2011	Whitlow and Harris 1979	Wenger 1984	USDA PLANTS Database[a]	Miscellaneous Sources
Douglas fir	*Pseudotsuga menziesii*	N/A	N/A	Low tolerance	Intolerant (no more than a few days)	Intolerant	Low	Winter flooding for 1–4 weeks causes severe injury; 0% seedling survival after 4 or 8 weeks during summer;[c] tolerated submergence for 14 days[d]
Cascara	*Frangula purshiana*	N/A	N/A	Medium tolerance	Intolerant (no more than a few days)	N/A	N/A	N/A
Oregon ash	*Fraxinus latifolia*	N/A	Tolerant (most of 1 growing season)	High tolerance	N/A	Weakly tolerant	High	Static flooding killed 2-year-old saplings after 4–6 days of flooding when water was above soil surface[i]

[a]USDA NRCS 2020b.

[b]Wakefield 1966, as cited in Whitlow and Harris 1979. Looks at days of average maximum flooding at elevations where species was found to be most common.

[c]Minore 1968.

[d]McCaughey and Weaver 1991.

[e]Harrington 1987.

[f]Brink 1954.

[g]Coutts 1981, as cited in McCaughey and Weaver 1991.

[h]Batzli and Dawson 1997.

[i]Ewing 1996.

4.3 Inundation Effects in FRE Temporary Reservoir and Proposed Pre-Construction Tree Harvest Rationale

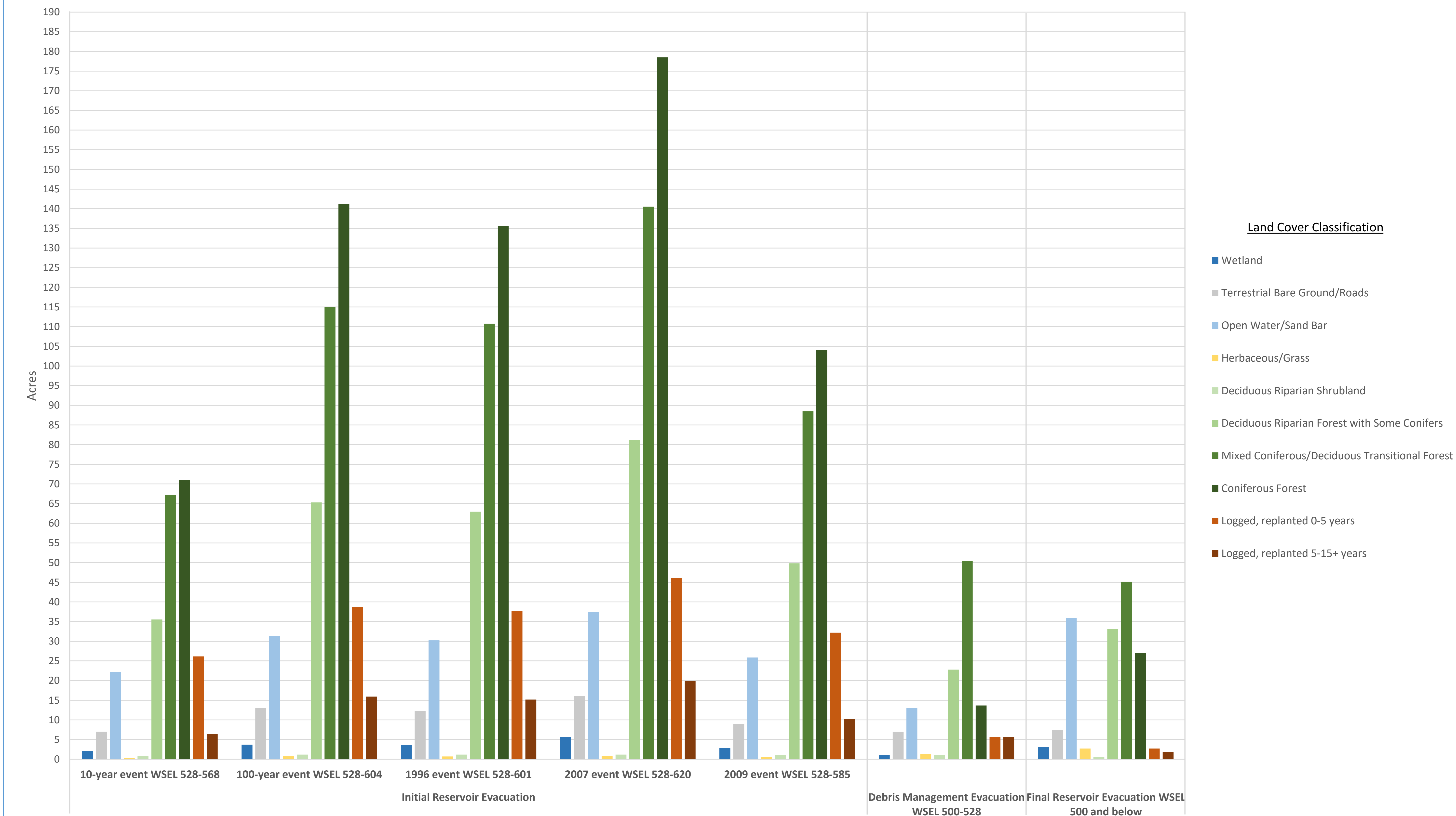
Figure 2 shows land cover acreage mapped within the project area at each evacuation stage. An existing land cover map of the study area is presented in Appendix A.

The Initial Reservoir Evacuation area consists mainly of Coniferous Forest, dominated by Douglas fir, and Mixed Coniferous/Deciduous Transitional Forest, dominated by Douglas fir, red alder, and big leaf maple. The Initial Reservoir Evacuation area would be inundated between 6 to 11 days during a flood event and some trees could be partially submerged, depending on the severity of the flood. As such, species with low anticipated flood tolerance (e.g., Douglas fir) would likely exhibit signs of flood stress and some mortality in the Initial Reservoir Evacuation area. These trees should be monitored and removed if they exhibit significant injury or mortality during facility operations. Species with moderate flood tolerance are not expected to experience significant mortality in the Initial Reservoir Evacuation area, but should be monitored for signs of flood stress after periods of prolonged inundation. Monitoring methods are described in more detail in Section 5.2.1.

The Debris Management Evacuation area consists primarily of Mixed Coniferous/Deciduous Transitional Forest, dominated by Douglas fir, red alder, and big leaf maple, and Deciduous Riparian Forest with Some Conifers, including species such as red alder, Western red cedar, Western hemlock, black cottonwood, willows, and big leaf maple. The Debris Management Evacuation area would be inundated between 20 and 25.2 days, and most trees throughout this area would be partially or fully submerged for the duration of this time. Submergence introduces additional novel stresses to trees, decreasing their likelihood of survival. Therefore, all tree species that are not highly tolerant of flooding—all species except for willows and black cottonwood—would need to be removed throughout the area.

The Final Reservoir Evacuation area consists mainly of Deciduous Riparian Forest with Some Conifers, Mixed Coniferous/Deciduous Transitional Forest, and Open Water land cover classifications. The Final Reservoir Evacuation area would be inundated between 26 and 32 days and trees in this zone would be fully submerged. It is highly unlikely that any trees would be able to survive in this area after prolonged inundation and full submergence. Therefore, all trees in this area would need to be removed.

Figure 2. Land Cover Acreage by Drawdown Stage



5.0 Pre-Construction and Facility Operations Selective Tree Harvest Plan

Selective tree harvest within the reservoir footprint during pre-construction and facility operations would be subject to Forest Practices Act Rules administered by the Washington Department of Natural Resources (WDNR) through the Forest Practices Application.

The Project would likely require deviations from the methods and requirements prescribed in the Forest Practices Act Rules. Through the use of alternate plans, applicants are permitted to develop management prescriptions that will achieve resource protection through alternative methods from the Forest Practices Act. The alternate plan policy for WDNR is outlined in WAC 222-12-040 and also discussed in the Forest Board Practices Manual Section 21 (WDNR 2013). To be approved, alternate plans must provide protection for public resources at least equal in overall effectiveness to the protection provided by the Forest Practices Act and rules (WAC 222-12-040(1)). Alternate plans should be submitted with the Forest Practices Application and must include a site map showing affected resources and proposed management activities. The plan must also include descriptions of current site conditions and proposed management activities, a list of the Forest Practices Act Rules that the alternate plan is intended to replace, and, if applicable, a monitoring and adaptive management plan and corresponding implementation schedule.

The selective tree harvest plan below describes the conceptual approach for selective tree harvest, and an overview of Forest Practices Act Rules that will need to be considered in development of the Alternate Plan for acquisition of a Forest Practices Permit.

5.1 Pre-Construction Selective Tree Harvest Plan

The proposed Project would require clearing of all vegetation from the proposed FRE facility and construction access and staging areas. As discussed in Section 4.3, most trees in the Debris Management Evacuation and Final Reservoir Evacuation areas of the temporary reservoir would experience significant stress or mortality resulting from prolonged inundation during a flood event. Dead or dying trees and woody debris pose a hazard to dam operations personnel and could potentially damage dam facilities (e.g., intake structure, flood gates). Due to these safety and logistical concerns, the FCZD proposes to selectively harvest trees from the Debris Management Evacuation area and harvest all trees from the Final Reservoir Evacuation area (Figure 3). This Pre-Construction Selective Tree Harvest Plan provides methods to identify trees within different inundation areas that will need to be targeted for removal prior to commencement of facility operations. The plan also outlines options for tree removal using guidance from the WDNR Forest Practices Board Manual and the Washington State Forest Practices Rules (Title 222 WAC).

The FCZD commits to the avoidance of burning of trees and other cleared vegetation at the FRE facility site, along routes of new roads, and within the FRE temporary reservoir area. To the extent practical, harvested trees would be used in the construction of mitigation measures or released downstream to resupply woody material to maintain natural aquatic habitats. Any surplus material would be sold.

Additional best management practices (BMPs) to avoid and minimize impacts on threatened and endangered species during vegetation management activities are in the *DRAFT Biological Assessment and Essential Fish Habitat Assessment – Chehalis River Basin Flood Damage Reduction Project: Flood Retention Facility, Airport Levee Improvements, and Mitigation Actions* (HDR 2020).

5.1.1 Tree Removal Methods and Guidelines

Trees and other vegetation would be completely cleared from the FRE facility site footprint and construction areas. In the Initial Reservoir Evacuation area, where inundation is expected to last between 6 to 11 days during a flood event, selective tree harvest is not proposed to occur prior to construction of the FRE facility. Species with low flood tolerance, such as Douglas fir, should be monitored and removed if they exhibit significant injury or mortality during facility operations, as outlined in the Facility Operations Selective Tree Harvest Plan below.

Selective tree harvest in the Debris Management Evacuation area would need to target all tree species that are not highly flood-tolerant (i.e., all tree species except for willows and black cottonwood). All trees in the Final Reservoir Evacuation area would need to be removed. Project pre-construction and facility operations tree harvest would require a Forest Practices Permit from WDNR under the Forest Practices Act; therefore, the selective tree harvest plans would need to comply, to the extent practical, with applicable timber harvest requirements outlined in the WDNR Forest Practices Board Manual and the Washington State Forest Practices Rules (Title 222 WAC).

5.1.1.1 Washington State Forest Practices Rules

5.1.1.1.1 Riparian Management Zones

The Forest Practices Rules designate a Riparian Management Zone (RMZ) on each side of a stream that to retain riparian function after timber harvest. In Western Washington, the RMZ is measured horizontally from the outer edge of the bankfull width or the outer edge of the Channel Migration Zone (CMZ), whichever is greater (WAC 222-16-010). The width of the RMZ is based on the “site-potential tree height” of a typical tree at age 100 and stream size (i.e., bankfull width) (Washington Forest Protection Association 2004). Site-potential tree height is derived by WDNR’s site classes, which refer to the growing conditions of the soil as described by the USDA NRCS (2019), and is a measure of the forest site productivity or growth potential of the forest.

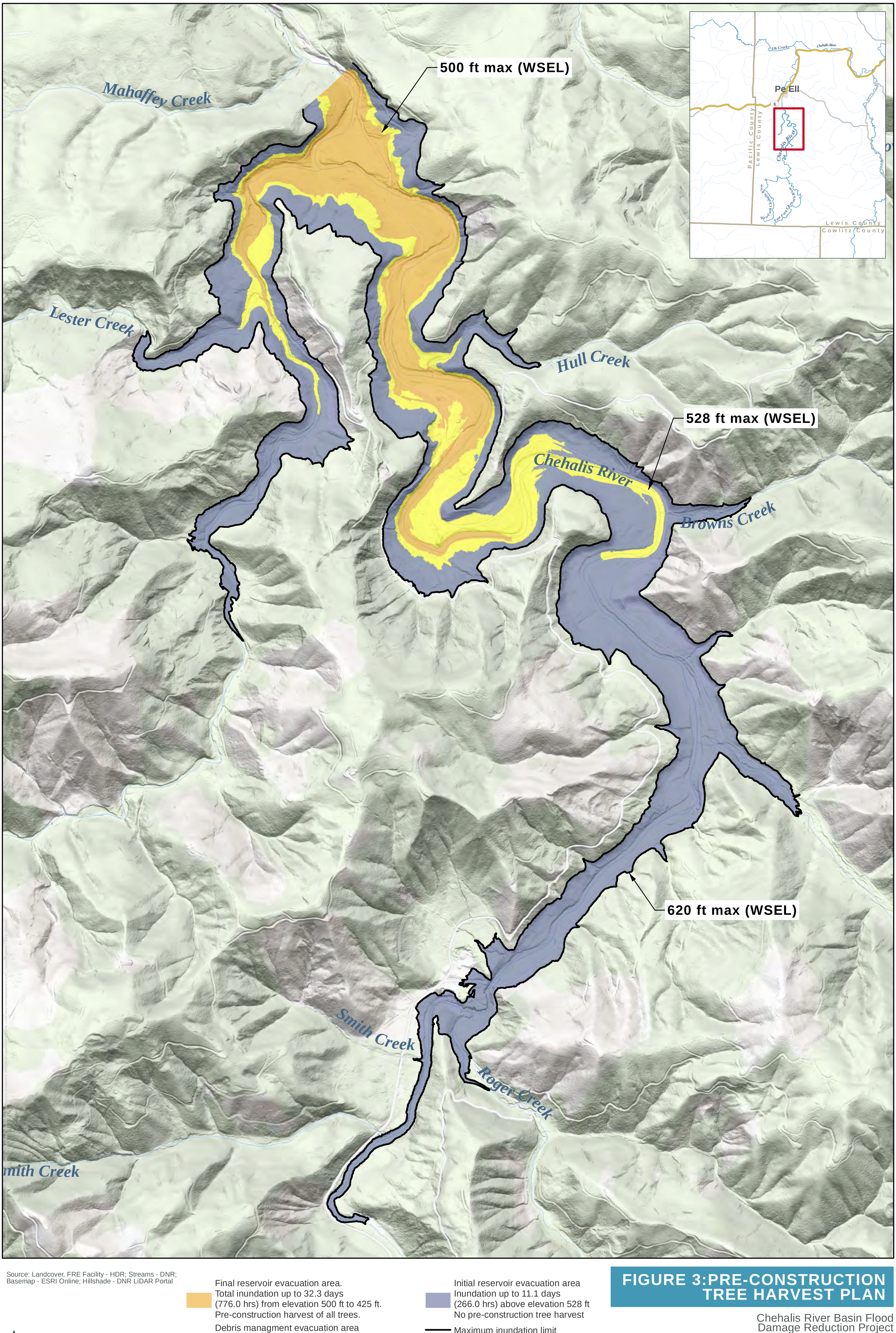


FIGURE 3: PRE-CONSTRUCTION TREE HARVEST PLAN

Chehalis River Basin Flood Damage Reduction Project

Date: 10/2/2020

Review of WDNR Site Class GIS Data (WDNR 2018) determined that the site class along the Chehalis River is primarily Site Class II, with some areas of Site Classes III and IV at higher elevations and along tributaries such as Crim Creek and Rogers Creek. Based on this assessment, the RMZ along the Chehalis River is generally 170 feet wide in areas categorized as Site Class II, with a width of 140 feet and 110 feet in areas of Site Classes III and IV, respectively (Table 5).

The RMZ is comprised of three different zones: the core zone, inner zone, and outer zone, defined below per WAC 222-16-010:

- In Western Washington, the **RMZ core zone** is defined as the 50-foot buffer of a Type S or F water, measured horizontally from the outer edge of the bankfull width or the outer edge of the channel migration zone, whichever is greater.
- In Western Washington, the **RMZ inner zone** is the area measured horizontally from the outer boundary of the core zone of a Type S or F water to the outer limit of the inner zone. The outer limit of the inner zone is determined based on the width of the affected water, site class, and management option chosen for timber harvest within the inner zone.
- The **RMZ outer zone** is the area measured horizontally between the outer boundary of the inner zone and the RMZ width, measured from the outer edge of the bankfull width or the outer edge of the channel migration zone, whichever is greater.

No timber harvest or construction is allowed in the 50-foot core zone except operations related to forest roads as detailed in WAC 222-30-021(1).

Forest practices in the inner zone must be conducted in such a way as to meet or exceed stand requirements to achieve the goal outlined in WAC 222-30-010(2), which seeks to “protect aquatic resources and related habitat to achieve restoration of riparian function; and the maintenance of these resources once they are restored.” To harvest in the inner zone, adequate shade must be present based on the guidelines outlined in WAC 222-30-040. Furthermore, harvest is permitted within the inner zone of an RMZ adjacent to a Type S or F[1] water in Western Washington only if the timber stand exceeds the “stand requirements” described in WAC 222-30-021(1). To determine inner zone harvest opportunity, detailed tree data must be entered into the WDNR Desired Future Condition Worksheet (WDNR 2009) for each stream segment within the reservoir footprint. If inner zone harvest is permitted, trees can be harvested using one of two options: thinning from below or leaving trees closest to the water.

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[1] Type S waters means all waters, within their bankfull width, that are inventoried as "shorelines of the state" under chapter 90.58 RCW. The segments of the Chehalis River, Crim Creek, and Rogers Creek that occur in the Project area are designated as Type S waters. Type F waters means segments of natural waters other than Type S Waters that are known to be used by fish, or meet the physical criteria to be potentially used by fish per WAC 222-16-030. For the purposes of this Conceptual VMP, it is assumed that all waters within the temporary reservoir area are Type S or Type F waters. Stream typing will be refined and confirmed with WDNR and WDFW during the permitting phase of the Project.

For the purposes of this VMP, the option to thin from below will be used as feasible, as this option reduces the amount of woody debris that could come loose and damage dam facilities following prolonged inundation, starting with smaller-diameter trees. Under this option, thinning must retain a minimum of 57 conifer trees per acre. Since the Chehalis River is more than 10 feet wide, the inner zone varies from 33 to 78 feet wide, depending on site class (WAC 222-30-021(I); Table 5).

Using the option of thinning from below in the inner zone, the outer zone width will vary depending on stream width and site class, outlined in Table 5. Timber harvest in the outer zone must leave 20 conifer riparian-leave trees per acre after harvest, either dispersed or clumped. Riparian-leave trees must be at least 12 inches diameter at breast height (dbh) and must be left uncut throughout all future harvests (WAC 222-30-021(1)(c)).

Table 5. Riparian Management Zone (RMZ) Widths in the Project Area[a]

Site Class[b]	RMZ Width	Core Zone Width[c]	Inner Zone Width[d]		Outer Zone Width[e]	
			Stream bankfull width ≤ 10 feet	Stream bankfull width > 10 feet	Stream bankfull width ≤ 10 feet	Stream bankfull width > 10 feet
II	170 feet	50 feet	63 feet	78 feet	57 feet	42 feet
III	140 feet	50 feet	43 feet	55 feet	47 feet	35 feet
IV	110 feet	50 feet	23 feet	33 feet	37 feet	27 feet
V	90 feet	50 feet	10 feet	18 feet	30 feet	22 feet

[a] RMZ widths from WAC 222-30-021(1)(b)(ii)(B)(1). For the purposes of this Conceptual VMP, the following are assumed: (1) all waters within the temporary reservoir area are Type S or Type F waters and (2) thinning from below in the inner zone is the treatment for tree harvest that will be required within the 50-foot core zone. Stream typing will be refined and confirmed with WDNR and WDFW during the permitting phase of the Project.

[b] Site Class I not present in project study area.

[c] Core zone measured from outer edge of bankfull width or outer edge of CMZ of water (WAC 222-16-010).

[d] Inner zone measured from outer edge of core zone to the outer limit of the inner zone.

[e] Outer zone measured from outer edge of inner zone to outer limit of the RMZ.

5.1.1.1.2 Wetland Management Zone

Selective tree harvest occurring near wetlands is also subject to wetland management zone (WMZ) requirements outlined in WAC 222-30-020 and WAC 222-16-035. The width of the WMZ is determined based on the size of the wetland and the wetland type, as described in WAC 222-30-020. Under the Washington State Forest Practices Rules, wetlands that require protection are categorized as Type A (nonforested), Type B (nonforested), or Forested Wetlands, defined below per WAC 222-16-035:

- **Nonforested wetlands** means any wetland or portion thereof that has, or if the trees were mature would have, a crown closure of less than 30%.
    - **Type A Wetland** classification applies to all nonforested wetlands that are greater than 0.5 acre in size, including acreage of open water where the water is completely surrounded by

the wetland; and are associated with at least 0.5 acre of ponded or standing open water. The open water must be present on the site for at least 7 consecutive days between April 1 and October 1 to be considered for the purposes of these rules.

  - **Type B Wetland** classification applies to all other nonforested wetlands greater than 0.25 acre.

- **Forested wetland** means any wetland or portion thereof that has, or if the trees were mature would have, a crown closure of 30% or more.

WMZ protection applies to Type A and Type B wetlands, and is measured horizontally from the wetland edge or the point where a nonforested wetland becomes a forested wetland (WAC 222-30-020(8)). The WMZ width for Type A wetlands ranges from 25 to 200 feet, depending on wetland size and if the wetland meets the definition of a bog. For Type B wetlands with more than 0.5 acre of nonforested wetland, the WMZ width ranges from 25 to 100 feet; no WMZ is required for Type B wetlands with less than 0.5 acre of nonforested wetland (WAC 222-30-020). No WMZ is required for forested wetlands; however, unless otherwise approved in writing by WDNR, harvest methods shall be limited to low-impact harvest or cable systems (WAC 222-30-020(7)).

In Western Washington, a total of 75 trees greater than 6 inches dbh must be left per acre of WMZ (WAC 222-30-020(8)(b)). Of these, 25 trees must be greater than 12 inches dbh and 5 must be greater than 20 inches dbh. Furthermore, ground-based equipment cannot be used within the minimum WMZ without written permission from WDNR (WAC 222-30-020(8)(e)). In areas where WMZ and RMZ protections overlap, the one providing the most protection to the resource shall be used (WAC 222-30-020(8)).

5.1.1.1.3 Other Considerations for Tree Removal

The Forest Practices Rules stipulate that no harvest or construction is permitted within the boundaries of a channel migration zone or within the bankfull width of any Type S or F water (WAC 222-30-020). There are also minimum shade requirements to prevent excessive increases in water temperature within a proposed harvest area. Shade requirements outlined in WAC 222-30-040 must be met regardless of harvest opportunities provided in the inner zone RMZ rules (WDNR 2000; WAC 222-30-021). Based on regional water temperature characteristics and the elevation of the Chehalis River and the tributaries where selective tree harvest is proposed, a minimum of 75% tree canopy cover is required after harvest (WDNR 2000, 2019; WAC 222-30-040(2)).

Landowners are also required to leave a minimum number and size of trees and down logs to provide current and future wildlife habitat within the harvest area. In Western Washington, for each acre of timber harvested, three wildlife reserve trees, two green recruitment trees, and two down logs must be left after harvest (Table 6; WAC 222-30-020(12)(b)). Wildlife reserve trees are defined as defective, dead, damaged, or dying trees that provide or have the potential to provide habitat for those wildlife species dependent on standing trees (WAC 222-16-010). Green recruitment trees are trees left after harvest for the purpose of becoming future wildlife reserve trees under WAC 222-30-020(12).

As outlined in Table 6, wildlife reserve trees must be at least 10 feet in height and 12 or more inches dbh to be counted toward wildlife reserve tree retention requirements (WAC 222-30-020(12)(c)). Green recruitment trees must be at least 10 inches dbh and 30 feet in height, with at least one-third of their height in live crown to be counted toward green recruitment tree requirements (WAC 222-30-020(12)(c)). Large, live defective trees with broken tops, cavities, or other severe defects are preferred as green recruitment trees. Down logs must have a small end diameter greater than or equal to 12 inches and a length greater than or equal to 20 feet or equivalent volume to be counted.

Table 6. Requirements for Retaining Leave Trees and Down Logs in Western Washington

Wildlife Tree Type	Number per acre	Minimum Height	Minimum Diameter
Wildlife Reserve Tree	3	10 feet	12 inches dbh
Down Log	2	20 feet	12 inches dbh at small end
Green Recruitment	2	30 feet with 1/3 live crown	10 inches dbh

Source: WAC 222-30-020(12).

To facilitate safe and efficient harvesting operations, wildlife reserve trees and green recruitment trees may be left in clumps. For the purposes of distribution, no point within the harvest unit shall be more than 800 feet from a wildlife reserve tree or green recruitment tree retention area (WAC 222-30-020(12)(e)).

5.1.2 Pre-Construction Vegetation Removal Goals and Objectives

The following goals and objectives for pre-construction vegetation removal have been established to minimize impacts on environmental resources in the Project area while meeting the safety and operational needs of the FRE facility.

5.1.2.1 Goal 1: Reduce potential for future damage to dam facilities and ensure safety of dam operations personnel.

Objective: Completely clear woody vegetation from the dam site and from any areas where temporary construction and associated access and staging will be required.

Objective: Remove vegetation that could pose a hazard to dam operations personnel, especially those responsible for wood material collection and transport.

Objective: Avoid burning of all cleared vegetation.

5.1.2.2 Goal 2: Harvest marketable timber in areas where projected inundation depths and durations would be expected to kill tree species that do not tolerate extended flooding or submersion.

Objective: Coordinate with landowners and WDNR to allow for removal of trees within RMZs along the Chehalis River and tributaries in the reservoir footprint.

Objective: Remove all tree species that are not highly flood-tolerant (all tree species except for willows and black cottonwood) in the Debris Management Evacuation area (Figure 3).

Clearly mark highly flood-tolerant trees that are designated to be retained.

Objective: Remove all trees in the Final Reservoir Evacuation area.

Objective: Avoid disturbing understory upland vegetation.

Objective: Harvest trees so as to retain stumps in order to minimize ground disturbance and potential sedimentation.

Objective: Avoid burning of all removed trees.

5.1.2.3 Goal 3: Harvest timber in a manner to avoid and minimize impacts to aquatic and riparian functions along the Chehalis River and its tributaries in the reservoir footprint.

Objective: Apply applicable BMPs as described in WAC 222-30-030 through 222-30-090 to all waterbodies and riparian management zones. Key BMPs include, but are not limited to:

(1) Avoid disturbing understory riparian vegetation.

(2) Avoid disturbing stumps and root systems and any logs embedded in the bank.

(3) Leave high stumps where necessary to prevent felled and bucked timber from entering the water.

(4) Leave any retained trees that display large root systems embedded in the bank.

(5) Use reasonable care during timber yarding to minimize damage to the vegetation providing shade to the stream or open water areas and to minimize disturbance to understory vegetation, stumps, and root systems.

(6) Minimize the release of sediment to waters downstream from the yarding activity.

5.1.2.4 Goal 4: Harvest timber in a manner to avoid and minimize impacts to wetland functions in the temporary reservoir footprint to the extent practical.

Objective: Apply applicable BMPs as described in WAC 222-30-030 through 222-30-090 to all wetlands and wetland management zones. Key BMPs include, but are not limited to:

(1) Avoid disturbing understory wetland vegetation.

(2) Avoid cable yarding timber in or across Type A or B wetlands except with approval by the WDNR.

(3) Minimize the release of sediment to waters downstream from the yarding activity.

5.1.2.5 Goal 5: Minimize temporal loss of tree canopy in the temporary reservoir footprint.

Objective: 20% of the proposed selective tree harvest would occur each construction year over the five-year construction period. Selective tree harvest would be sequenced such that trees within the Riparian Management Zones of the Chehalis River and its tributaries (Figure 4) are harvested last.

Objective: Replace trees removed each construction year at a 1:1 ratio with tree saplings. Replaced trees will be planted during the planting season (October-March) immediately following tree harvest. Tree species selection will be based on the reservoir evacuation area where replanting is needed (Table 7 in Section 6.4.2.1).

5.2 Facility Operations Selective Tree Harvest Plan

5.2.1 Monitoring Methods

During facility operations, trees in the temporary reservoir area would be monitored for significant stress and mortality in areas where selective harvest was not conducted prior to construction. Flood stress in plants can cause yellowing or browning of leaves, curled leaves, leaf wilt and drop, reduced size of new leaves, early fall color, branch dieback, the formation of sprouts along stems or trunk, and greater susceptibility to harmful organisms such as canker fungi and insects (Jull 2008). There would be uncertainty in predicting an elevation at which trees would likely be severely stressed or killed once the FRE facility is activated during major flood events. The uncertainty is due in part to the unpredictable nature of flood events and in part to the difficulty in predicting how individual trees will respond to inundation.

Trees in the FRE temporary reservoir should be monitored by a forester or other WDNR-approved professional annually and after periods of prolonged inundation for signs of flood stress. Unhealthy and dead trees should be marked and removed on an as-needed basis to eliminate potential risks to dam operations personnel and facility infrastructure. Monitoring efforts should also evaluate the reestablishment of tree species in areas where selective harvest was conducted prior to construction (i.e., Debris Management Evacuation and Final Reservoir Evacuation areas).

Since a small portion of trees must be left in place in the Debris Management Evacuation and Final Reservoir Evacuation areas to comply with Forest Practices Rules, it is anticipated that a number of these trees will experience significant stress and mortality. Leave trees in the RMZ and WMZ and those selected to serve as wildlife habitat should be identified and evaluated annually and after periods of prolonged inundation. These trees should be removed if they become a safety hazard or pose a risk of damage to dam facilities.

5.2.2 Facility Operations Selective Tree Harvest Plan

The FCZD proposes that every 7 to 10 years, trees that are not highly tolerant of flooding (all tree species except for willows and black cottonwood) larger than 6 inches in diameter within the Debris Management Evacuation area and all trees in the Final Reservoir Evacuation area be removed to reduce accumulation of woody material at the FRE conduits. Tree harvest conducted during facility operations would be subject to the Forest Practices Rules outlined in Section 5.1.1.1, and would adhere to pre-construction vegetation removal Goals and Objectives described in Section 5.1.2.

6.0 Conceptual Adaptive Management Plan

6.1 Overview

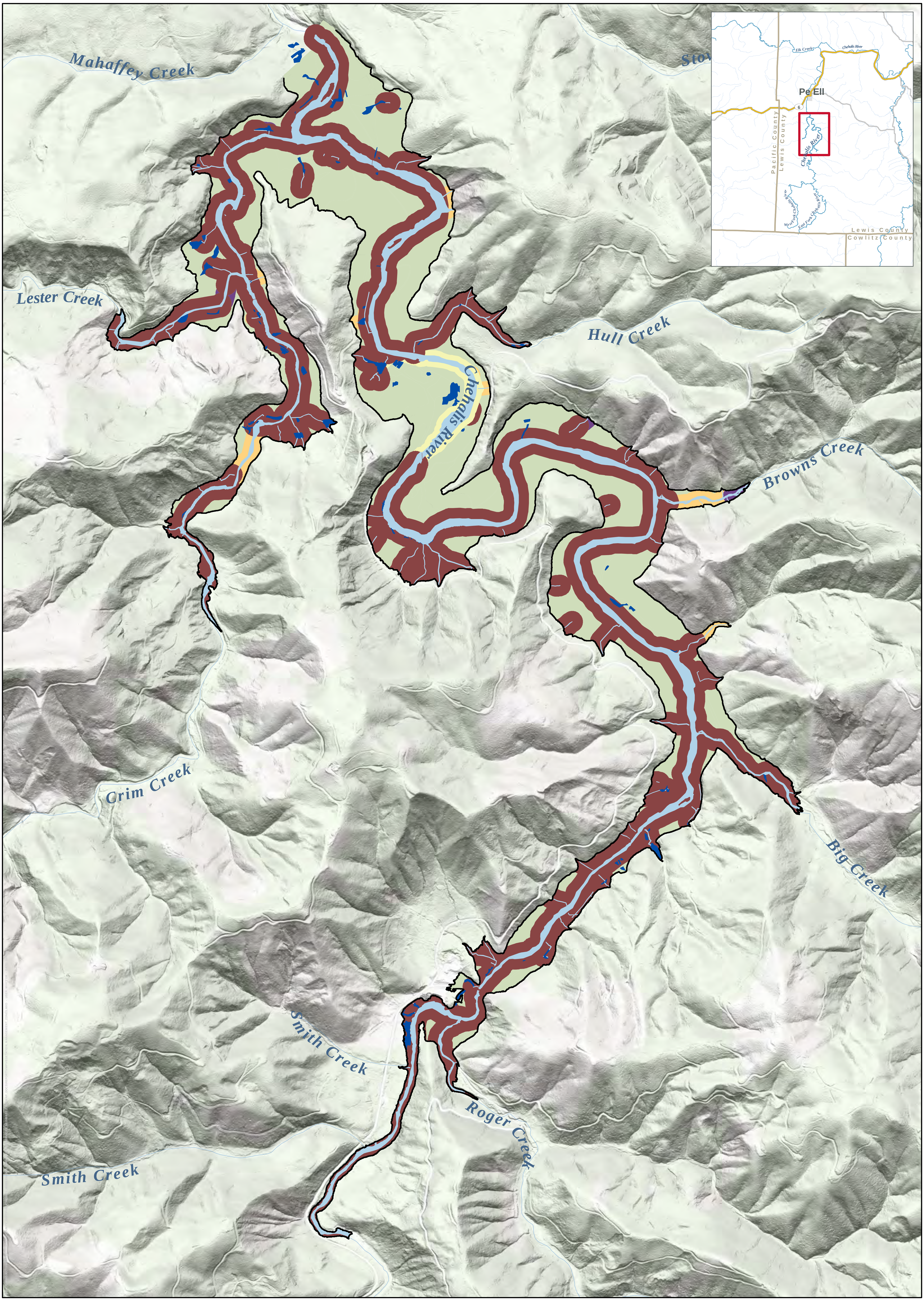
As described in Chapter 5, the FCZD anticipates that an Alternate Plan will need to be developed with an Interdisciplinary Team in order to acquire a Forest Practices Permit from WDNR since tree harvest activities during pre-construction and facility operation would likely vary from prescribed Forest Practices Rules. Therefore, the framework of the adaptive management plan focuses primarily on criteria that would be required for an Alternate Plan.

This adaptive management plan addresses how uncertainties regarding the frequency, duration, and intensity of future flood events and resulting impacts to vegetation will be considered in order to inform the management of vegetation in the reservoir footprint. For the purposes of this plan, "adaptive management" refers to actions taken as part of the project to:

- Establish long-term ecological goals and objectives to avoid and minimize long-term impacts to riparian, wetland, and upland habitats;
- Identify uncertainties associated with future flood events and potential impacts to vegetation in the temporary reservoir footprint;
- Identify potential problems, possible solutions, and site management adjustments to rectify foreseeable issues based on results of long-term monitoring;
- Provide contingency plans if needed for proposed vegetation management; and
- Serve as part of the feedback loop between vegetation monitoring and management actions that will lead to appropriate adjustment.

Figure 4 delineates proposed zones for which pre-construction monitoring, adaptive management goals and objectives, and replanting treatments will be applied:

- Riparian Vegetation Management Zone (RMZ): these zones are established based on the RMZ widths outlined in Section 5.1.1.1. The RMZ's would encompass approximately 16.3 river miles of streams and 444 acres of adjoining riparian lands.
- Wetland Vegetation Management Zone: these zones are established based on wetlands identified and delineated by Anchor QEA (2018).
- Upland Vegetation Management Zone: remaining lands within the FRE temporary reservoir extent that are not wetlands, waterbodies, or RMZs.



Source: Landcover, FRE Facility - HDR; Streams - DNR; Basemap - ESRI Online; Hillshade - DNR LiDAR Portal

Streams
Maximum Inundation Limit

Vegetation Management Zones
Upland Vegetation Management Zones
Wetland Vegetation Management Zones

Riparian Vegetation Management Zones

WDNR Site Class
II (RMZ 170 ft wide)
III (RMZ 140 ft wide)
IV (RMZ 110 ft wide)
VIII (RMZ 90 ft wide)

N

0 1,000 2,000
Feet

FIGURE 4: VEGETATION MANAGEMENT ZONES

Chehalis River Basin Flood Damage Reduction Project

Date: 10/5/2020

The conceptual adaptive management plan described below presents basic plan elements that will be developed in more detail into a Final Adaptive Management Plan in coordination with the Project's WDNR Interdisciplinary Team once permitting is underway.

6.2 Pre-Construction Monitoring

Monitoring will be conducted throughout the FRE Temporary Reservoir to document pre-construction riparian functions, wetland management zone conditions, and upland habitat conditions as they pertain to vegetation community composition.

6.2.1.1 Methods

6.2.1.1.1 Riparian Functions

Pre-construction riparian functions will be documented along the Riparian Management Zones of streams in the FRE temporary reservoir footprint (Figure 4). The following functions will be assessed using the "Assessing Riparian Function" guidelines presented in Section 21, Guidelines for Alternate Plans, in the *Forest Practices Board Manual* (WDNR 2000):

- Stream shading
- Stream bank stability
- Woody debris availability and recruitment
- Sediment filtering
- Nutrients and leaf litter fall

6.2.1.1.2 Wetland Management Zone Existing Conditions

Pre-construction monitoring of wetland management zones in the FRE temporary reservoir footprint shall be coordinated with the wetland impact analyses required for federal, state, and local wetland permitting. Pre-construction wetland functions have been documented in the Anchor QEA (2018) *Wetland, Water, and Ordinary High Water Mark Delineation Report.* Pre-construction monitoring will confirm status of wetland functions as they pertain to vegetation communities, as documented in the delineation report.

6.2.1.1.3 Uplands Existing Conditions

Pre-construction monitoring of uplands in the FRE temporary reservoir footprint will evaluate the condition and extent of upland habitats as presented in Section 3.1. Similar desktop and field reconnaissance methods will be utilized to confirm current upland habitat conditions. Pre-construction monitoring of upland conditions will be conducted in conjunction with the pre-construction marbled murrelet nesting habitat suitability surveys described in the *DRAFT Biological Assessment and Essential Fish Habitat Assessment – Chehalis River Basin Flood Damage Reduction Project: Flood Retention Facility, Airport Levee Improvements, and Mitigation Actions* (HDR 2020).

6.2.1.2 Monitoring Schedule

Pre-construction monitoring should be conducted once, 1 to 2 years prior to start of construction activities during the growing season.

6.3 Adaptive Management Goals and Objectives

Adaptive Management Goals describe the overall intent of the adaptive management plan; Adaptive Management Objectives describe individual components of the adaptive management plan designed to achieve the goals. Performance standards, which identify measurable, quantifiable indicators of performance relative to the restoration goals and objectives, will be developed as part of the final VMP once proposed goals and objectives are confirmed with the Interdisciplinary Team during permitting.

6.3.1 Goals and Objectives

6.3.1.1 Goal 1: Maintain the minimal acceptable level of riparian function in the temporary FRE reservoir footprint compared to pre-construction conditions.

Objective: Maintain the following functions in Riparian Management Zones at the minimal acceptable level as determined with the Interdisciplinary Team:

(1) Stream shading

(2) Stream bank stability

(3) Woody debris availability and recruitment

(4) Sediment filtering

(5) Nutrients and leaf litter fall

6.3.1.2 Goal 2: Minimize loss of tree and shrub wetland vegetation communities in the FRE temporary reservoir compared to pre-construction conditions.

Objective: The net acreage of wetlands identified as forested wetlands during pre-construction monitoring shall be retained as forested or forested, scrub-shrub wetlands per the definitions in Cowardin et al. (1979).

Objective: There will be no net loss of acreage of scrub-shrub wetlands as defined by Cowardin et al. (1979) pre-construction monitoring.

6.3.1.3 Goal 3: Minimize loss of forested and shrub upland vegetation communities in the Upland Vegetation Management Zones compared to pre-construction conditions.

Objective: The net acreage of forested upland vegetation communities quantified during the pre-construction monitoring shall not degrade to a condition below shrubland.

Objective: There will be no net loss of acreage of shrubland vegetation communities quantified during pre-construction monitoring.

6.3.1.4 Goal 4: Limit the establishment of noxious and invasive weeds throughout the FRE

temporary reservoir footprint following periods of prolonged inundation.

Objective: Eradicate all Class A weeds and control selected Class B weeds on Lewis County's noxious weed list (2020) if identified in the reservoir footprint.

6.4 Adaptive Management Monitoring

6.4.1 Methods

Long-term monitoring will be conducted annually to evaluate vegetation conditions in the FRE temporary reservoir footprint during FRE facility operations, especially following periods of prolonged inundation. Monitoring efforts will focus on evaluating whether performance standards are being met; performance standards will be identified in the final VMP. The monitoring phase of the project is expected to consist of iterative and corrective measures, such as removing invasive species, and is expected to occur for the lifetime of the FRE facility operations. Performance standards will be identified in the final VMP.

6.4.2 Revegetation Guidelines

This section presents concepts for potential revegetation treatments if long-term adaptive management goals and objectives are not being met. Detailed planting plans are not proposed to be developed at this time, since the actual frequency, intensity, and extent of flood events over time will determine which areas need to be revegetated and cannot be predicted during the design phase. It is anticipated that some areas that are subject to more frequent flooding may need to be revegetated soon after start of facility operations to allow establishment of more flood-tolerant species. Conversely, some vegetation communities will likely show slower transition over time and not need immediate or whole-scale revegetation efforts.

6.4.2.1 Conceptual Plant Palette

Areas within the FRE temporary reservoir that are determined to require revegetation with trees and/or shrubs will need to be primarily assessed based on the evacuation area where revegetation is needed, as duration, extent, and frequency of flooding will be the primary drivers for survival of vegetation in replanted areas. Therefore, the plant palettes presented below are based on respective evacuation zones as opposed to specific Vegetation Management Zones. Revegetation in the Debris Management Evacuation and Final Reservoir Evacuation areas likely will experience more prolonged and deeper flooding after major flood events, and therefore will require revegetation with more flood- tolerant species. The Initial Reservoir Evacuation area will experience shorter, shallower periods of flooding and therefore moderately flood-tolerant species are expected to survive in this zone. Plant species identified in Section 4.2.2 and other flood-tolerant native species found in wetlands in the study area (Anchor QEA 2018) have been selected for proposed plant palettes by replanting zone (see Table 7).

Table 7. Proposed Plant Palette by Replanting Zone

Replanting Zone	Scientific Name	Common Name
Initial Evacuation Area	***Trees***	
	Alnus rubra	Red alder
	Picea sitchensis	Sitka spruce
	Thuja plicata	Western red cedar
	Shrubs	
	Acer circinatum	Vine maple
	Oemleria cerasiformis	Indian plum
	Frangula purshiana	Cascara
	Rubus spectabilis	Salmonberry
	Sambucus racemosa	Red elderberry
	Symphoricarpos albus	Snowberry
Debris Management Evacuation Area	***Trees***	
	Fraxinus latifolia	Oregon ash
	Populus balsamifera	Black cottonwood
	Salix lasiandra	Pacific willow
	Shrubs	
	Cornus alba	Red-osier dogwood
	Lonicera involucrata	Twinberry
	Rubus spectabilis	Salmonberry
	Rosa nutkana	Nootka rose
	Rubus parviflorus	Thimbleberry
	Rubus spectabilis	Salmonberry
Final Reservoir Evacuation Area	***Trees***	
	Salix lasiandra	Pacific willow
	Shrubs	
	Cornus alba	Red-osier dogwood
	Salix exigua	Narrow-leaf willow
	Salix hookeriana	Hooker’s willow
	Spiraea douglasii	Hardhack

6.4.2.2 Site Preparation and Planting Details

Site preparation will be focused mainly on preparing revegetation areas so that plantings can successfully establish with minimal maintenance, and avoid disturbance to surrounding live vegetation. Site preparation methods shall include use of native soils and stockpiling native soils if necessary, scarifying or disking to break up any compacted soils, and use of compost or other soil amendments to improve soil media.

Plant material will be provided from commercial nurseries. Inspection of all woody plants will be conducted to ensure compliance with the revegetation plan specifications regarding size requirements, root ball mass, and overall health of the plant. Planting zones will be delineated per the revegetation plan, with planting conducted under the supervision of FCZD biologists or other qualified staff. Planting is to occur from October through March, avoiding times of FRE operation.

6.4.3 Contingency Plan

Contingency plans describe what actions can be taken to correct deficiencies in achieving a plan's goals and objectives. The adaptive management plan goals, objectives, and performance standards create a baseline by which to measure whether the site is performing as proposed and whether or not a contingency plan is necessary. All contingencies cannot be anticipated.

The contingency plan will be flexible so that modifications can be made if portions of the adaptive management plan do not produce the desired results. Problems or potential problems will be evaluated by the FCZD and Interdisciplinary Team. Specific contingency actions will be developed, agreed to by consensus, and implemented based on all scientifically and economically feasible recommendations.

Table 8. Potential Contingency Actions for the Vegetation Management Zones

Resource/Issue	Contingency Action [a]
Sites do not meet goals and objectives for scrub-shrub or forested cover	• Revegetate with appropriate woody plant species. • Re-evaluate the suitability of the plant species for site conditions. • Consider use of alternate species. • Undertake additional monitoring.
Over-competition by invasive species	• Identify/Evaluate predominant invasive species in the mitigation areas. • Initiate invasive species control protocols appropriate to species type, conditions of infestation area, and level of infestation (e.g., herbicide application, mowing).

[a] Contingency actions listed are only a subset of potential actions. All contingency actions discussed above should be considered and the appropriate actions taken based on an understanding of the actual causes of poor performance.

7.0 References

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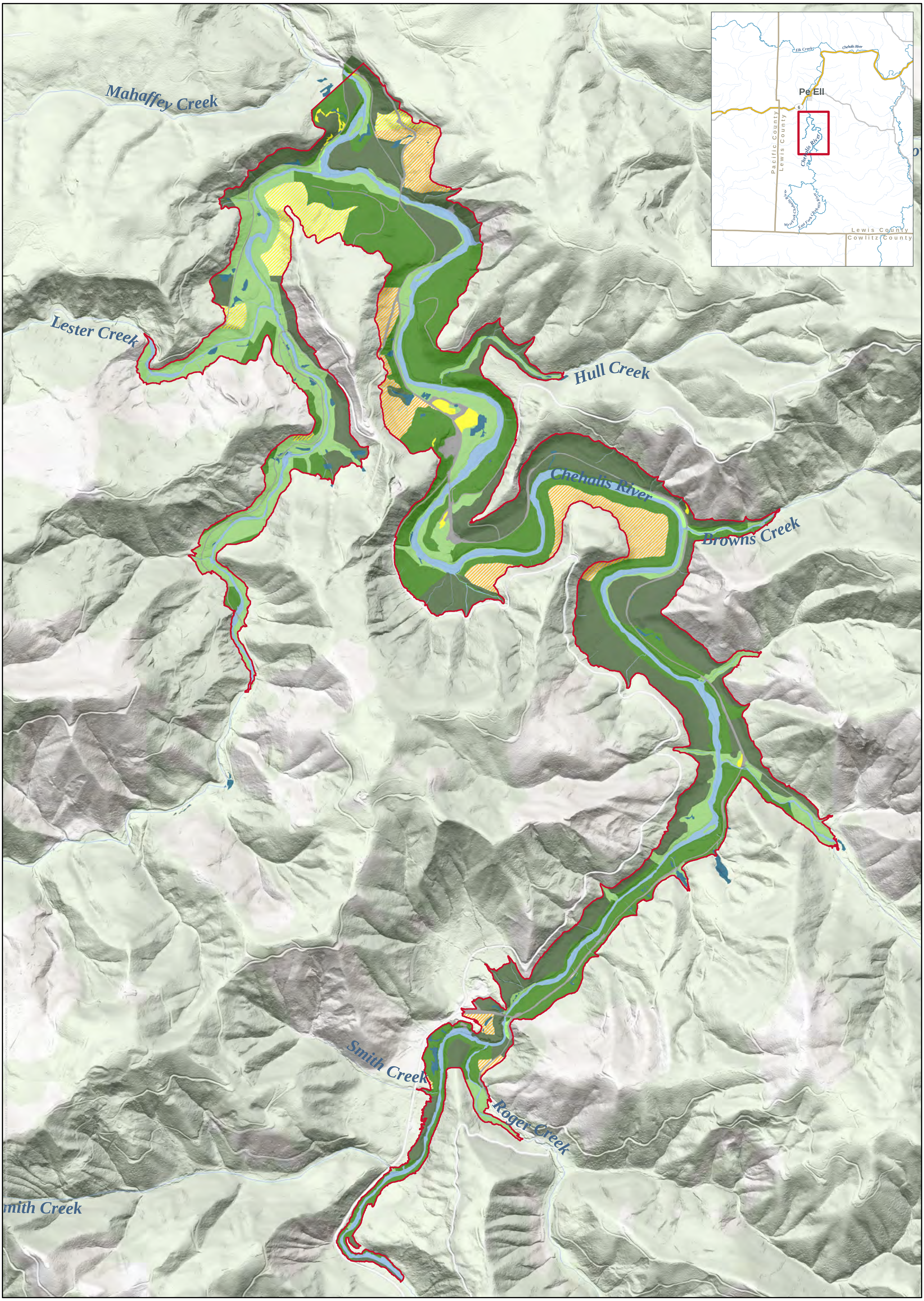
Appendix A. Existing Vegetation Mapping



Source: Landcover, FRE Facility - HDR; Streams - DNR; Basemap - ESRI Online; Hillshade - DNR LiDAR Portal

Landcover

- Coniferous Forest
- Mixed Coniferous/Deciduous Transitional Forest
- Deciduous Riparian Forest w/some Conifers
- Deciduous Riparian Shrubland
- Herbaceous/Grass
- Wetland
- Logged, replanted 5-15+ years
- Logged, replanted 0-5 years
- Open Water/Sand Bar
- Terrestrial Bare Ground/Roads
- Streams
- Study Area (WSEL: 628ft)

N

0 1,000 2,000
Feet

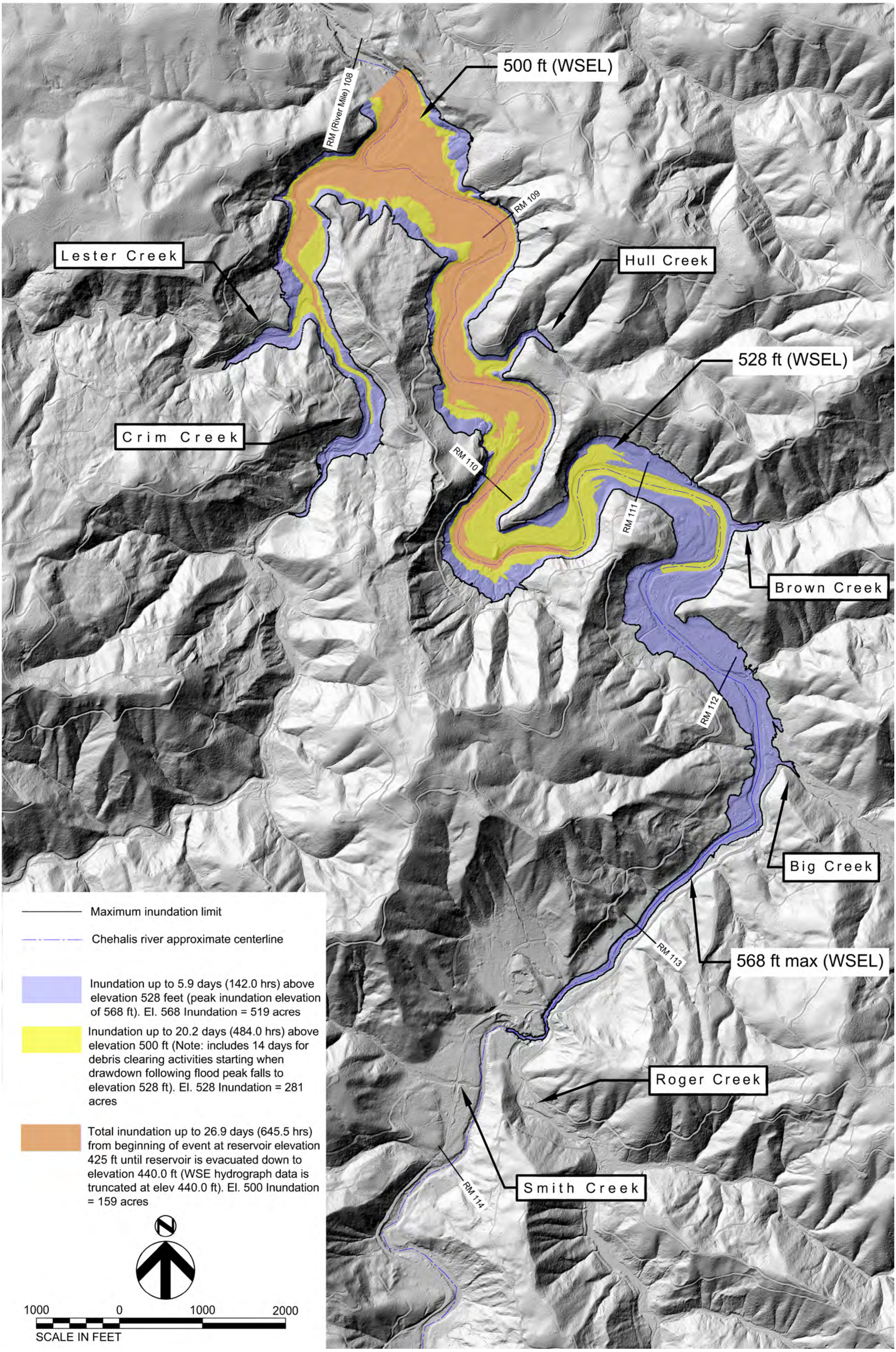
LAND COVER CLASSIFICATION

Chehalis River Basin Flood Damage Reduction Project

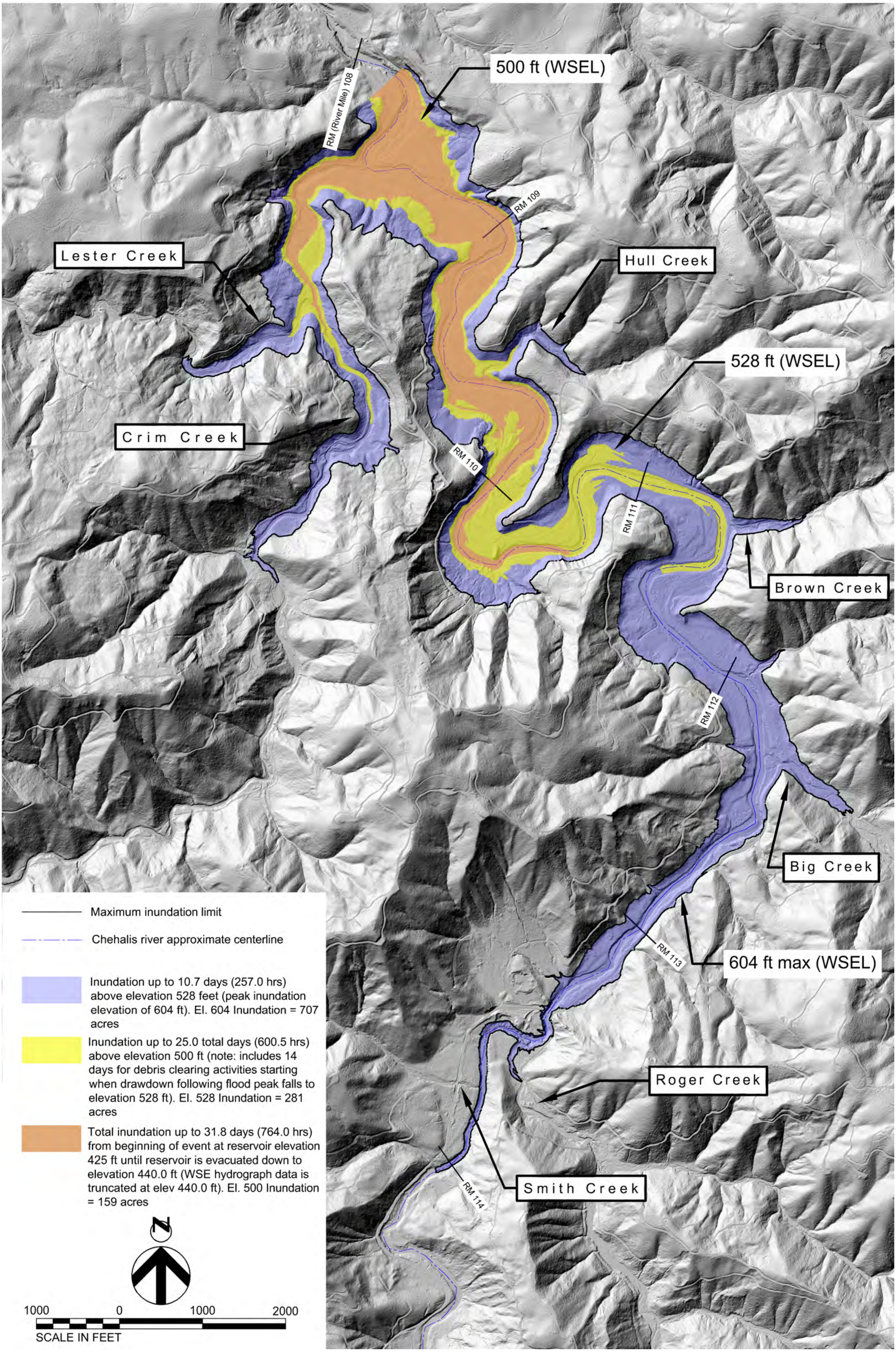
Date: 10/2/2020

Appendix B. Inundation Maps for Historic and Modeled Major Flood Events

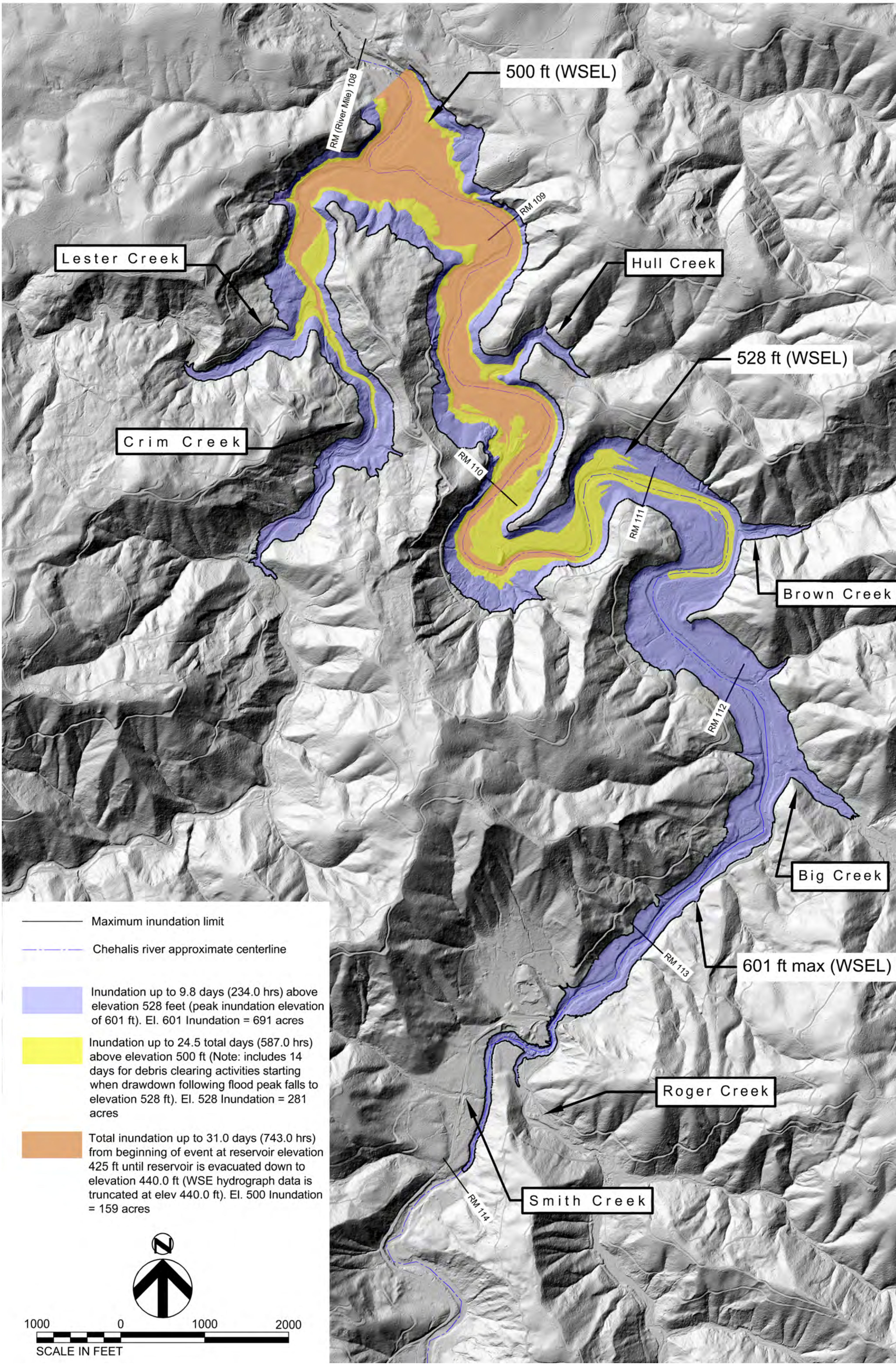
10 Year Event Inundation Map for Proposed Dam (FRE)



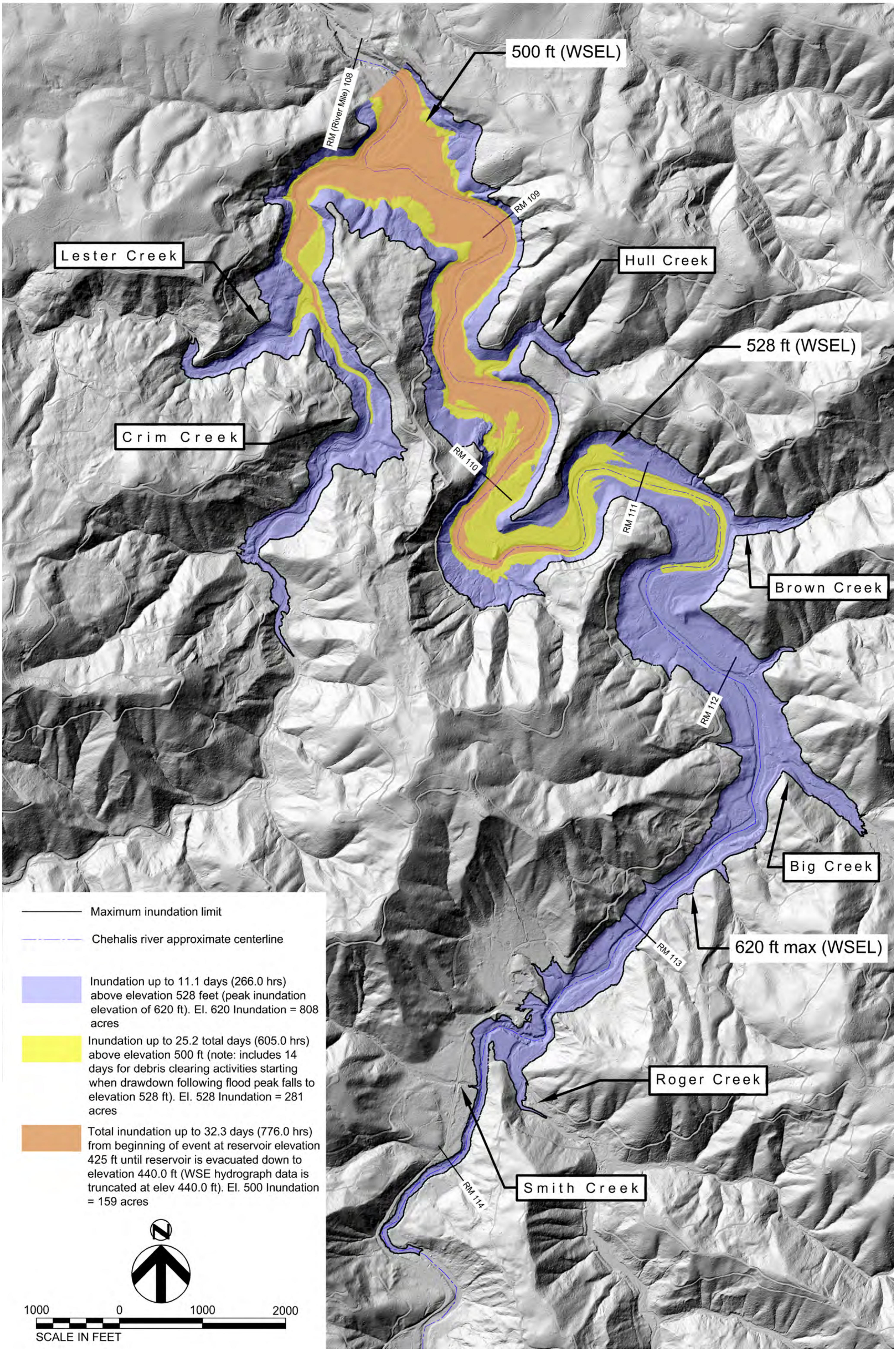
100 Year Event Inundation Map for Proposed Dam (FRE)



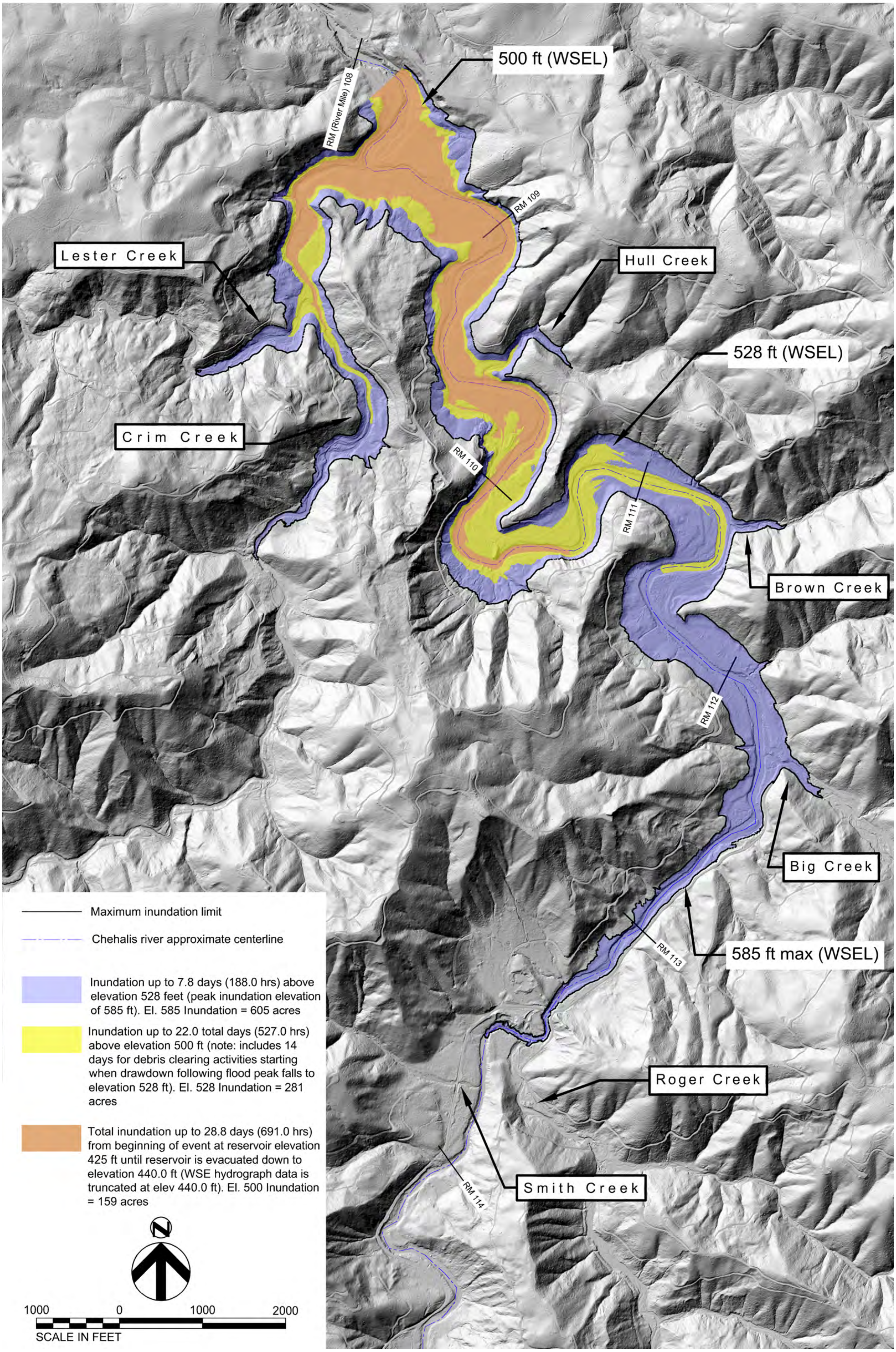
1996 Event Inundation Map for Proposed Dam (FRE)



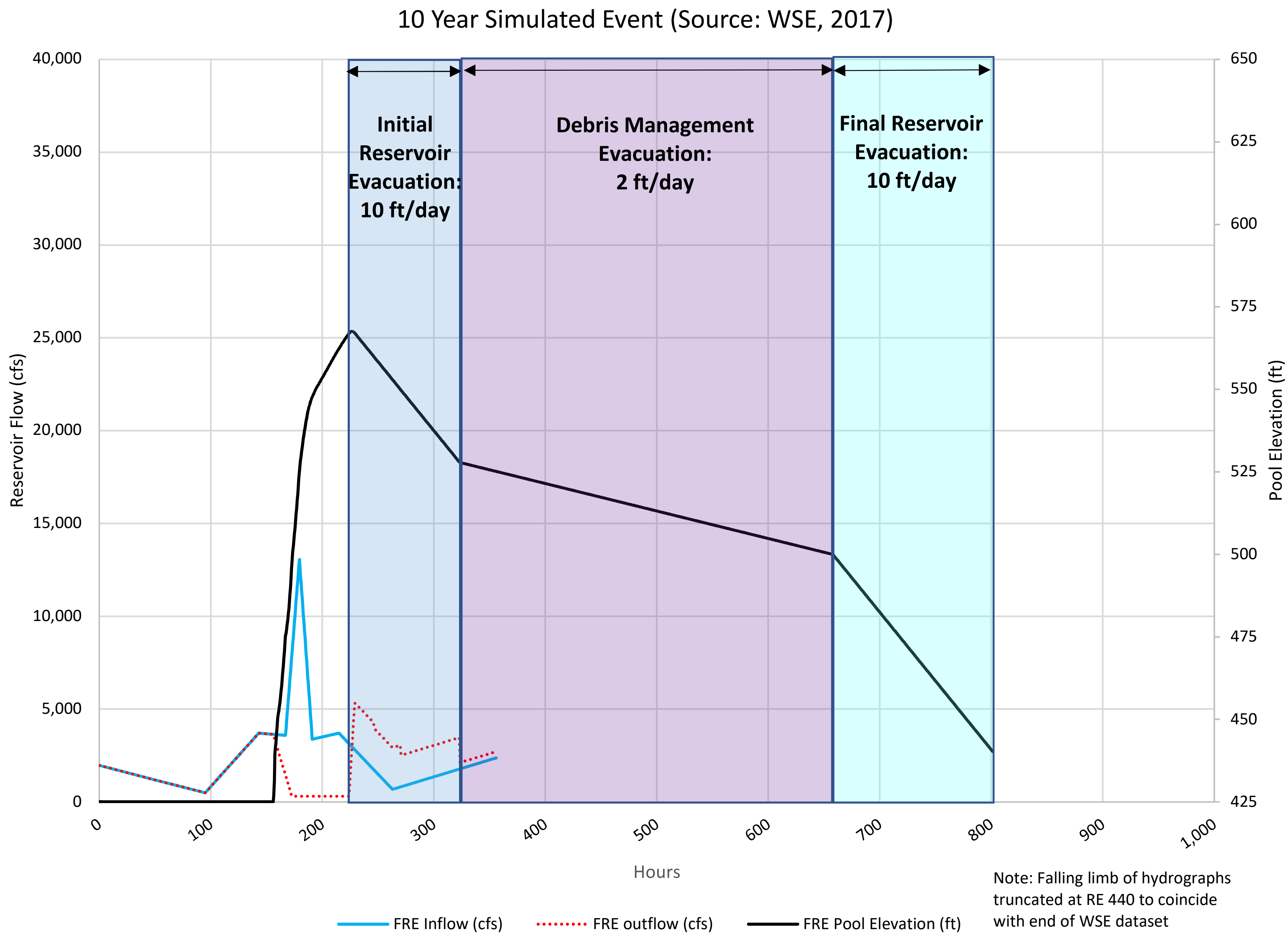
2007 Event Inundation Map for Proposed Dam (FRE)



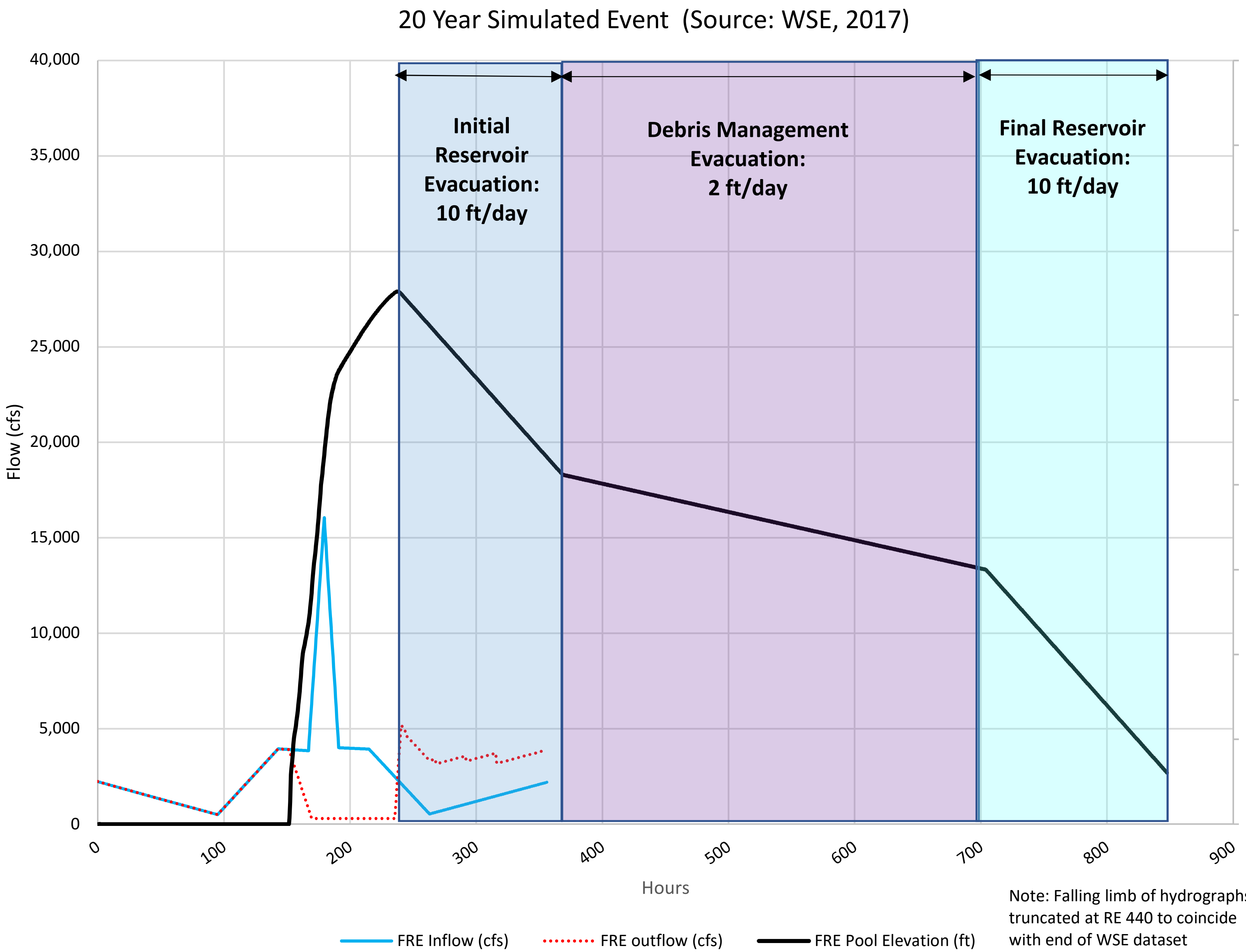
2009 Event Inundation Map for Proposed Dam (FRE)

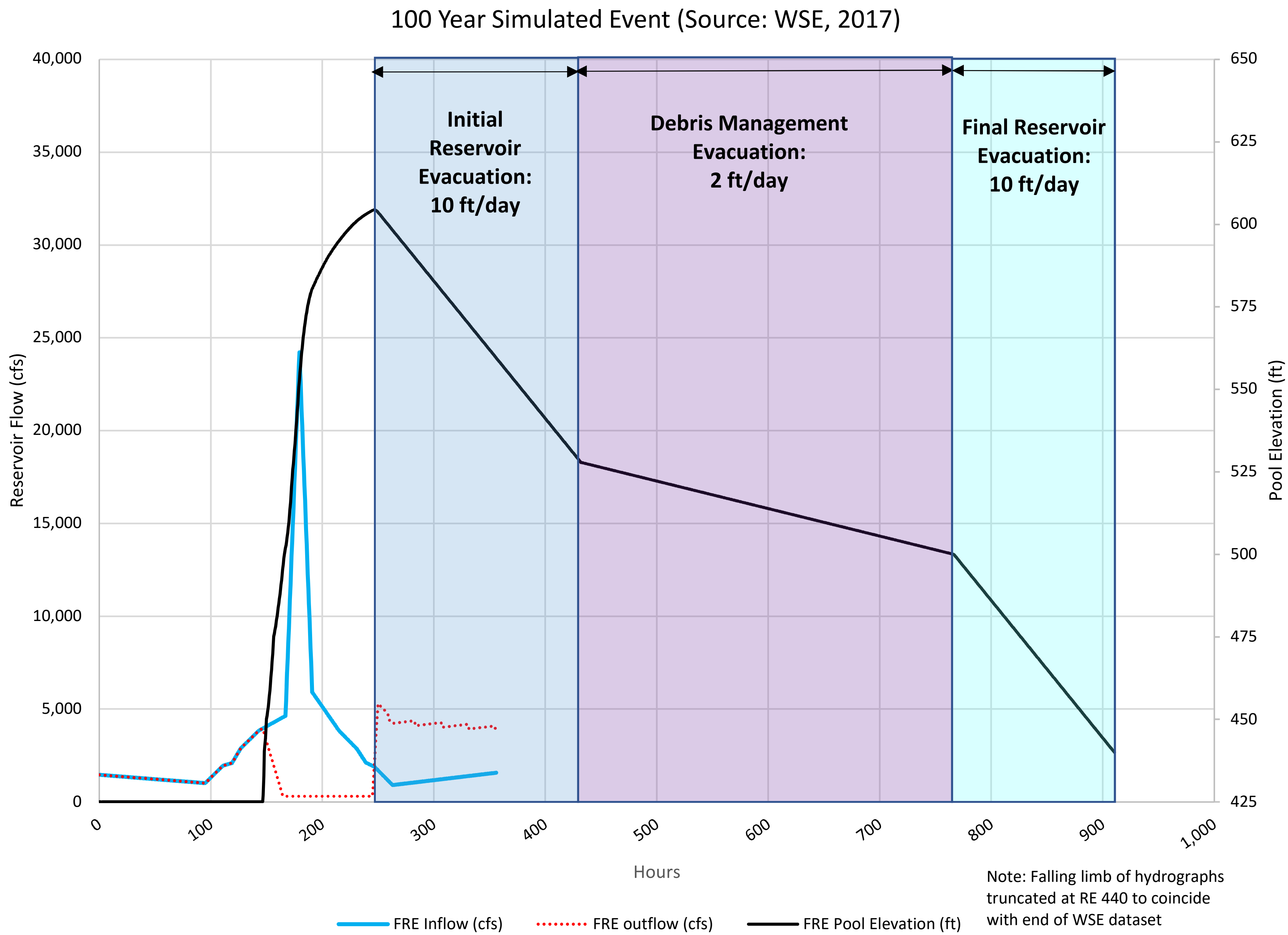


Appendix C. Hydrographs for Major Flood Events

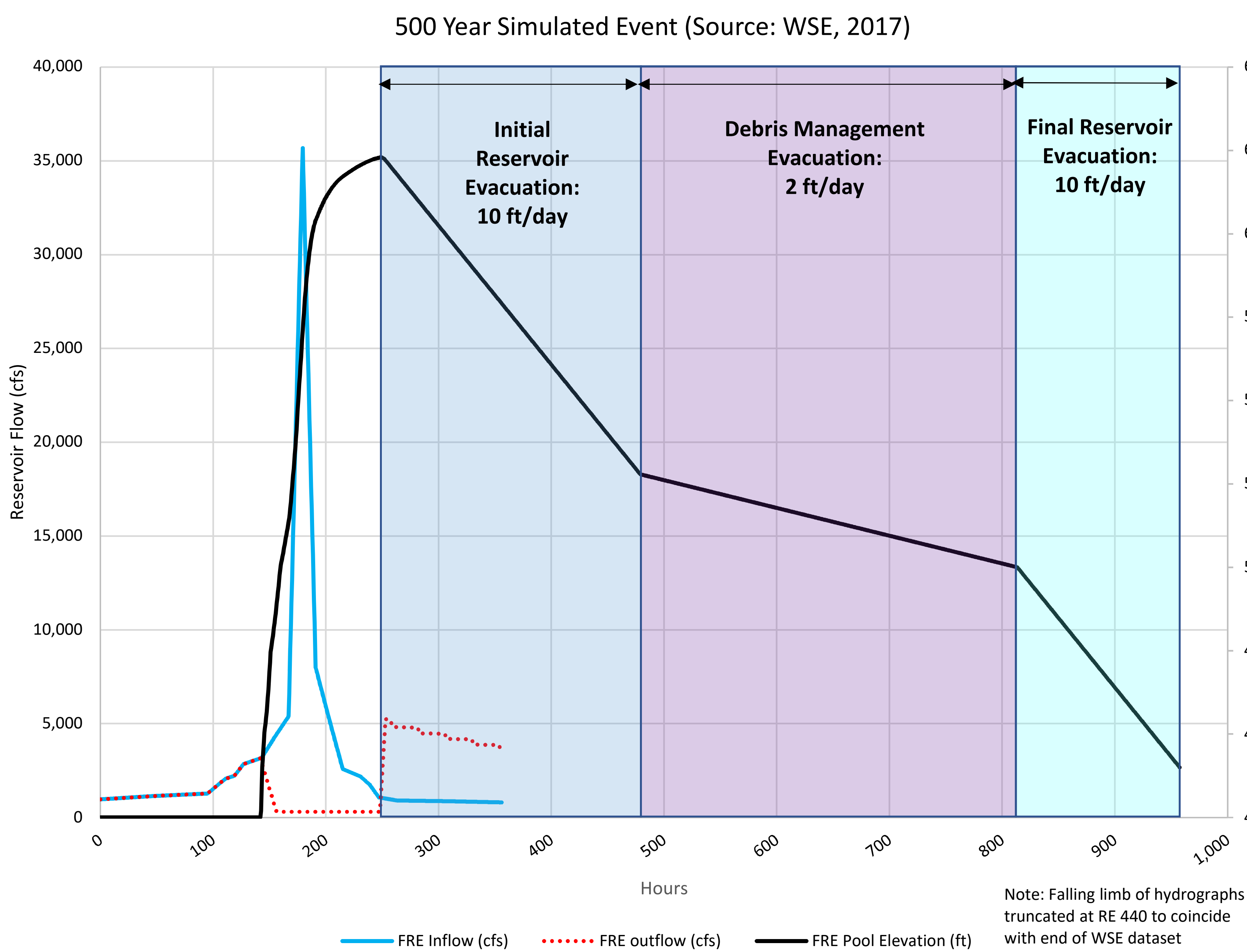


Note: Falling limb of hydrographs truncated at RE 440 to coincide with end of WSE dataset

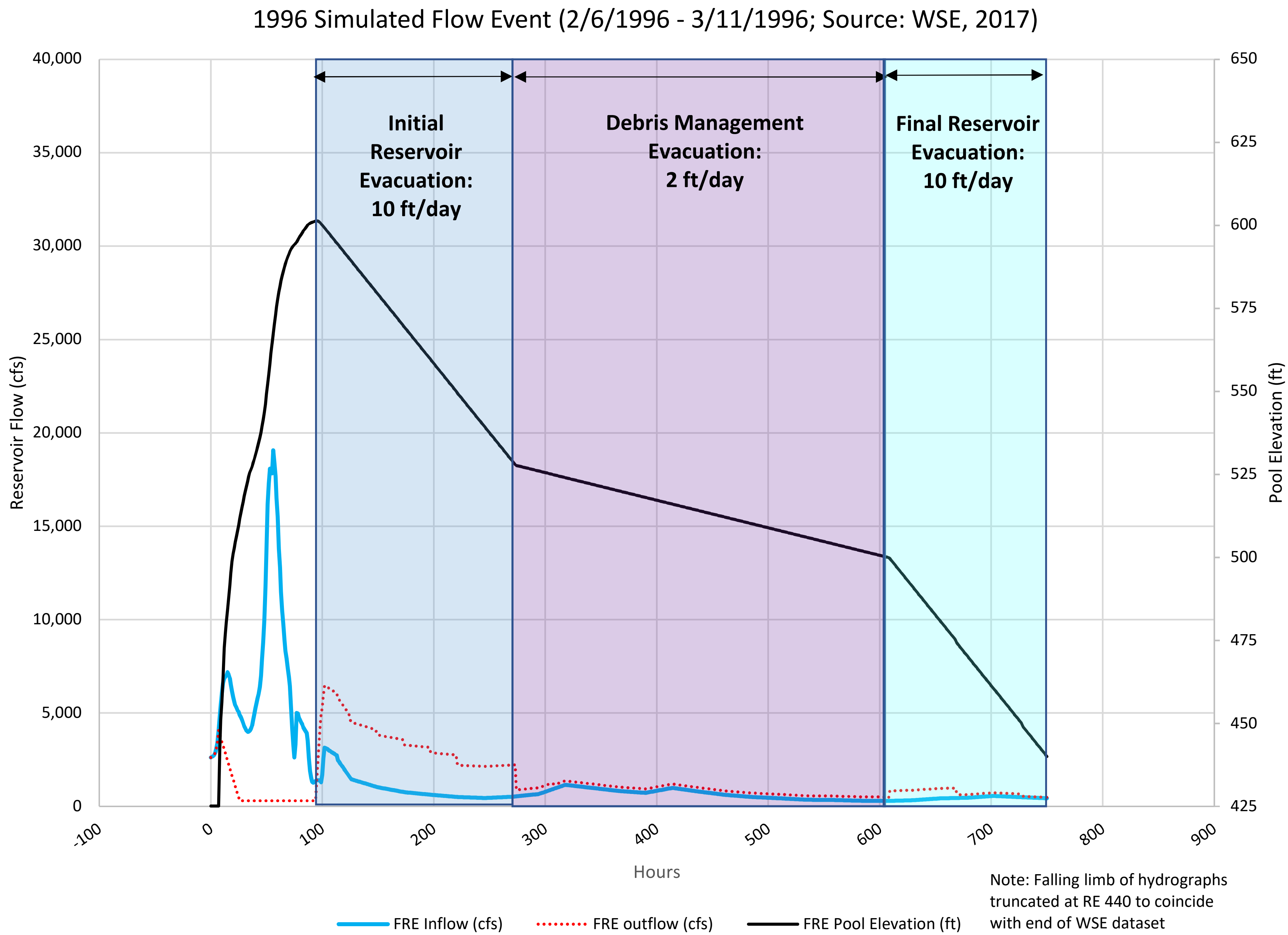

20 Year Simulated Event (Source: WSE, 2017)
Initial Reservoir Evacuation: 10 ft/day
Debris Management Evacuation: 2 ft/day
Final Reservoir Evacuation: 10 ft/day
Flow (cfs)
Pool Elevation (ft)
Hours
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
425
450
475
500
525
550
575
600
625
650
0
100
200
300
400
500
600
700
800
900
FRE Inflow (cfs)
FRE outflow (cfs)
FRE Pool Elevation (ft)
Note: Falling limb of hydrographs truncated at RE 440 to coincide with end of WSE dataset

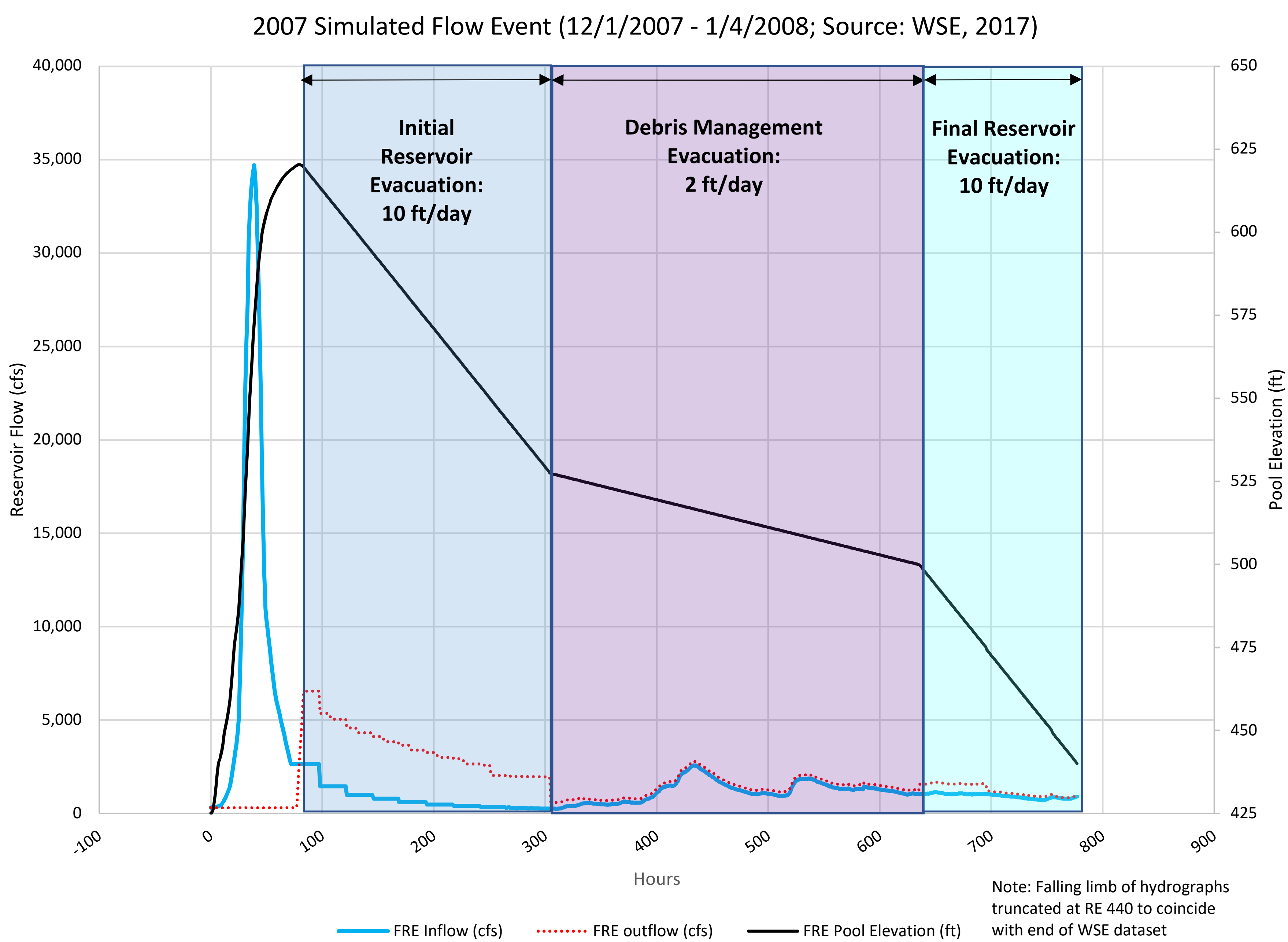


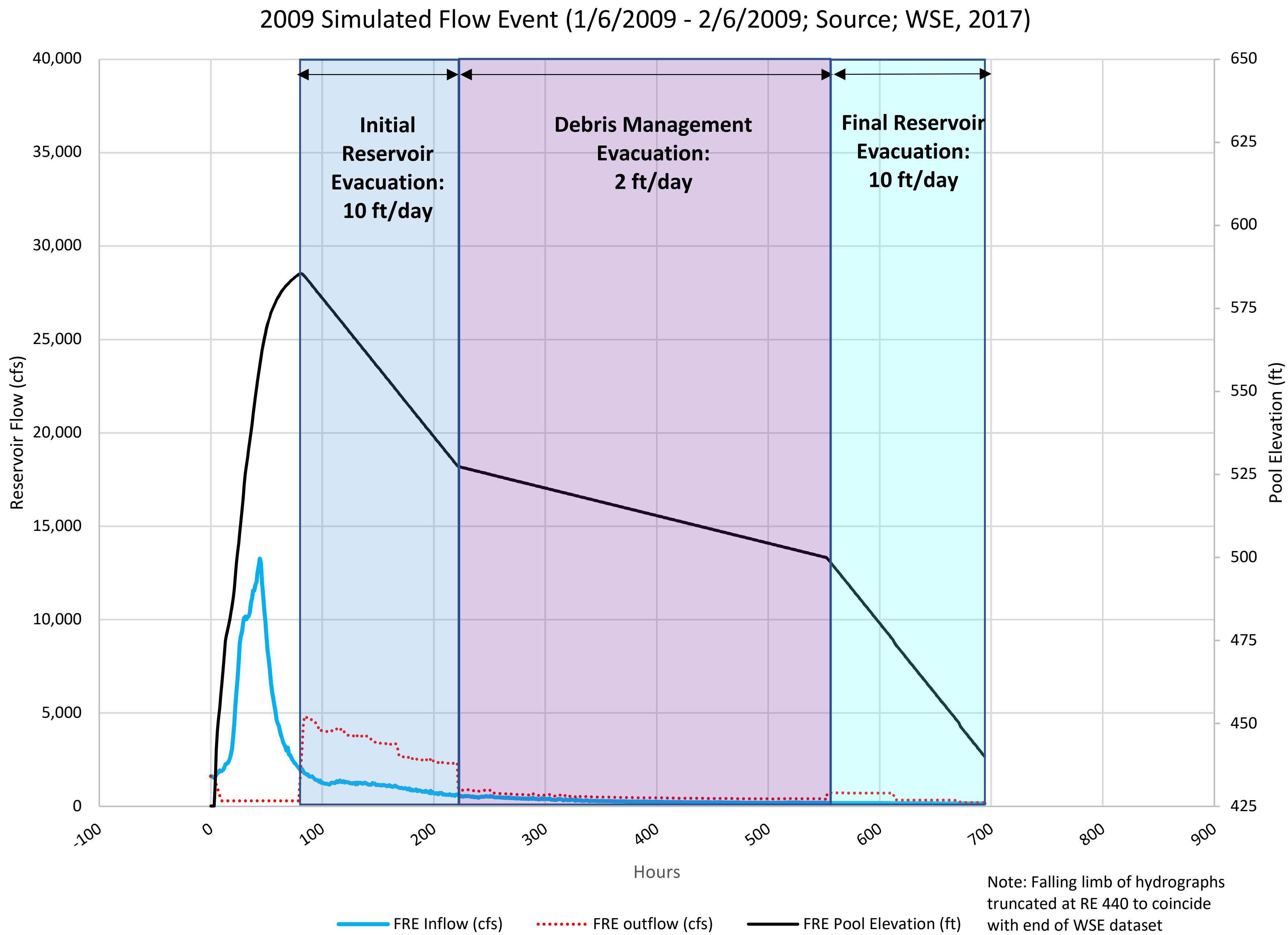
100 Year Simulated Event (Source: WSE, 2017)
Initial Reservoir Evacuation: 10 ft/day
Debris Management Evacuation: 2 ft/day
Final Reservoir Evacuation: 10 ft/day
Reservoir Flow (cfs)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Pool Elevation (ft)
650
625
600
575
550
525
500
475
450
425
0
100
200
300
400
500
600
700
800
900
1,000
Hours
FRE Inflow (cfs)
FRE outflow (cfs)
FRE Pool Elevation (ft)
Note: Falling limb of hydrographs truncated at RE 440 to coincide with end of WSE dataset



500 Year Simulated Event (Source: WSE, 2017)
Initial Reservoir Evacuation: 10 ft/day
Debris Management Evacuation: 2 ft/day
Final Reservoir Evacuation: 10 ft/day
Reservoir Flow (cfs)
Pool Elevation (ft)
Hours
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
650
625
600
575
550
525
500
475
450
425
0
100
200
300
400
500
600
700
800
900
1,000
FRE Inflow (cfs)
FRE outflow (cfs)
FRE Pool Elevation (ft)
Note: Falling limb of hydrographs truncated at RE 440 to coincide with end of WSE dataset


1996 Simulated Flow Event (2/6/1996 - 3/11/1996; Source: WSE, 2017)
Initial Reservoir Evacuation: 10 ft/day
Debris Management Evacuation: 2 ft/day
Final Reservoir Evacuation: 10 ft/day
Reservoir Flow (cfs)
Pool Elevation (ft)
Hours
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
650
625
600
575
550
525
500
475
450
425
-100
0
100
200
300
400
500
600
700
800
900
FRE Inflow (cfs)
FRE outflow (cfs)
FRE Pool Elevation (ft)
Note: Falling limb of hydrographs truncated at RE 440 to coincide with end of WSE dataset


2007 Simulated Flow Event (12/1/2007 - 1/4/2008; Source: WSE, 2017)
Initial Reservoir Evacuation: 10 ft/day
Debris Management Evacuation: 2 ft/day
Final Reservoir Evacuation: 10 ft/day
Reservoir Flow (cfs)
Pool Elevation (ft)
Hours
FRE Inflow (cfs)
FRE outflow (cfs)
FRE Pool Elevation (ft)
Note: Falling limb of hydrographs truncated at RE 440 to coincide with end of WSE dataset



Note: Falling limb of hydrographs truncated at RE 440 to coincide with end of WSE dataset

Appendix D
Temperature Model Sensitivity Analysis

Water Temperature Model Sensitivity Analysis

Chehalis River Basin Flood Damage Reduction Project

Submitted by the Chehalis River Basin Flood Control Zone District

August 2021

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Preface

Preface

This document contains the Water Temperature Model Sensitivity Analysis for the Chehalis River Basin Flood Damage Reduction Project (proposed project) proposed by the Chehalis River Basin Flood Control Zone District. The purpose of the water temperature modeling is to (1) perform a sensitivity analysis of the modeled water temperature predictions from changes in vegetation heights and (2) provide more refined information to Washington State Department of Ecology (Ecology) and the United States Army Corps of Engineers (USACE) for their consideration when updating the impacts analysis that evaluates the effects of predicted riparian vegetation changes on water temperature presented in the State Environmental Policy Act (SEPA) Draft Environmental Impact Statement (DEIS) (Ecology 2020a) and National Environmental Policy Act (NEPA) DEIS (USACE 2020a).

This document reviews the SEPA and NEPA DEISs impact analysis of the proposed project's impact on water temperature and provides an updated baseline scenario for vegetation in the temporary inundation area. Further, refined assumptions for future vegetation conditions in the temporary inundation area are provided based on additional information pertaining to vegetation management and a review of an existing analog site (Mud Mountain Dam). This document also includes more detailed information regarding the impact of the proposed project and the impact of climate change on water temperature conditions within the temporary inundation area of the downstream reach of the Chehalis River near the proposed Flood Retention Expandable (FRE) facility.

Acronyms and Abbreviations

°C	degrees Celsius
7-DADMax	7-day average of the daily maximum water temperature
CE-QUAL-W2 model	Corps of Engineers-Quality-Width-averaged 2-dimensional model
DEIS	Draft Environmental Impact Statement
DHM	digital height model
District	Chehalis River Basin Flood Control Zone District
DSM	digital surface model
DTM	digital terrain model
Ecology	Washington Department of Ecology
FRE	flood retention expandable
GIS	Geographic Information System
HEC-RAS	Hydrologic Engineering Center – River Analysis System
LiDAR	light detection and ranging
NEPA	National Environmental Policy Act
NRCS	Natural Resources Conservation Service
PSU	Portland State University
SEPA	State Environmental Policy Act
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
VMP	vegetation management plan
WSEL	Water Surface Elevation

Glossary

Boundary Condition – An edge of the modeled region that requires inputs be defined to be able to perform the mathematical computations. For example, a condition usually must be specified at the upstream end of a modeled river reach.

Climate Change Conditions – A modeling condition using the constructed model based on 2014 data but replacing air and dewpoint temperature, flow, and inflow water temperature with estimates representing climate change.

Current Conditions – A modeling condition using the constructed model based on 2013 and 2014 data.

FRE Facility – The proposed flood retention expandable facility dam site.

FRE Site – The operation of a proposed flood retention expandable facility including the dam site and the upstream area that would be temporarily inundated and become a temporary pool during a flood event in which the upland and riparian vegetation may be impacted.

Inputs or Model Inputs – The values used by the model to perform its mathematical computations.

Model – A representation of something or a system. Herein, mathematical equations based on scientific evidence that are coded within a software program to represent the processes that occur in a river. The model used is CE-QUAL-W2.

Modeling or Modeled – The use of a model applied to a specific river to represent conditions within that river either historically or as estimations of climate change, based upon historical data, mathematical equations, scientific evidence, and/or best professional judgment of conditions.

Scenario or Model Scenario – Input(s) to the model are modified to represent an alternative condition, the model is simulated, and the results are examined and compared to the original condition to explore how the model responded to the change in input(s).

Segments or Model Segments – The discretization of an area into gridded blocks or cells for which the model performs the mathematical computations and then routes the results of those computations to the adjoining cells. Usage is when referring to model segments use lower case, when referring to a specific model segment number use upper case; e.g., Segment 111.

Sensitivity or Sensitivity Analysis – A method to analyze the difference an input value causes to predicted output values. Herein, the input value of shade was varied and the effect on the output value of water temperature was evaluated.

Simulation or Run or Model Simulation – The computing of the model mathematical equations as coded within a software program as done in a computer's electronics based on the user's inputs. The computer processing may take from seconds to days depending upon the scope and complexity of the equations and the computer processor. Herein, simulation is the period when the software program is executed or run.

Sub-basin – An area that contributes flow to the river.

Temporary Inundation Area – The area that would be under water due to retention of water during a flooding event.

Water quality – The physical, chemical, and biological processes occurring within a river as indicated by specific parameter(s). Herein the parameter of interest is water temperature.

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1 Introduction and Purpose

As part of a strategy to reduce flood damage to life and property along the Chehalis River, the Chehalis River Basin Flood Control Zone District (District) proposes to construct a flood retention facility near the town of Pe Ell on the mainstem of the Chehalis River. The Draft Environmental Impact Statements (DEISs) prepared by the Washington Department of Ecology (Ecology) and the United States Army Corps of Engineers (USACE) evaluate anticipated impacts on abiotic and biologic resources associated with construction and operation of the proposed flood retention expandable (FRE) facility (i.e., the Chehalis River Basin Flood Damage Reduction Project [proposed project]). The State Environmental Policy Act (SEPA) DEIS (Ecology 2020a) and National Environmental Policy Act (NEPA) DEIS (USACE 2020a) assessed potential impacts on water temperature, dissolved oxygen, turbidity, fecal coliform, and pH from the construction and operation of the proposed FRE facility. Of specific concern are the significant impacts of the proposed project on water temperature based on results from a water quality model and documented in each of the DEISs. Due in part to the projected increases in water temperature, the SEPA and NEPA DEISs subsequently determined that the proposed project will have significant impacts on aquatic resources and anadromous salmonids.

This report reviews the SEPA and NEPA DEISs water temperature impact findings (Section 2.1) and reports on an analysis to assess the sensitivity of water temperature increases to vegetation and shading assumptions used in the water quality modeling. This report presents water temperature modeling results based on more recent information regarding existing vegetation conditions in the temporary inundation area upstream of the proposed FRE facility. In addition, refined shade parameters for the temporary inundation area from those assumed in the SEPA and NEPA DEISs are presented (Section 3) and water temperature results from the sensitivity analysis modeling are described (Section 4). Shade inputs in the sensitivity analysis modeling include inputs that are consistent with anticipated vegetation heights of intended plant communities following implementation of a Conceptual Vegetation Management Plan (VMP) (see Attachment A).[1]

A water quality model developed by Portland State University (PSU) and employed for Ecology and the USACE for preparation of the SEPA and NEPA DEISs was used for this analysis with no changes to its code, inputs, or operation. The model as applied to the Chehalis River was not changed except for the shade inputs established for the sensitivity analysis modeling. The model was run by PSU, and the results were reported to the consulting team.

[1] In 2020, HDR, Inc., in coordination with the District consultant team, developed a Conceptual VMP. The Conceptual VMP has informed the water quality modeling effort described in this report and will subsequently be reflected as a Final VMP to be implemented following further agency and stakeholder coordination.

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2 SEPA and NEPA DEIS Water Temperature Assessment

The SEPA and NEPA DEISs assessed the effects on water temperature in the temporary inundation area when storing water, when not storing water, and downstream of the proposed FRE facility under storage and non-storage conditions. The Corps of Engineers-Quality-Width-averaged 2-dimensional (CE-QUAL-W2) model was used for both DEIS assessments based on suitability and history of use for rivers and reservoirs. CE-QUAL-W2 is a computer model for predicting water flow and quality in rivers, estuaries, lakes, reservoirs, and river basin systems (Cole and Wells 2016, PSU 2017) that is maintained by researchers at PSU. The model operates in two dimensions and includes a complex suite of biological and chemical reactions that describe several regulated and unregulated water quality constituents. However, the SEPA and NEPA DEISs took different approaches in the assessment of the project's impacts with the additional temperature increases due to climate change. The SEPA DEIS included changes to air and dew point temperature, flow, and inflow water temperature when modeling climate change, and the NEPA DEIS did not include a quantitative assessment that included climate change in the water quality modeling.

2.1 SEPA and NEPA DEIS Water Temperature Impact Findings

The SEPA DEIS identified *significant impacts* on water temperature from the removal of vegetation in the upland and riparian areas of the proposed FRE site. The SEPA EIS states that the proposed project results in a 2 to 3 degrees Celsius (°C) increase in water temperature in mid- to late summer in the temporary inundation area and immediately downstream, and a 2 to 5°C increase in Crim Creek.

The NEPA DEIS identified *high impacts* on water temperature from the construction of the proposed FRE facility, *low–high impacts* upstream from the operation of the proposed FRE facility when the facility is both impounding and not impounding water, and *high impacts* downstream. Similar to the SEPA DEIS, the NEPA DEIS attributes the impacts on water temperature to the removal of vegetation in the temporary inundation area. The NEPA DEIS states that the proposed project will result in an increase of up to 2°C in mid-July in the area of the temporary inundation area and immediately downstream, reducing to 1°C at Pe Ell and 0.3°C at the confluence of Elk Creek.

The SEPA and NEPA analyses attribute the increase in water temperature to the reduction of shade due to the removal of vegetation in the temporary inundation area. A previous developed Pre-Construction Vegetation Management Plan (Anchor QEA 2016) informed assumptions made in the SEPA DEIS that construction activities would include the removal of all non-flood-tolerant trees within approximately 420 acres of the temporary inundation area and all other trees greater than 6 inches diameter breast height throughout the temporary inundation area as a conservative approach (Ecology 2020a). The NEPA analysis assumes 485 acres of clearing and limited (2-meter height) vegetative shading throughout the entire temporary inundation area (USACE 2020b).

The SEPA DEIS includes a quantitative analysis of climate change impacts on water temperature. Appendix N of the SEPA DEIS (Ecology 2020b) states that an increase in water temperature of 3 to 4°C in the vicinity of temporary inundation area is expected under climate change, driven by increases in air temperature. However, the SEPA DEIS does not make clear if the modeling results that show a 2 to 3°C increase in water temperature due to the proposed project were determined using discrete modeling runs without climate change. The NEPA DEIS qualifies impacts from climate change, stating that water temperature may increase with climate change, but does not consider this qualitative assessment in the impact analysis and does not provide any quantitative assessment of climate change on water temperature.

2.2 Water Quality Modeling Documentation

The SEPA DEIS included a technical appendix documenting the findings of the water quality modeling and assessment of impacts (Ecology 2020b). Multiple studies and reports are cited as additional references documenting the analysis, including the Chehalis Modeling Technical Memorandum (TM) (PSU 2017). The NEPA DEIS also included a technical appendix documenting the findings of the water quality modeling and assessment of impacts (USACE 2020b).

The SEPA and NEPA DEISs used the same computer model, the application of the CE-QUAL-W2 model configured and run by the same personnel at PSU. The application of the CE-QUAL-W2 model to the Chehalis River relied upon multiple data sources and other models as documented in the Chehalis Modeling TM (PSU 2017). The following is a summary of the model components and data sources.

The conversion of the channel shape into CE-QUAL-W2 model cells was achieved using Hydrologic Engineering Center – River Analysis System (HEC-RAS) input files "cross-sectional data provided by Anchor QEA" (PSU 2017). HEC-RAS is a USACE model commonly used for flood studies. In this case, detailed cross sections were provided as inputs that were then converted into grids for the block representation format used by CE-QUAL-W2. Meteorological inputs used in the CE-QUAL-W2 model included measured data from the Chehalis River Basin Flood Authority Thrash Creek Station. Flow and water temperature inputs were developed by Anchor QEA (2017). No further information about these data were available or documented in the previous modeling reports. Topographic shading input was based on a digital elevation map of the area (PSU 2017). The vegetative shading inputs were estimated and are described further below.

For climate change, Anchor QEA used data made available by the University of Washington to develop air and dewpoint temperature inputs and flow multipliers to adjust the flow inputs. Water temperature was assumed to increase by the same magnitude as the increase in air temperature:

> "Meteorological, flow, and temperature data were the only inputs to the model that were altered to simulate future conditions. All other model conditions and input data remained the same as for the baseline calibration simulations" (PSU 2017).

The methods for evaluating impacts on water quality include the use of the CE-QUAL-W2 model as applied using specific sets of inputs. A brief description of each application is provided in USACE 2020a and include:

- CE-QUAL-W2 applied to the Chehalis River at and upstream of the proposed FRE facility. This model is known as the Chehalis Reservoir Footprint Model (Footprint Model) as named in the Chehalis Modeling TM (PSU 2017).
    - Modeled area is the temporary inundation area during free-flowing conditions.
- CE-QUAL-W2 applied to the Chehalis River at and upstream of the proposed FRE facility with the facility in place. This model is known as the Chehalis Temporary Reservoir Model (PSU 2017).
    - Modeled area is the temporary inundation area during a flood event and the proposed FRE facility is retaining water.
- CE-QUAL-W2 applied to the Chehalis River downstream of the proposed FRE facility. The model is known as the Chehalis River Downstream Model (PSU 2017).
    - Modeled area is downstream of the proposed FRE facility.

The Footprint Model was selected as the appropriate model for the sensitivity analysis of water temperature to shade inputs because the spatial extent of the model includes the temporary inundation area where vegetation management will be implemented. Furthermore, the Footprint Model provides for the assessment of water temperature changes over the course of multiple years (under current conditions) during free-flowing river conditions, including changes to water temperature during late summer low-flow months. The late summer months are when the SEPA and NEPA DEISs identified water temperature increases to be greatest and are therefore an important period to assess the sensitivity analysis of water temperature to shade inputs. The Footprint Model is further described in Section 2.3.

2.3 Footprint Model Framework

The Footprint Model is composed of a grid overlain on portions of the Chehalis River, Crim Creek, Lester Creek, Big Creek, and Roger Creek. This grid is composed of 191 model segments, with each segment being either 150 or 152.4 meters long in the direction of water flow. Some segment numbers are inactive in the model and are of zero length. Figure 1 below provides a map of the Footprint Model segments. Model segments corresponding to specific locations include four mainstem locations along with the upstream and downstream ends of the four tributaries to the mainstem, identified as follows:

- Segment 2 Chehalis River, upstream model boundary, located approximately 8 miles south of Pe Ell, Washington.
- Segment 44, uppermost reach of the temporary inundation area during an extreme flood retention event.

- Segment 111 Chehalis River, location of proposed FRE facility.
- Segment 122 Chehalis River, downstream model boundary.
- Segments 125 and 161 Crim Creek tributary, upstream and downstream model boundaries, respectively.
- Segments 164 and 171 Lester Creek tributary, upstream and downstream model boundaries, respectively.
- Segments 174 and 181 Big Creek tributary, upstream and downstream model boundaries, respectively.
- Segments 184 and 190 Roger Creek tributary, upstream and downstream model boundaries, respectively.

Vegetation heights for the sensitivity analysis (Section 3) are input into the Footprint Model using the references to the segment numbering at the specific locations along the Chehalis River.

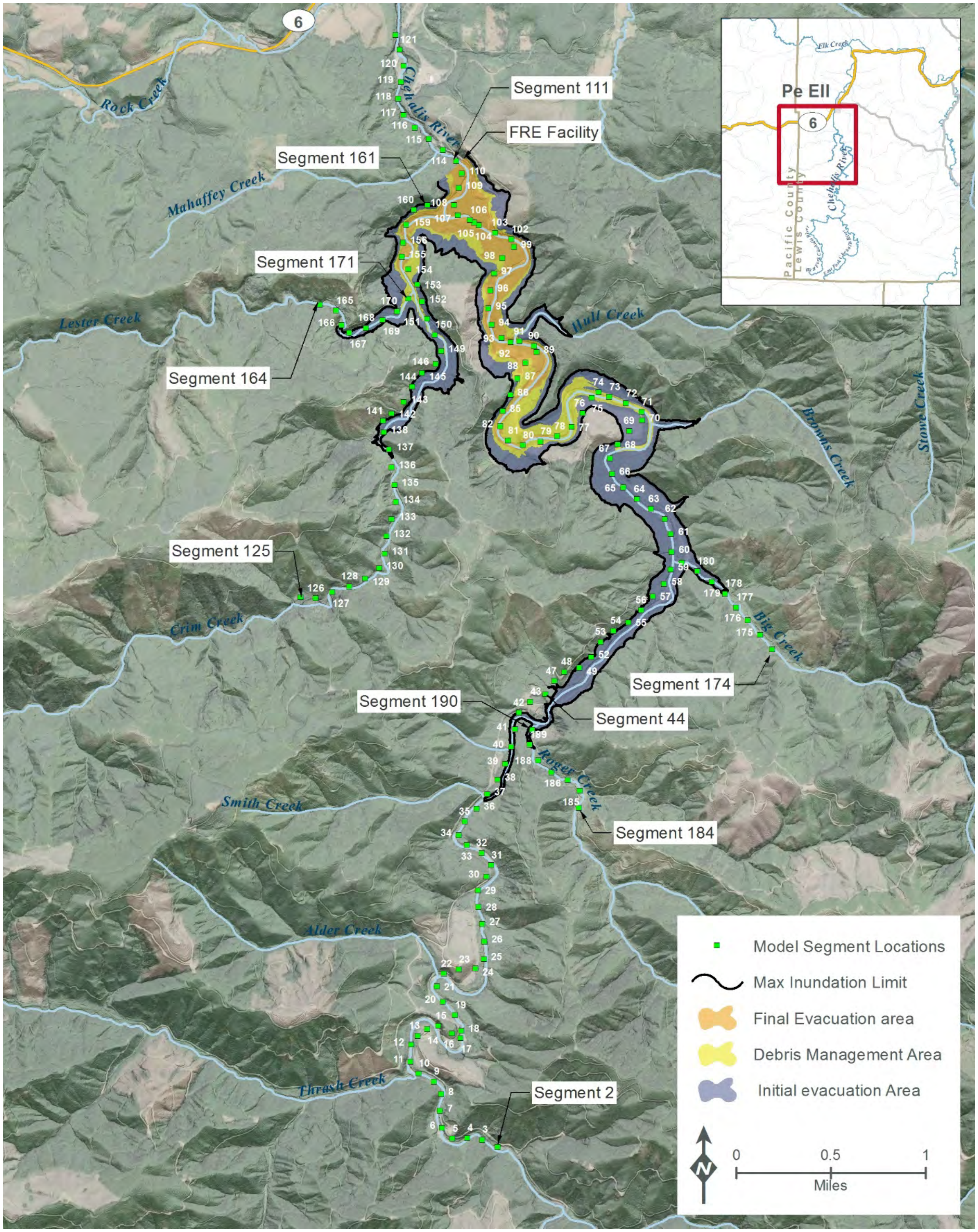

Figure 1. Locations of Footprint Model Segments (Modified from PSU 2017)

Note: The symbology for Model Segment Locations (green squares) signifies the center-point of the model segment. In the model, segments are connected from the upper to lower boundaries, have a length equal to the reach of flow modeled and are oriented in the direction of flow.

2.3.1 Model Computations of Water Temperature

The following provides an overview of how the model works. Inputs are critical to the predictive abilities of the Footprint Model. Inputs such as flow, water temperature, and meteorological conditions are time-varying boundary conditions for which the quality and frequency of data influences the model predictions. Model inputs that affect the computation of water temperature include the following:

- Channel shape, orientation, and latitude as described in the bathymetry input.
- Meteorological inputs, air and dew point temperature, wind speed and direction, and cloud cover, which affect simulated heat fluxes, including short-wave solar radiation, long-wave atmospheric radiation, evaporation, and conduction.
- Flow at the starting locations for the Chehalis River, Crim Creek, Lester Creek, Big Creek, and Roger Creek along with distributed flow along the modeled segments representing unaccounted tributaries, groundwater, seeps, and springs.
- Water temperature associated with each river, creek, and distributed inflow where it enters the modeled system.
- Shading described by vegetation height, distance from water, density or opacity, time of year (i.e., leaf on or off for deciduous species), and topography.

Of the above list of model inputs the only input modified for this study was the input of shading parameters.

Multiple waterbody applications and peer-reviewed papers are documented in the CE-QUAL-W2 manual (Cole and Wells 2016) and demonstrate the capabilities of the model for predicting changes to water temperature. The model calculations include water surface and bottom heat exchange along with solar radiation absorption within the water column. It is important to understand the model computations because while vegetation heights influence water temperature, so do many other factors within the model as the water moves down the Chehalis River. For the sensitivity analysis described in Section 3, only the shade inputs were changed.

2.3.2 Model Scenarios and Assumptions

The following is a summary of the model scenarios and assumptions made during the modeling for the DEISs. After development of the Footprint Model, multiple scenarios were defined to represent a range of conditions, and appropriate model inputs were developed for each scenario (PSU 2017). The Chehalis River scenarios previously simulated by PSU are documented in the Chehalis Modeling TM (see Table 35 of PSU 2017). The subset of these scenarios specific to the proposed FRE facility and shading are summarized in Table 1 below. In addition to the baseline simulation, PSU ran two scenarios identified as riparian shading and no shading, which were run for the current and climate change conditions. (These scenarios, with different shade inputs, were simulated for the sensitivity analysis as described in Section 4.)

The analysis of current conditions simulated two consecutive years (2013 and 2014) using meteorological data measured at Thrash Creek, computed flow for each sub-basin, and estimated inflow water temperature. The years 2013 and 2014 were used because the proposed project study was underway and field sampling had been completed to support the data needs of the model. Meteorological data from Chehalis River Basin Flood Authority at Thrash Creek were used because the data are from near the proposed FRE facility and include data at a 15-minute frequency. Anchor QEA developed total flow at the proposed FRE facility. This total flow was divided between the upstream boundary condition and the tributary inflow. The division was calculated as the fraction of the sub-basin area divided by the total proposed FRE site area multiplied by the total flow.

The model with climate change simulated 1 annual year based on 2014, with changes in the meteorological, flow, and inflow water temperature. The annual year 2014 was used for climate change because the transit time of water to travel the modeled reach was found to be short and simulating 1 year reduced the model run time for simulation. Meteorological inputs were modified by Anchor QEA (2017) and based on data from the University of Washington; flow multipliers were used to change flow; and inflow water temperature was assumed to increase by the same magnitude as the increase in air temperature.

Table 1. Summary of Footprint Model Simulations Used for the DEIS Water Temperature Prediction

DEIS Scenarios	Condition	
	Current	Climate Change
Baseline	Baseline Meteorology Baseline Inflow Baseline Inflow Water Temperature Estimated Existing Shade	Increased Air and Dew Point Temperature Multiplier Inflow Increased Inflow Water Temperature Estimated Existing Shade
Riparian Shading	Baseline Meteorology Baseline Inflow Baseline Inflow Water Temperature Riparian 2-meter Shade	Increased Air and Dew Point Temperature Multiplier Inflow Increased Inflow Water Temperature Riparian 2-meter Shade
No Shading	Baseline Meteorology Baseline Inflow Baseline Inflow Water Temperature No Shade	Increased Air and Dew Point Temperature Multiplier Inflow Increased Inflow Water Temperature No Shade

The model inputs for current and climate change conditions for air temperature, flow, and water temperature are shown on Figure 2, Figure 3, and Figure 4, respectively.[2] The upstream location was selected because it contributes the greatest amount of flow to the temporary inundation area and subsequently is one of the biggest factors contributing to the downstream water temperature. Climate change is represented in Figure 2 with the air temperature higher than the air temperature for current conditions. The air temperature for climate change was based on the 2014 data (current conditions) but are greater than the current conditions by 2.8 to 4.6°C depending on the month. Dewpoint temperature

[2] Figure 2, Figure 3, and Figure 4 have the date shown on the horizontal axis, the parameter on the left vertical axis for the plot of the current and climate change conditions, and the difference between current and climate change conditions for the parameter on the right vertical axis.

inputs were adjusted by a similar amount. Figure 3 shows the flow at the upstream boundary condition. Flow for climate change are the 2014 data (current conditions) but are shifted to reflect anticipated impacts due to climate change. Figure 4 shows water temperature associated with the flow at the upstream boundary condition. Water temperature for climate change was based on the 2014 data (current conditions) but are greater by the same amount as the increase in air temperature depending on the month.

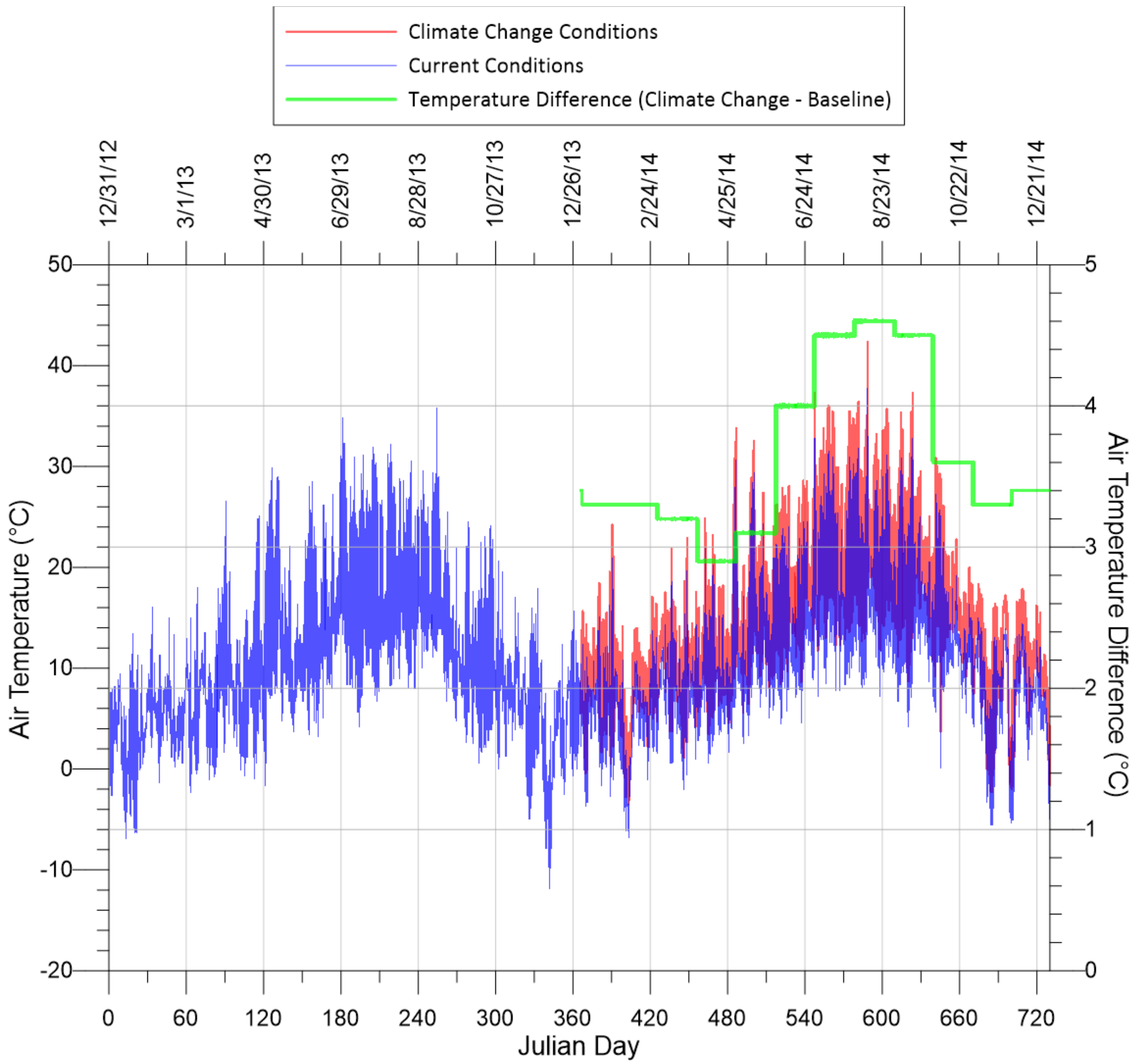

Figure 2. Air Temperature Model Inputs Current and Climate Change Conditions and Difference (second y-axis)

Note: Scenarios with climate change used a 1-year simulation based on 2014.

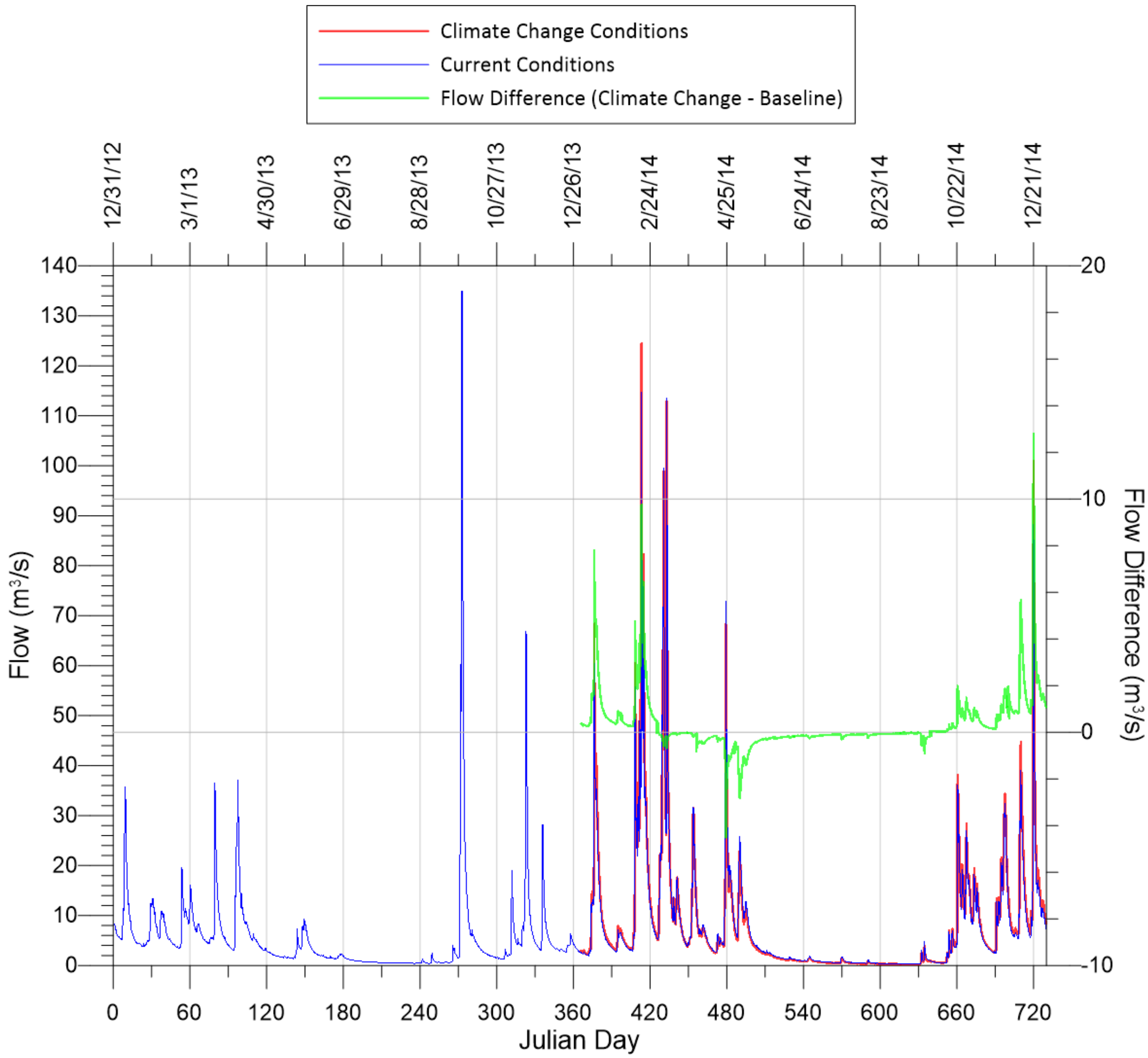

Figure 3. Chehalis River Flow Model Inputs Current and Climate Change Conditions and Difference (second y-axis)

Note: Flow multipliers for climate change (2014) were developed by Anchor QEA. The upstream boundary condition flow and the tributary flow were multiplied by these multipliers for climate change. Flow multipliers were January 1.129x, February 1.085x, March 0.994x, April 0.938x, May 0.889x, June 0.851x, July 0.817x, August 0.785x, September 0.813x, October 1.055x, November 1.058x and December 1.145x.

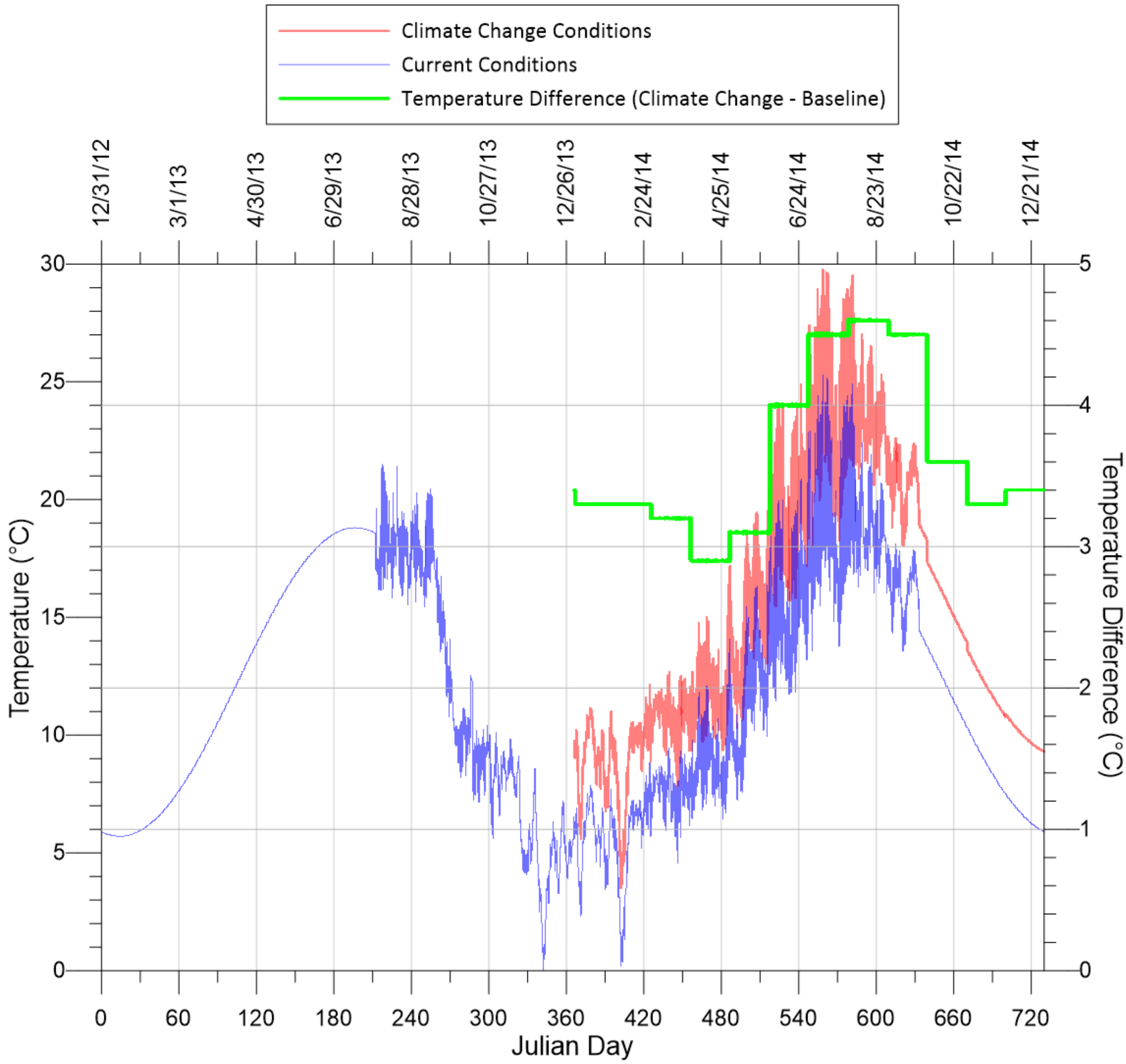

Figure 4. Chehalis River Water Temperature Model Inputs Current and Climate Change Conditions and Difference (second y-axis))

Note: Current conditions inflow water temperature was developed by Anchor QEA (2017) using measured data and a sinusoidal function that was fitted to monthly medians of the historical data (1977 to 2015) when data were not available.

The baseline scenarios under the current and climate change conditions were simulated using estimated vegetation heights for shade. The vegetation heights for the baseline scenarios were based on the following:

> "…vegetative shading data did not exist in the footprint model area. Vegetative shading was assumed to be equivalent to vegetative shade in branch 1 of the downstream model, which is the river reach extending for 2 km directly downstream of the dam location" (PSU 2017).

For the SEPA DEIS, two vegetation scenarios were simulated: riparian shading and no shading. For riparian shading, the "vegetation in the deciduous riparian shrubland area was assumed to be 2-meter high and used a shade reduction factor of 0.5" (PSU 2017). In the model, vegetation heights are inputs for each segment, with one input for the left bank and one input for the right bank. The input vegetation height is the same for the length of the model segment (either 150 meters or 152.4 meters). In the model, each segment has a bottom elevation, and the vegetation height is added to the bottom elevation to calculate the vegetation elevation. The channel-bottom elevation, along with the vegetation elevations in baseline and riparian shading scenarios, are shown in Figure 5, and the vegetation elevations in baseline and no shading scenarios are shown in Figure 6.[3] The model segments for which the riparian shading and no shading scenario elevations are lower than the baseline scenario vegetation elevations correspond to the temporary inundation area. Figure 5 and Figure 6 show the baseline scenario vegetation to be a repeating pattern, and the riparian shading and the no shading scenarios to be of mostly uniform elevations. These elevations do not provide an accurate representation of existing or planned conditions and thus led to the benefit of performing the sensitivity analysis.

[3] Figure 5 and Figure 6 show the model segments along the x-axis with the highest elevation on the left corresponding to the upstream boundary and the lowest elevation on the right corresponding to the proposed FRE facility. Numbering of model segments starts at 2 for the upstream boundary and increases downstream (unlike other numbering systems such as river miles). A list of specific locations corresponding to model segments, such as the proposed FRE facility at Segment 111, is provided in Section 2.3.

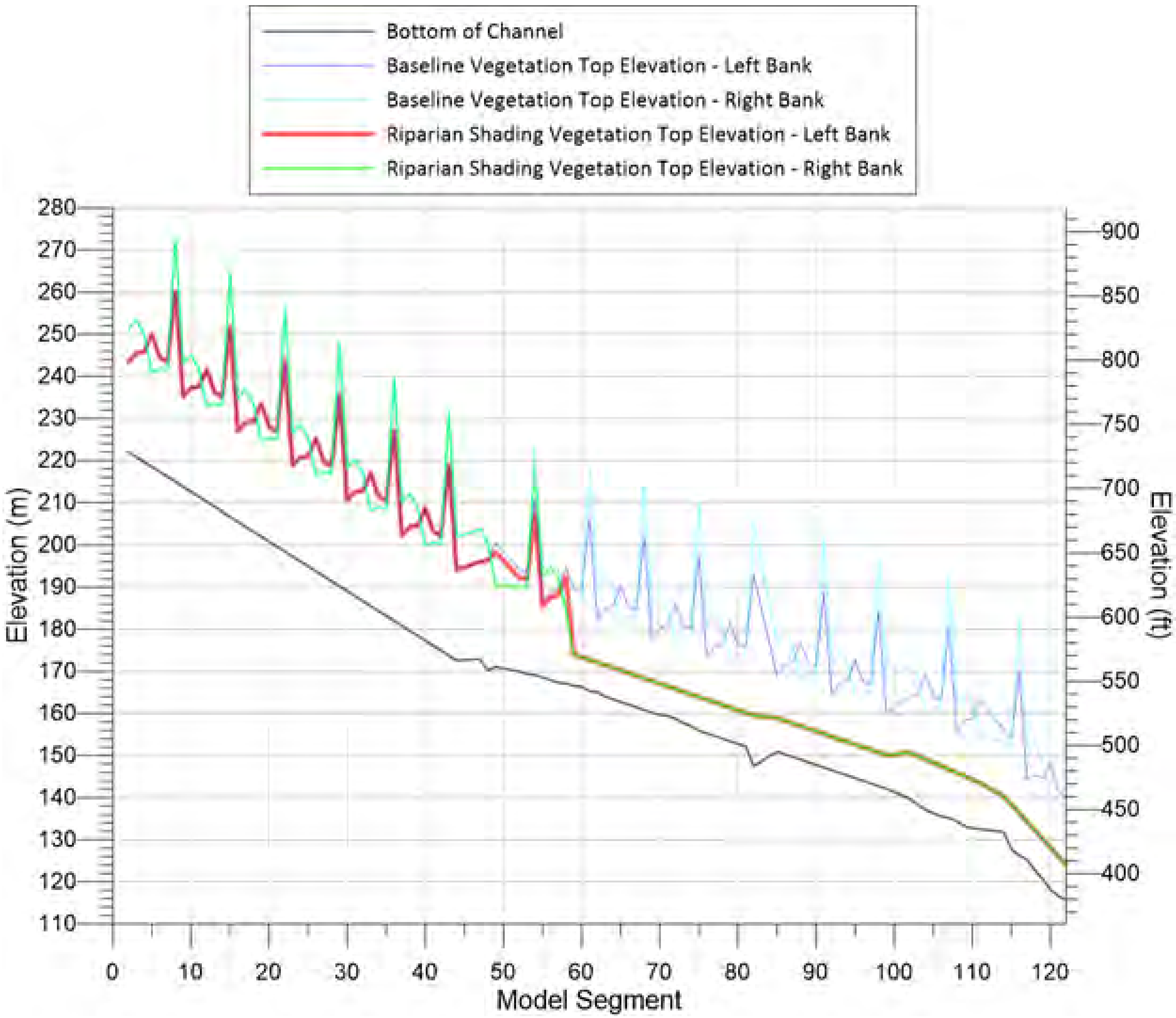

Figure 5. Chehalis River Channel Bottom with Top of Vegetation Elevation Model Inputs for Baseline and Riparian Shading Scenarios

Note: For the "Riparian Shading" scenario, a 2-meter vegetation height was assumed in the temporary inundation area.

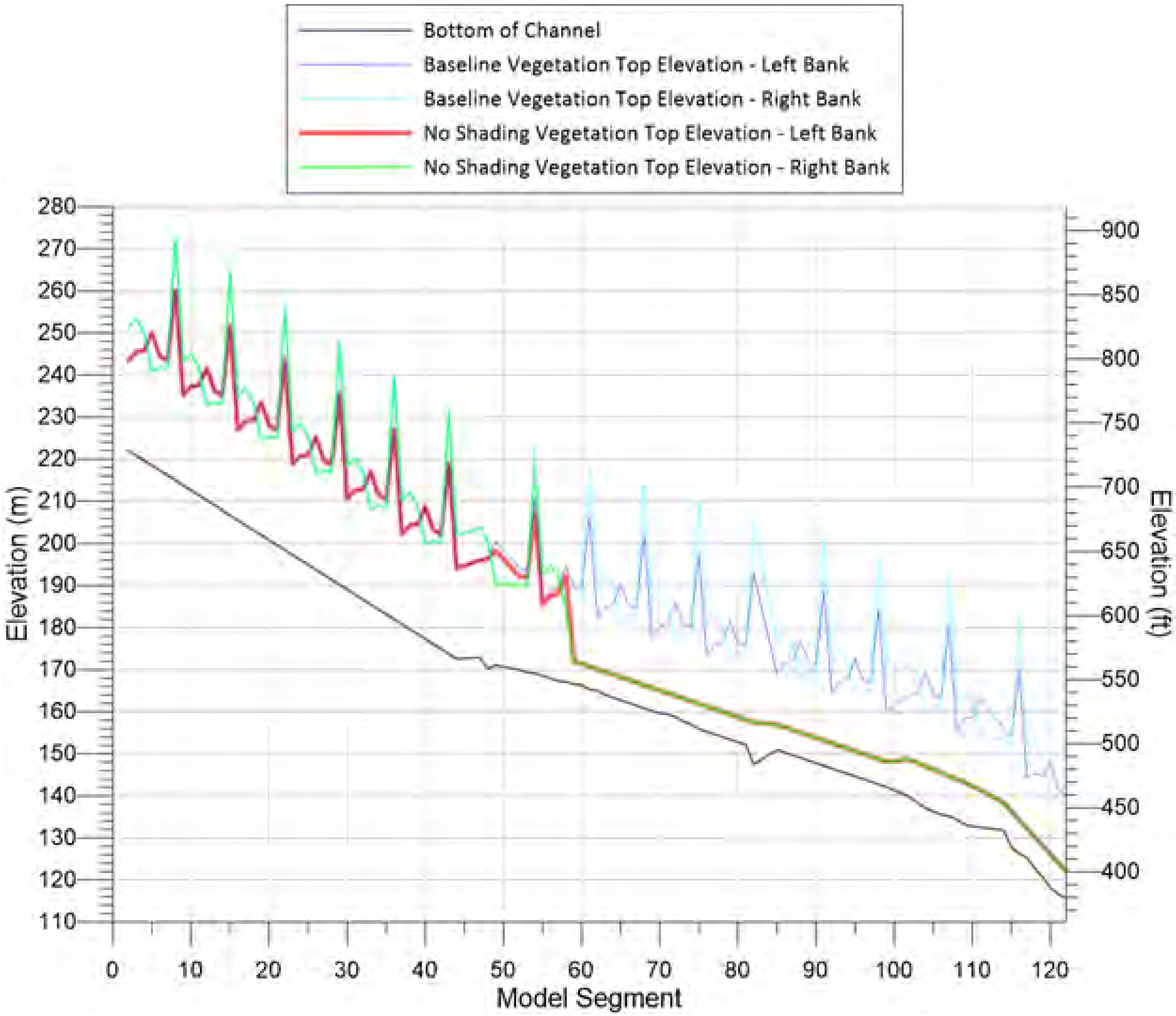

Figure 6. Chehalis River Channel Bottom with Top of Vegetation Elevation Model Inputs for Baseline and No Shading Scenarios

Note: For the "No Shading" scenario, a 0-meter vegetation height was assumed in the temporary inundation area.

2.3.3 CE-QUAL-W2 Model Outputs and Analysis

The model can be set to output water temperature for any segment, time-step, or depth in the water column. For the Footprint Model, "daily maximum temperature predictions at the proposed dam location for current and climate change conditions…" were output and graphed (PSU 2017). The modeling results were provided for the development of the DEISs.

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3 Methods for Water Quality Modeling Sensitivity Analysis

The purpose of the water quality modeling using the Footprint Model is to perform a sensitivity analysis of the modeled water temperature predictions to changes in vegetation heights. If it is determined that water temperature is influenced by changes in vegetation height, then this sensitivity analysis may inform the refinement and implementation of a VMP. The hypothesis is that higher vegetation, when compared to lower vegetation, in the riparian zone provides greater shading; thus, there is less solar radiative heating, and therefore water temperature increases are minimized. As described in Section 2.3, the baseline scenario under current conditions used in the SEPA and NEPA DEISs were estimated using vegetation data from a river reach downstream of the proposed FRE facility. The current modeling work included an updated baseline scenario with vegetation base on recent site-specific information that characterized existing vegetation within the temporary inundation area. The continuous water temperature error statistics from the model for the DEIS analysis were compared with those using the updated baseline vegetation heights and found to have improved by 0.01 to 0.06°C. Model scenarios were developed to investigate the relationship between vegetation height and water temperature. In this context, the vegetation height input to the CE-QUAL-W2 was changed, and the model simulated the specified conditions for each scenario to predict water temperature. The results are summarized in Section 4.

3.1 Existing Riparian Vegetation

An objective of the sensitivity analysis was to use the same Footprint Model scenarios used in the SEPA and NEPA DEISs to evaluate revised riparian shading as proposed by the Conceptual VMP on water temperature. The vegetation heights for the existing conditions modeling (baseline scenario) were reviewed during preparation of the model scenarios for the sensitivity analysis.

A review of available data since the Chehalis Modeling TM (PSU 2017) identified more recent light detection and ranging (LiDAR) data providing a three-dimensional representation of the landscape, including vegetation heights and bare earth elevation. These data were collected between 2015 and 2019 by the Washington Department of Natural Resources, and the resulting data files were used to calculate the updated baseline scenario vegetation conditions. The processing of the LiDAR data consisted of using Geographic Information System (GIS) to plot specific locations (every 10 feet) along the riparian area. These locations are referred to as nodes. A distance of 50 feet offset from the stream edge was used to create the riparian offset buffer.

The process of creating node data started with downloading accurate LiDAR data that have the components of both surface and terrain. Digital surface models (DSM) ignore objects such as trees and give the elevation of the surface of the ground. Digital terrain models (DTM) represent their elevation data including terrain objects such as trees. Using these data, the difference between the two elevation models and the canopy height of trees was calculated.

The Node Data Line is the linear feature that has a Node every 10 feet. This feature is a line that is offset 50 feet from the Observed High-Water Mark . A distance of 50 feet from the edge of the river was chosen because it lies clearly within the riparian buffer, and woody plants (particularly trees) could be expected to shade the river at this distance. Furthermore, this distance is far enough away from the river for the data to reflect more long-term established vegetation and less likely to encounter a roadway or clearcut area. The Node Data are created by placing a data point every 10 feet along the Node Data Line using the ArcGIS tool "Generate Points Along Lines."

An important feature of vegetation management includes expected vegetation survivability based on the depth and duration of inundation when the proposed FRE facility is operating (see Attachment A – Conceptual VMP). The temporary inundation area of the proposed FRE facility are documented in the FRE Facility Temporary Reservoir Inundation and Vegetation Analysis Clarification (HDR 2020).[4] The results of the inundation mapping show that the maximum pool water surface elevation(WSEL) of the Initial Reservoir Evacuation area will range between 620 and 568 feet. The acreage of inundation above 528 feet (lower limit of the Initial Reservoir Evacuation area) will range between 238 and 527 acres, and the duration of inundation will range between 5.9 and 11.1 days. The Debris Management Evacuation area will have 122 acres of inundation between WSEL 528 and 500 feet and will be inundated between 20.2 and 25.2 days. The Final Reservoir Evacuation area will have 159 acres of inundation between WSEL 500 and 425 feet. This area will be inundated at least 26 days under each flood event and up to 32 days under the event of record (historic 2007 flood event). Inundation zones at Mud Mountain Dam were approximated using the same relative distances in elevation as those defined at the proposed FRE facility.

The attributes from the previously mentioned data (DSM, DTM, digital height models [DHM], Evacuation Zone) are added to the Node attributes by using the ArcGIS tool "Extract Values to Points" for all LiDAR-based layers and by using a SQL selection to determine the Inundation Zone into which each point falls. Once the Node Data are established to include the DHM, DTM, DSM, and Inundation Zone values for each specified location in an ArcGIS feature class, the "Table to Excel" tool in Arc Map is used to export the attribute data for the points to an Excel table for data analysis.

Figure 7 presents the mapping results of the temporary inundation area and the Node Data locations at the proposed FRE facility. The results of the GIS analysis of the LiDAR data resulted in a spreadsheet table listing left or right bank, segment reach, DTM elevation (bare earth), DSM (first return), and the DHM (DSM minus DTM). Multiple heights were provided because the GIS analysis used a shorter interval than the model segment length. The heights were averaged for each model segment. The model uses

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[4] The District provided the referenced document (HDR 2020) with the District's comments to Ecology's DEIS and also included as Appendix D to the Biological Assessment and the Essential Fish Habitat Assessment submitted to the USACE on September 18, 2020.

one vegetation height value for each of the 138 model segments. An average height was used to approximate vegetation heights across each model segment and discount anomalous vegetation (abnormally high or low) that may have little effect on the shading provided within the entire model segment. The heights for the left and right banks were then paired and aligned to the segment numbers in preparation for the model shade input file, where the variable treetop elevations on the left and right banks were revised for each model segment (see Attachment B).

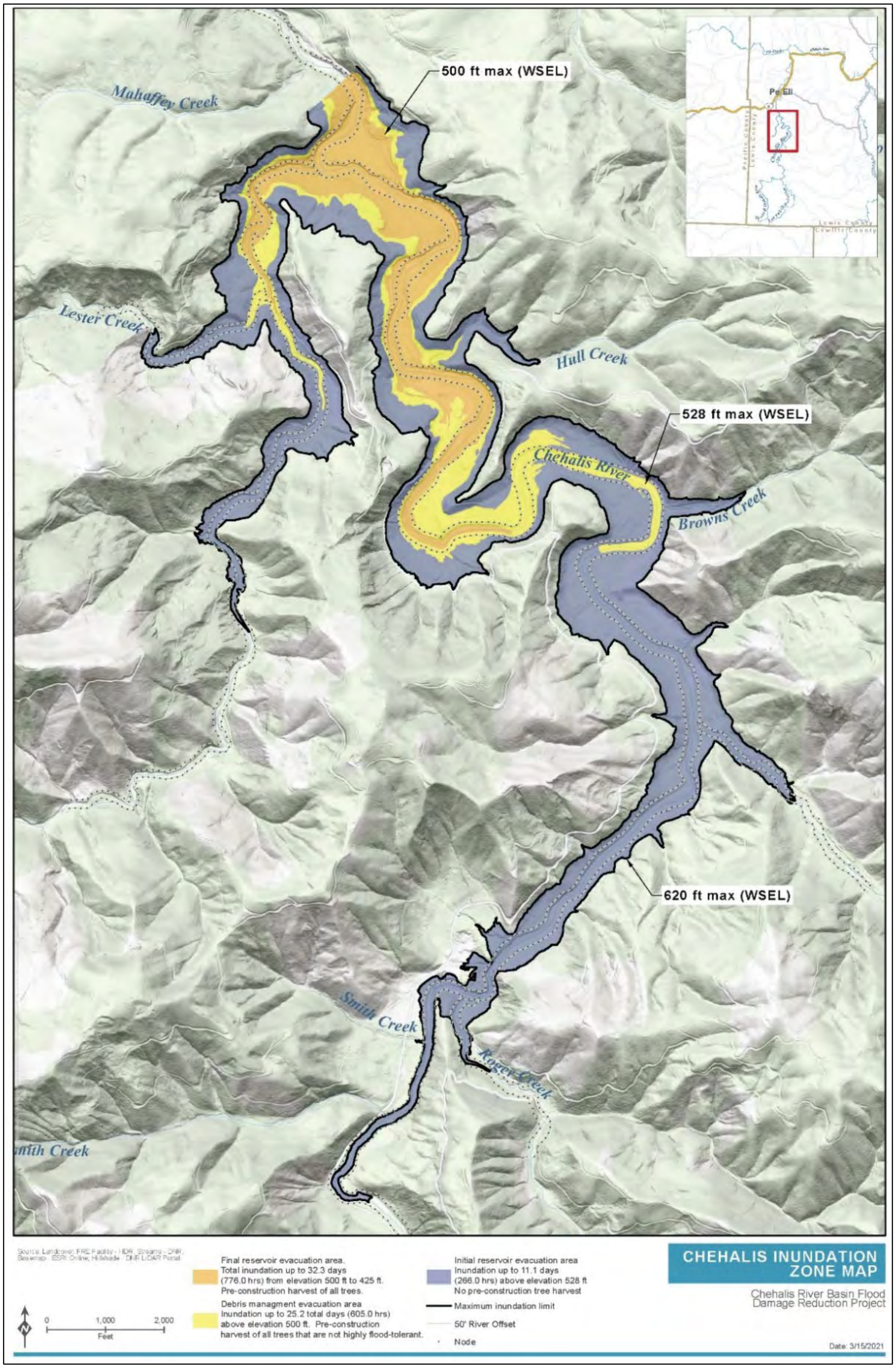

Figure 7. Proposed FRE Site Temporary Inundation Area with Three Inundation Zones with Identified Node Locations for GIS Analysis of Riparian Vegetation

3.2 Scenario Riparian Vegetation

The vegetation scenarios used in the sensitivity analysis were selected to conceptually represent two vegetation conditions: low and high vegetation growth. The low vegetation scenario was selected to represent a volunteer vegetation community comprised mostly of willows throughout the temporary inundation area. The high vegetation scenario was selected to represent a varying height condition that could result from active vegetation management, including active thinning, planting, and replanting flood-tolerant species that reach normal heights in maturity for the temporary inundation area within three inundation zones, the initial evacuation zone, the debris management zone, and the final evacuation zone. The anticipated riparian vegetation height used in this sensitivity analysis was informed by review of the plant communities documented at Mud Mountain Dam, a similar flood storage project located on the White River in western Washington.

3.2.1 Mud Mountain Dam Vegetation as an Analog

Mud Mountain Dam, developed by the USACE in the 1940s, was identified by the project team as a comparative reference facility to help understand how vegetation and specific plant species respond to repeated episodic inundation within a temporary reservoir managed for flood hazard mitigation. Mud Mountain Dam is located in Pierce County and temporarily impounds the White River during storm events. The facility was constructed solely to control flood impacts; it floods to similar depths and for similar durations compared to those of the proposed FRE facility and is located within the same physiogeographic province as the proposed facility. Since its construction in the 1940s, the USACE has not implemented any form of vegetation management within the Mud Mountain Dam reservoir footprint. The vegetation was cleared and removed when the facility was built, and volunteer vegetation established and propagated itself without management resulting in the present-day vegetation communities. An important difference between Mud Mountain Dam and the proposed FRE facility is the frequency of operations and subsequent inundation of vegetation communities. Mud Mountain Dam typically operates multiple times annually, so the vegetation communities are frequently inundated (at least once each year and more than once each year in most years). This is in contrast to the proposed FRE facility, which will operate approximately every 7 years as stated in the SEPA DEIS (Ecology 2020a), resulting in less-frequent inundation of the vegetation communities compared to Mud Mountain.

The Mud Mountain facility is an important reference site to help inform anticipated woody vegetation heights in response to the expected inundation from operation of the proposed FRE facility. Since there are differences in the geology, soil conditions, hydrology, and other characteristics between the Chehalis River Basin and the White River Basin, the Mud Mountain Dam example is not intended to represent an exact comparison of the proposed FRE facility operations. The importance of the Mud Mountain example is to inform the VMP for the proposed FRE facility by suggesting woody plant species that are likely to survive frequent inundation. The specific species can be used to replant the area of the temporary inundation area during implementation of the VMP. In addition, review of the Mud Mountain facility provides a projection of future vegetation communities that are likely to persist in the temporary inundation area.

Mud Mountain was selected as a reference facility to inform assumptions for vegetation heights in the CE-QUAL-W2 model. The project team reviewed the following elements of the Mud Mountain facility:

- Operations
- Vegetation succession based on a recent vegetation study
- Vegetation height data based on LiDAR data
- Mud Mountain flooding regime data

The vegetation distribution within the Mud Mountain temporary reservoir provided by a recent Engineer Research and Development Center study of the Mud Mountain facility (USACE-ERDC, Environmental Laboratory 2019) shows that an assemblage of woody plants is able to survive regular winter inundation events. In the immediate vicinity of the Mud Mountain Dam, plants are typically shorter, increasing in height farther upstream from the facility. Woody plants, particularly Sitka willow (*Salix sitchensis*), occur throughout the reservoir, including at the lowest elevation reach of the facility. Trees, including Black cottonwood (*Populus balsamifera*), Red alder (*Alnus rubra*), and Sitka spruce (*Picea sitchensis*), are established within the flooded part of the reservoir.

Existing vegetation heights at the Mud Mountain Dam inundation area were also calculated using LiDAR data provided by the Washington Department of Natural Resources. Similar methods were used at Mud Mountain to make the data comparable to data for the proposed FRE facility (see Section 3.1). To complete this exercise at Mud Mountain, the edge of the White River through the inundation area was digitized and riparian offset transects (nodes) were developed at which vegetation height data were calculated. The table showing the results of this exercise is included as Attachment C. The heights of vegetation used for the sensitivity analysis were based on the typical mature heights of the species of plant that was mapped at the Mud Mountain facility for each of the flooding regimes. LiDAR data were used to validate the baseline assumption that woody plants would cover the inundation area but were not used to prescribe future tree heights because several other factors, independent of the flooding regime, may influence actual tree heights, including sediment loading, surficial geology, recruitment, and aspect. The tallest tree heights at Mud Mountain appear to be taller than the model inputs, and portions of the inundation area contain low-growing vegetation, but when averaged over the inundation area, the heights were approximately 28 feet. The temporary inundation area with three inundation zones that indicate depths of flooding similar to those at the proposed FRE facility are shown on Figure 8.

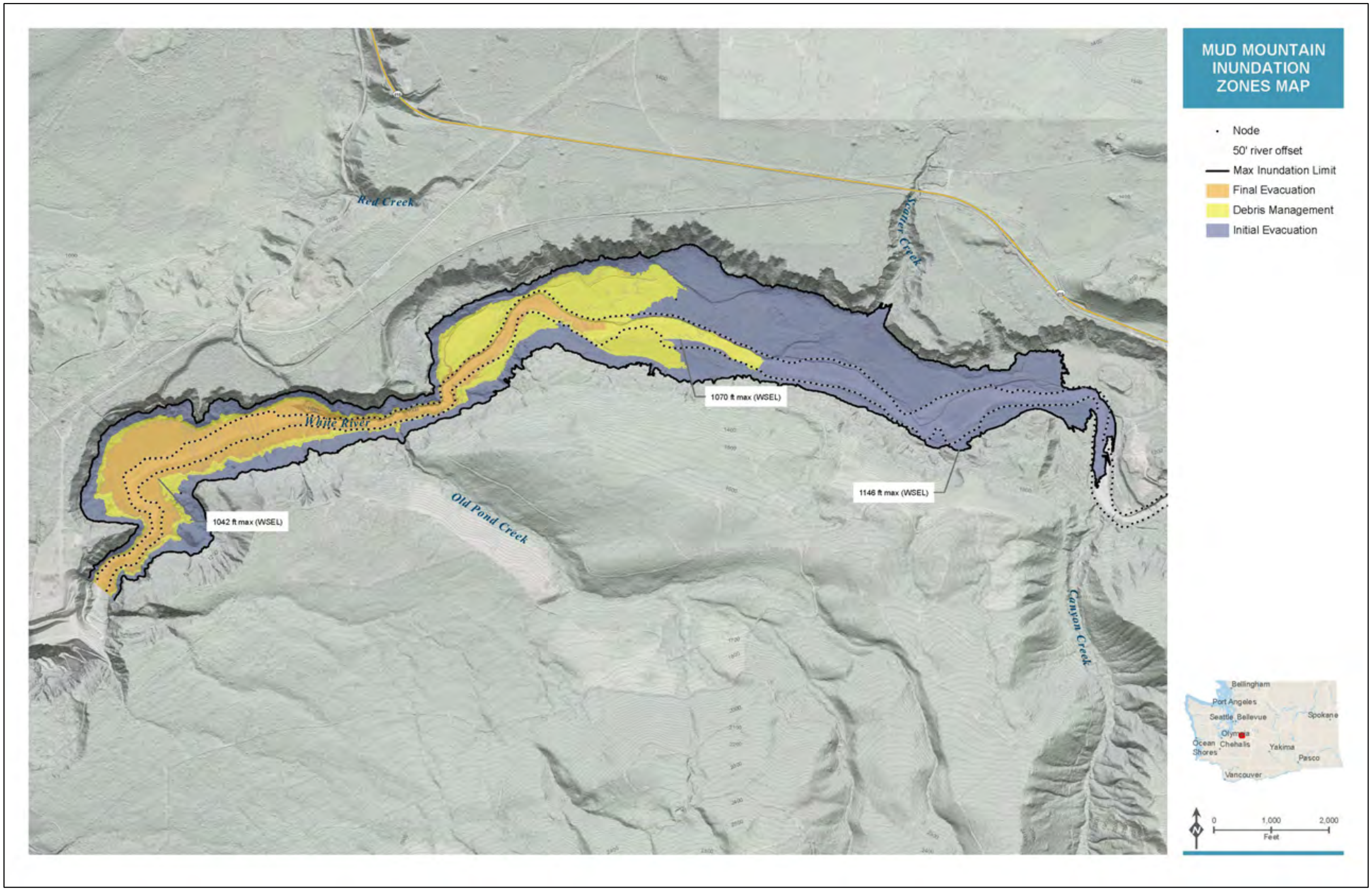

Figure 8. Mud Mountain Temporary Inundation Area with Three Inundation Zones

3.2.1.1 Future Riparian Vegetation Heights

In addition to the 2-meter vegetation height selected for use in the model within the DEIS documents, two other vegetation heights were selected. These include a low vegetation scenario that is based on a lower overall vegetation height composed mostly of volunteer willows, and a high vegetation scenario that anticipates that some woody vegetation and trees may survive inundation and the positive effects introduced by active vegetation management within the temporary inundation area.

The low vegetation scenario vegetation height assumes that existing vegetation will be removed throughout the temporary inundation area because the existing vegetation will not tolerate flooding. Subsequently, woody vegetation, comprised primarily of Sitka willow and other willow species, will recolonize the affected land and will achieve a mature height of at least 20 feet. Sitka willow grow to a mature height of 30 feet according to the United States Department of Agriculture, Natural Resources Conservation Service (USDA, NRCS) PLANTS database (2021). They are a common riparian shrub found throughout the Pacific Northwest and common within the Mud Mountain facility and are appropriate for the proposed FRE site. The 20-foot height is also validated within the Mud Mountain vegetation height data, as the average riparian vegetation height at Mud Mountain is approximately 28 feet, even though some parts of the Mud Mountain facility have lower and higher vegetation.

The high vegetation scenario segregates vegetation heights based on the three inundation zones that were identified in the inundation analysis (HDR 2020) and described in the Conceptual VMP (Attachment A). Under this scenario, the Final Evacuation Area (the lowest part of the temporary reservoir and the area that would be inundated for the greatest duration) would have the lowest vegetation height, modeled at 20 feet. The Debris Management Zone (the middle portion of the temporary reservoir) would be expected to retain some residual vegetation and be actively planted with flood-tolerant species. Riparian vegetation in this zone would be modeled at 60 feet. This height corresponds to the mature height of a Red alder or Oregon ash tree, according to the USDA PLANTS database. The Final Evacuation Zone (the upper part of the temporary inundation area and the area flooded less frequently and inundated for the shortest duration) would be actively managed to promote taller vegetation, and taller trees can be expected to tolerate the flooding conditions anticipated in this zone. A mature vegetation height of 90 feet was selected for the Final Evacuation Zone based on the mature height of Black cottonwood and Sitka spruce. Both species are observed within the upper reaches of the Mud Mountain inundation zone under similar flooding regimes and are present in the vicinity of the proposed FRE facility.

LiDAR estimates of the vegetation heights at the Mud Mountain facility confirm the following:

1) The low vegetation scenario used for the sensitivity analysis is an appropriate worst-case estimation since the average height of vegetation exceeds the model low vegetation height.

2) Taller trees that exceed the model input heights for the high vegetation scenario persist, given the flooding regime.

Choosing the high vegetation height for the input to the model based directly on the observed vegetation heights at Mud Mountain within each flooding zone does not appear to be appropriate. This would ignore the differences in flooding regime, soil type and geomorphology, water temperature, site aspect, and other local factors that affect plant growth. Instead, we selected plant species based on their presence at Mud Mountain and projected these species to an anticipated growth height over a 30-year growth horizon.

3.2.2 Vegetation Scenarios Model Input Shade Files

The baseline shade input file was the starting point for the development of the shade input file for each vegetation scenario. The temporary inundation area corresponds with model Segments 44 (upper limit of the temporary inundation area) through Segment 111 (proposed FRE facility). The baseline vegetation heights were modified only for these segments based on the revised existing vegetation mapping described in Section 3.1. For the low vegetation scenario, the updated baseline vegetation height on both the left and right banks was replaced with a value of 6.1 meters (20 feet) for Segments 44 through 111. For the high vegetation scenario, the updated baseline vegetation on both the left and right banks was replaced with a value of 27.4 meters (90 feet) for Segments 44 through 73, representing the least inundated area with the highest vegetation. The area of intermediate inundation used a value of 18.3 meters (60 feet) for Segments 74 through 86. The area of most frequent and longest-lasting inundation used a value of 6.1 meters (20 feet) for Segments 87 through 111.

The vegetation height is added to the bottom elevation to calculate the vegetation elevation. The channel-bottom elevation along with the vegetation elevations in the updated baseline and low vegetation scenarios are shown in Figure 9, and the vegetation elevations in the updated baseline and high vegetation scenarios are shown in Figure 10[5]. The setup of these figures is the same as described for Figure 5 and Figure 6. Although constant vegetation heights were used, the left and right banks have varying elevations that create the varying vegetation elevations shown in Figure 9 and Figure 10. For the low vegetation scenario, the low elevation of the vegetation in the temporary inundation area is visible. For the high vegetation scenario, the three zones of vegetation heights are visible, although the middle Debris Management Zone is less distinctive due to its short length and variable bank elevations. The segments upstream of the temporary inundation area have the same vegetation elevations as the updated baseline.

[5] Figure 9 and Figure 10 show the model segments along the x-axis with the highest elevation on the left corresponding to the upstream boundary and the lowest elevation on the right corresponding to the proposed FRE facility. A list of specific locations corresponding to model segments, such as the proposed FRE facility at Segment 111, is provided in Section 2.3.

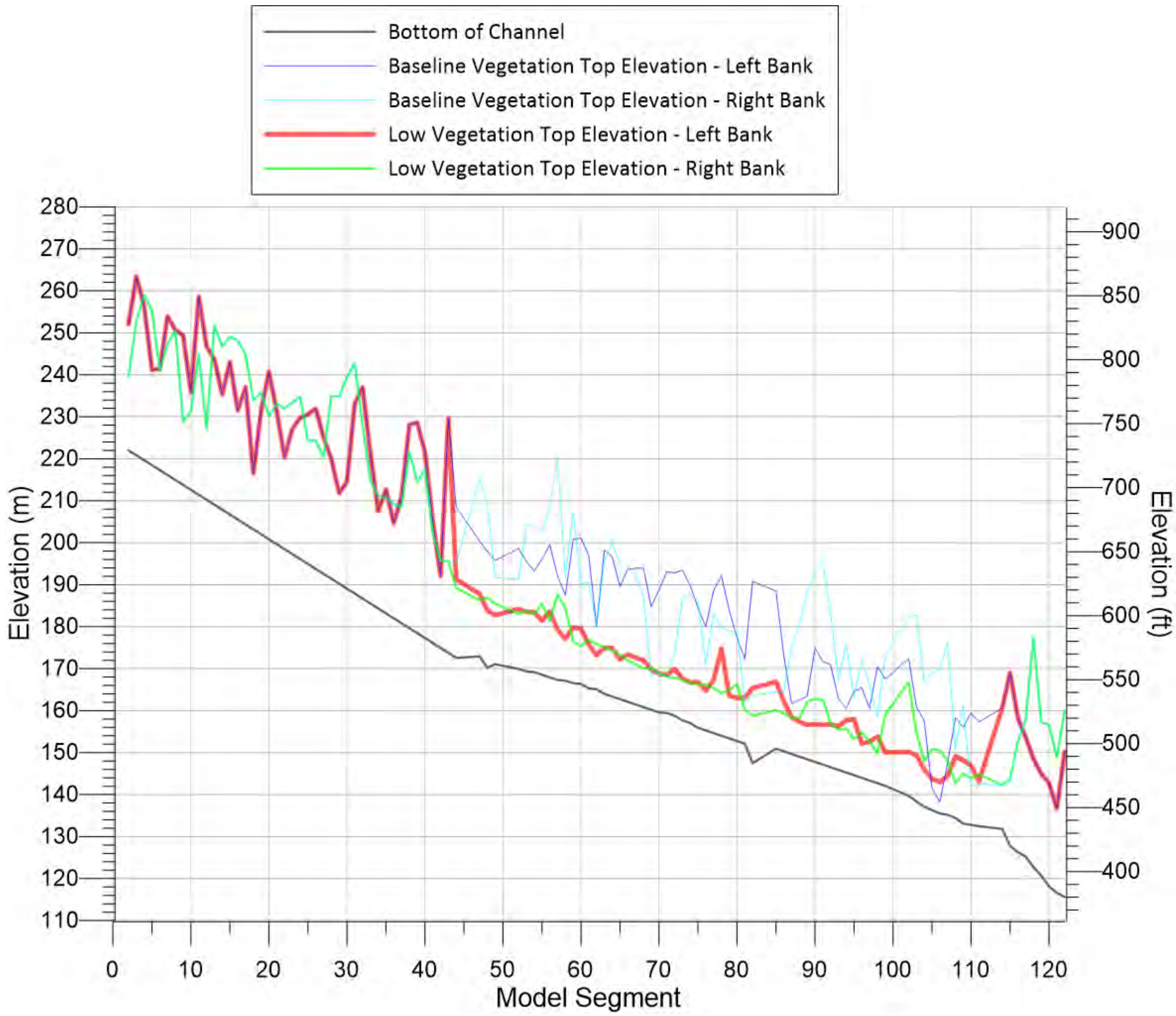

Figure 9. Chehalis River Channel Bottom with Top of Vegetation Elevation Model Inputs for Updated Baseline and Low Vegetation

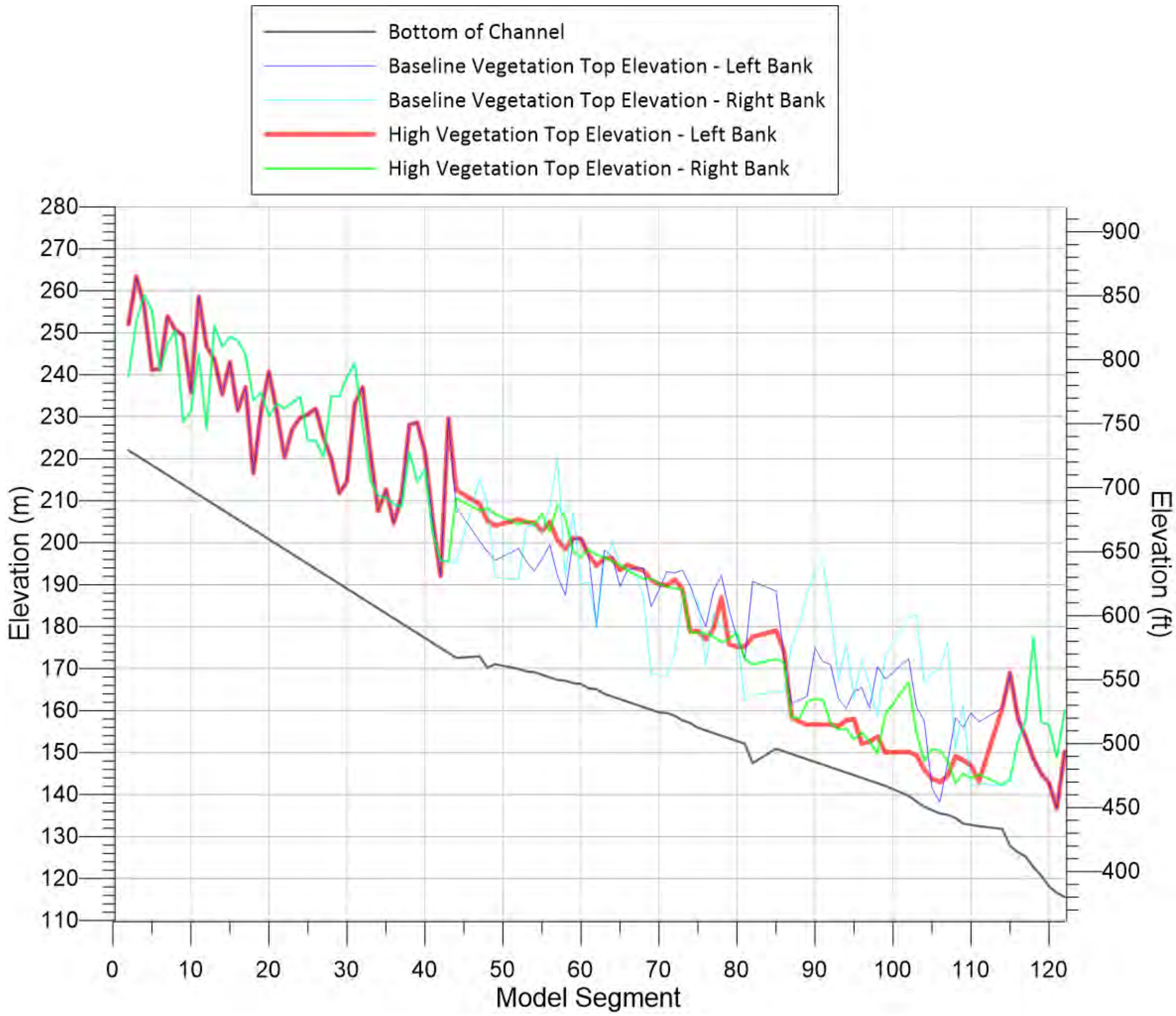

Figure 10. Chehalis River Channel Bottom with Top of Vegetation Elevation Model Inputs for Updated Baseline and High Vegetation

The modeling for the DEIS included a subset of scenarios specific to the proposed FRE facility and shading as summarized in Table 1. For the baseline scenario, the inputs for the vegetation heights were changed to use the vegetation heights calculated based on recent information. Rather than use the DEIS riparian shading and no shading scenarios, the new sensitivity analysis scenarios using vegetation height inputs estimated as high and low vegetation were used. Again, two conditions were simulated for the scenarios—current and climate change—with climate change including increases to air and water temperature inputs and a flow shift. The updated baseline and vegetation scenarios under two sets of conditions resulted in a total of six model simulations for sensitivity analysis, as summarized in Table 2.

Table 2. Summary of Footprint Model Simulations for the Sensitivity Analysis

Sensitivity Analysis Scenarios	Condition	
	Current	Climate Change
Updated Baseline	Baseline Meteorology Baseline Inflow Baseline Inflow Water Temperature Updated Baseline Vegetation	Increased Air and Dew Point Temperature Multiplier Inflow Increased Inflow Water Temperature Updated Baseline Vegetation
High Vegetation (Vegetation Management Plan)	Baseline Meteorology Baseline Inflow Baseline Inflow Water Temperature Riparian Vegetation in Inundation Zones of 6.1, 18.3, or 27.4 meters	Increased Air and Dew Point Temperature Multiplier Inflow Increased Inflow Water Temperature Riparian Vegetation in Inundation Zones of 6.1, 18.3, or 27.4 meters
Low Vegetation (Volunteer Willows)	Baseline Meteorology Baseline Inflow Baseline Inflow Water Temperature Riparian Vegetation in Inundation Area of 6.1 meters	Increased Air and Dew Point Temperature Multiplier Inflow Increased Inflow Water Temperature Riparian Vegetation in Inundation Area of 6.1 meters

4 Model Simulation Results

The CE-QUAL-W2 model was run by PSU using the input scenarios shown in Table 2. Model output (see Attachment D) was post-processed to generate graphs and other statistics of interest. Results of the sensitivity analysis evaluated water temperature response to vegetation shading at the following locations:

- Segment 2 upstream starting location along the Chehalis River.
- Segment 44 the uppermost reach of temporary inundation area during an extreme flood retention event reach.
- Segment 111 proposed FRE facility.
- Segment 122 downstream ending location along the Chehalis River.

These locations provide the model water temperature results upstream of the temporary inundation area, changes through the temporary inundation area, and changes downstream of the proposed FRE facility. Since the regulatory water temperature standard (Washington Administrative Code 173-201A) is based on the 7-day average of the daily maximum water temperature (7-DADMax), the maximum daily water temperature predicted by the model was averaged over a running 7-day period.

4.1 Scenario Results by Location

The 7-DADMax values of the model results are presented for select locations. The comparisons demonstrate the influence of vegetation height on water temperature as predicted by the model for the selected locations.

4.1.1 Segment 2 – Boundary Condition

Water temperature 7-DADMax values at the upstream boundary along the Chehalis River are shown in Figure 11[6]. This location is unaffected by the proposed project and reflects the boundary condition. The scenario results are the same under the current and climate change conditions, respectively, because the vegetation heights were not changed for this location.

[6] Figure 11 and Figure 12 show the approximately 2-year model run time along the x-axis starting 1/1/2013 and ending 1/1/2015 and water temperature (◦C) along the y-axis at the respective model segment. The blue line is the updated baseline scenario under current conditions, and the yellow line is the updated baseline scenario under climate change. The model setup only allowed for climate change to be modeled starting 1/1/2014.

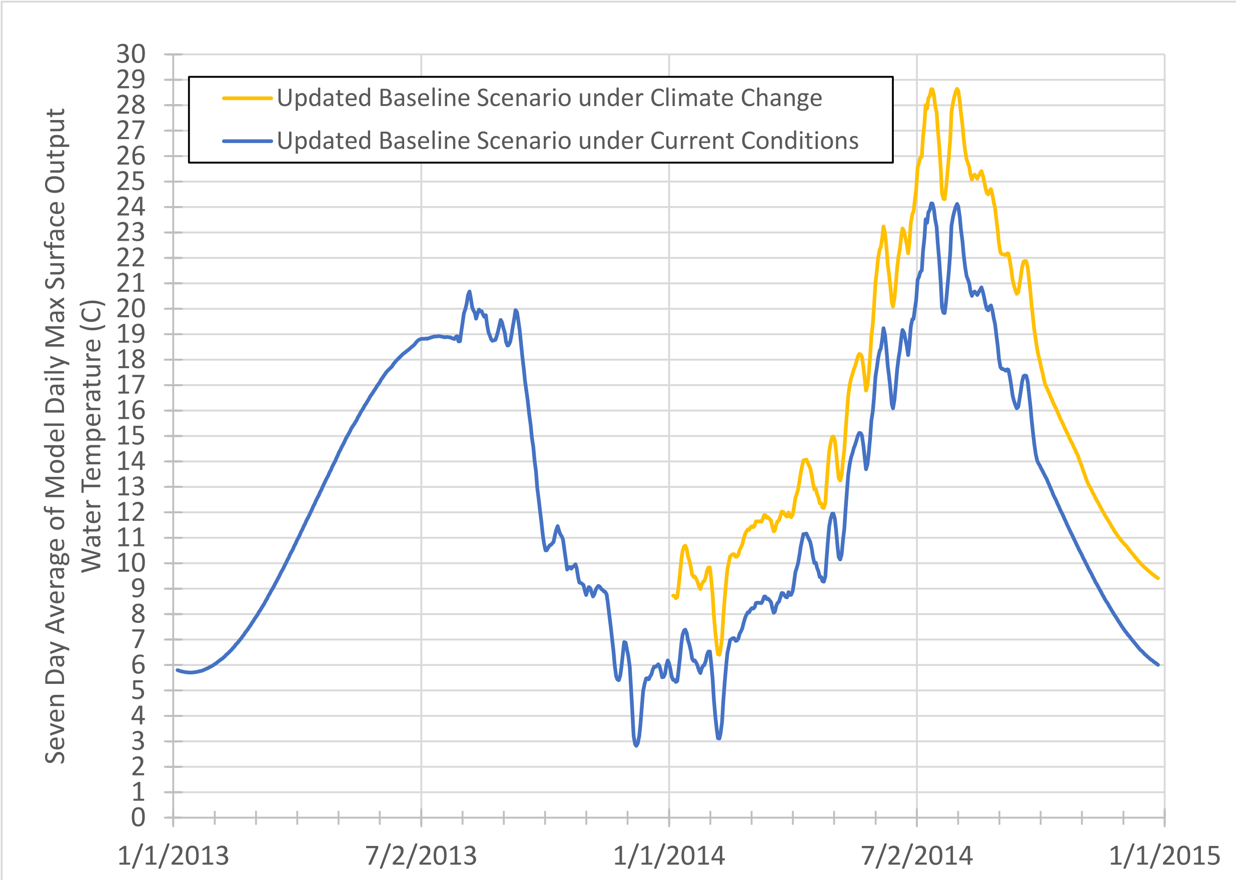

Figure 11. Water Temperature Results as 7-DADMax for Model Scenarios from Segment 2

4.1.2 Segment 44 – Upper Limit of Temporary Inundation Area

Water temperature 7-DADMax values at the uppermost reach of the temporary inundation area during an extreme flood retention event along the Chehalis River are shown in Figure 12. The scenario results are the same under the current and climate change conditions, respectively, because the vegetation heights were not changed for this location or upstream locations.

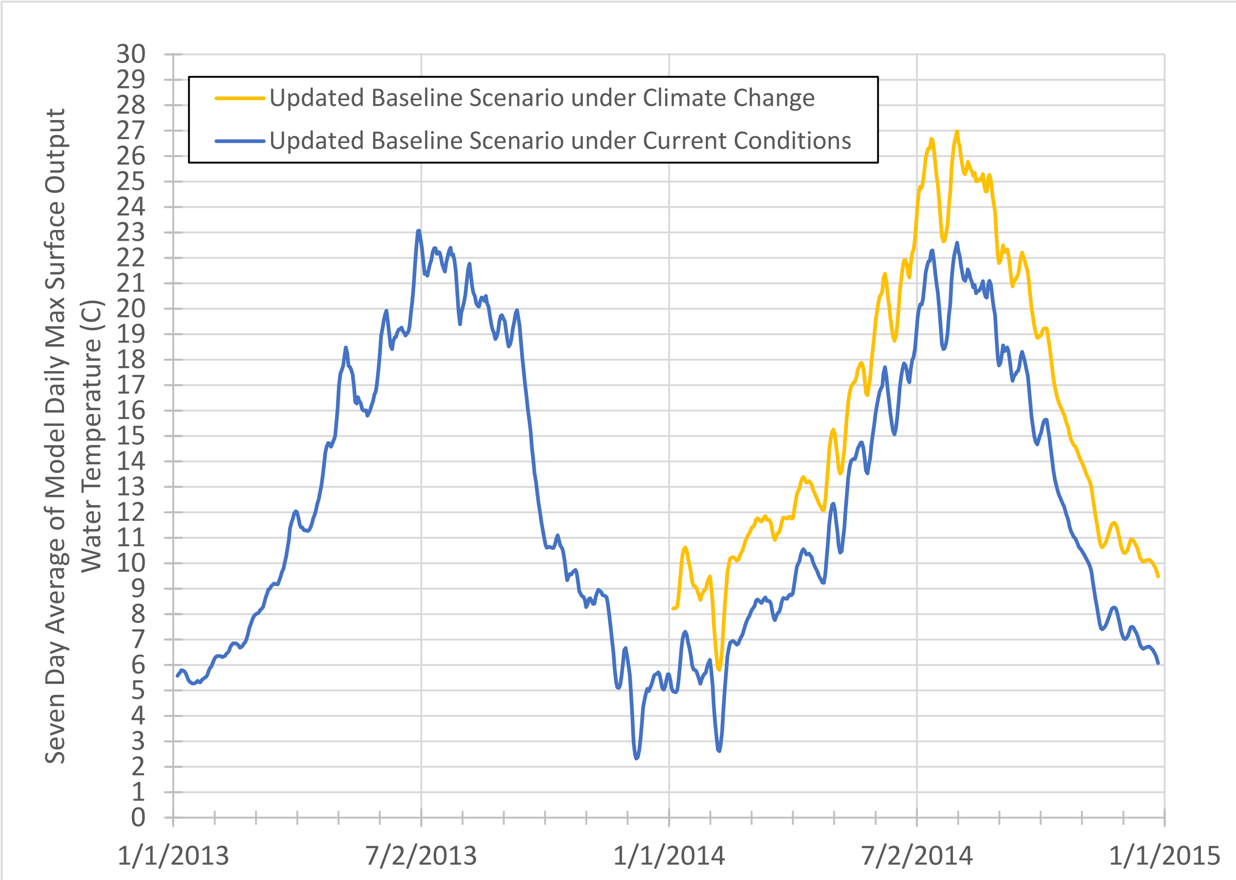

Figure 12. Water Temperature Results as 7-DADMax for Model Scenarios from Segment 44

4.1.3 Segment 111-Proposed FRE Facility

Water temperature 7-DADMax values at the proposed FRE facility along the Chehalis River are shown in Figure 13[7]. At this location, upstream changes to vegetation heights have influenced the model predictions of water temperature. The greatest differences occur between approximately June 20 and September 22. Table 3 provides the statistical differences between the updated baseline scenario and the low vegetation and high vegetation scenarios under both current and climate change conditions during the referenced summer period when flow is lowest. The high vegetation scenarios show an average difference of 0.3°C or less.

[7] Figure 13 and Figure 14 show the approximately 2-year model run (time) along the x-axis starting 1/1/2013 and ending 1/1/2015 and water temperature (◦C) along the y-axis at the respective model segment. In addition to the blue and yellow scenarios provided in the Figure 11 and Figure 12, Figure 13 and Figure 14 provide the additional scenarios for low and high vegetation.

Table 3. 7-DADMax Water Temperature Results at Segment 111 during Low Flow of Summer (June 20 to September 22)

Scenarios Compared	Water Temperature Change (°C)			
	Minimum	Median	Average	Maximum
Low Vegetation Scenario under Climate Change minus Updated Baseline Scenario under Climate Change	0.7	1.0	1.0	1.3
High Vegetation Scenario under Climate Change minus Updated Baseline Scenario under Climate Change	0.1	0.4	0.3	0.5
Low Vegetation Scenario under Current Conditions minus Updated Baseline Scenario under Current Conditions	0.7	1.0	1.0	1.4
High Vegetation Scenario under Current Conditions minus Updated Baseline Scenario under Current Conditions	0.1	0.3	0.3	0.5

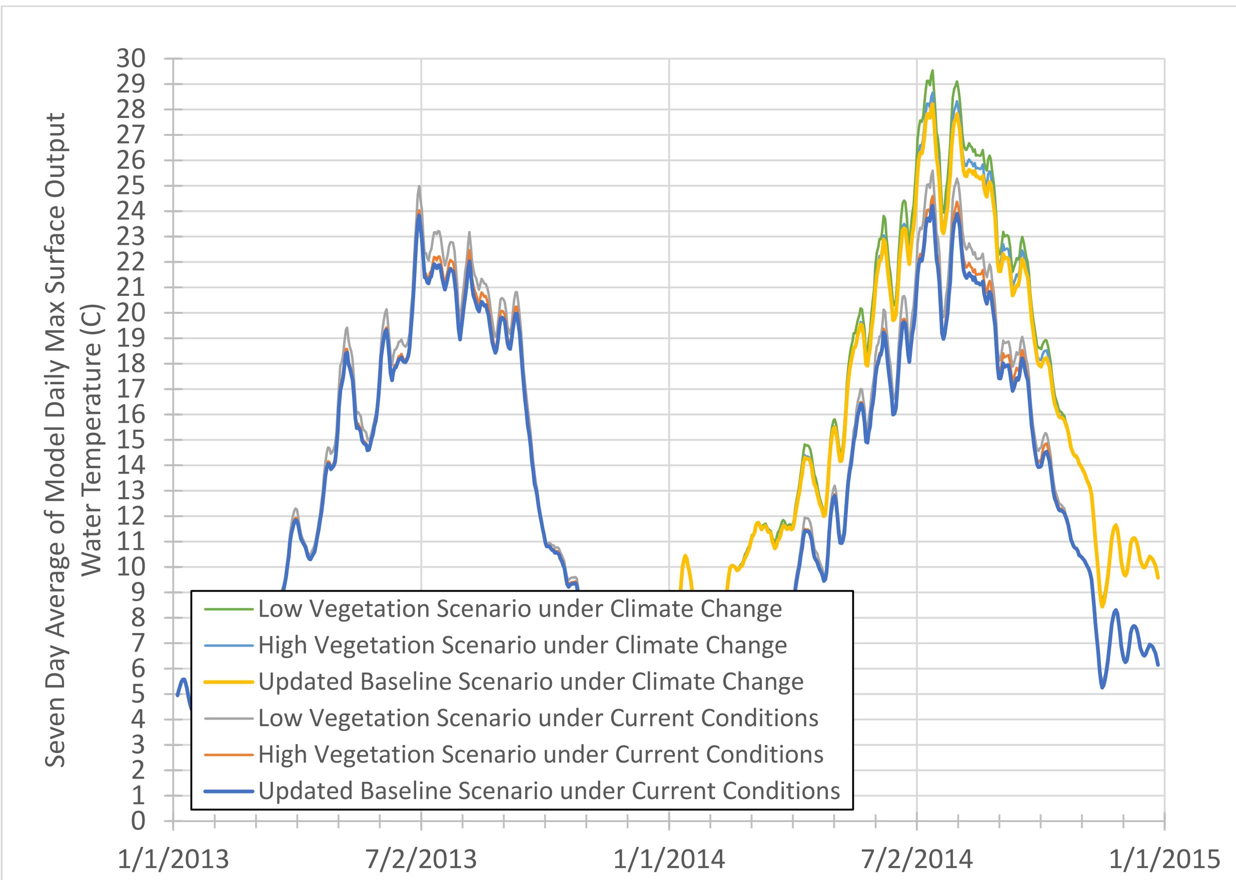

Figure 13. Water Temperature Results as 7-DADMax for Model Scenarios from Segment 111

4.1.4 Segment 122

Water temperature 7-DADMax values at the downstream boundary along the Chehalis River are shown in Figure 14. At this location, upstream changes to vegetation heights have influenced the model predictions of water temperature. The greatest differences occur between approximately June 20 and

September 22. The statistical differences during the referenced summer period are summarized in Table 4. The high vegetation scenarios show an average difference of 0.3°C or less.

Table 4. 7-DADMax Water Temperature Results at Segment 122 during Low Flow of Summer (June 20 to September 22)

Scenarios Compared	Water Temperature Change (°C)			
	Minimum	Median	Average	Maximum
Low Vegetation Scenario under Climate Change minus Updated Baseline Scenario under Climate Change	0.6	0.8	0.8	1.1
High Vegetation Scenario under Climate Change minus Updated Baseline Scenario under Climate Change	0.2	0.2	0.3	0.4
Low Vegetation Scenario under Current Conditions minus Updated Baseline Scenario under Current Conditions	0.6	0.9	0.9	1.1
High Vegetation Scenario under Current Conditions minus Updated Baseline Scenario under Current Conditions	0.1	0.2	0.3	0.4

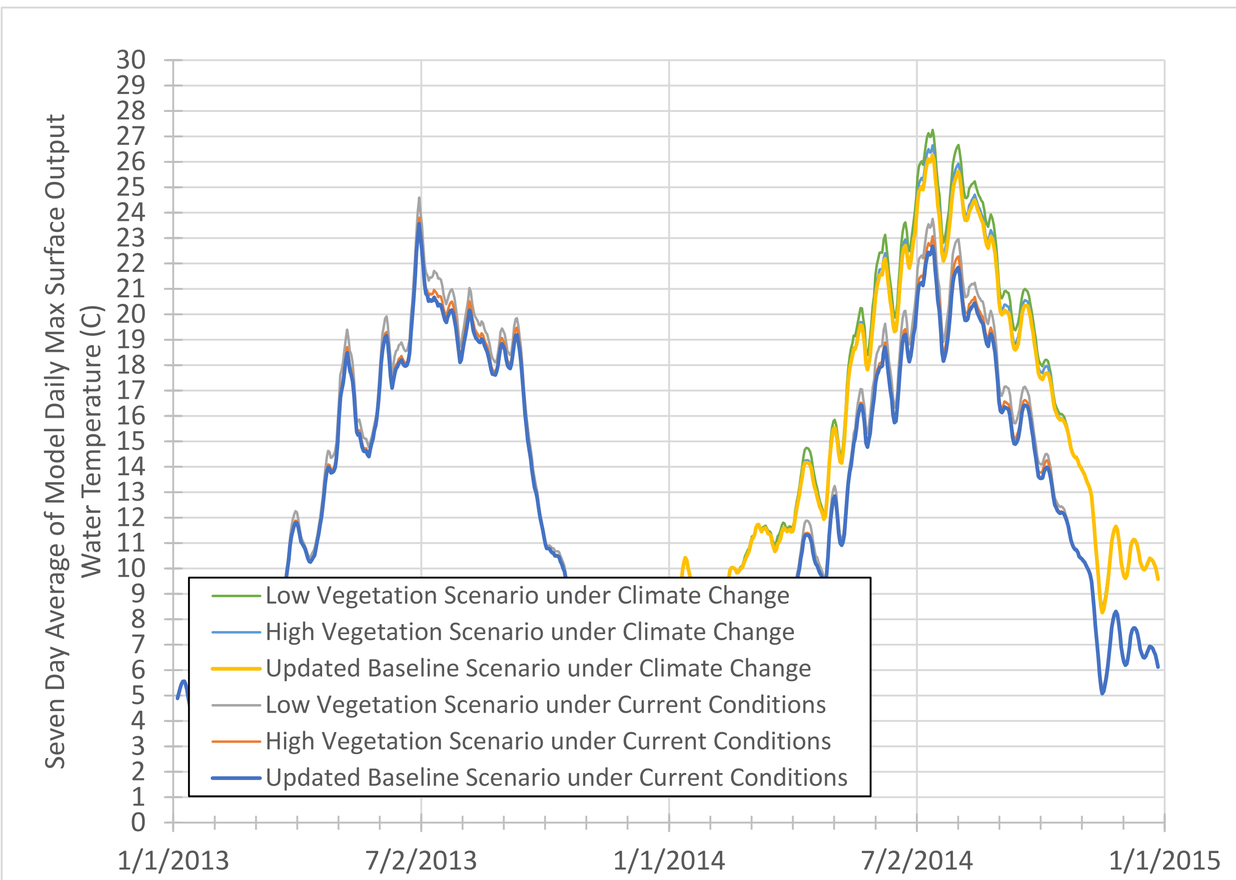

Figure 14. Water Temperature Results as 7-DADMax for Model Scenarios from Segment 122

4.2 Scenario Results Longitudinally

The 7-DADMax values of the model results for the scenarios may be presented as a difference between two select locations as a representation of longitudinal changes. The following figures present the water temperature at Segment 44 (upper limit of the temporary inundation area) and at Segment 111 (proposed FRE facility) from mid-April to mid-October along with the difference. Figure 15 shows the updated baseline scenario. Figure 16 shows the high vegetation scenario. Figure 17 shows the low vegetation scenarios. The three scenarios are under current conditions.

Segment 44 and Segment 111 were selected for the as they represent the upper and lower limits of the temporary inundation area and where vegetation management actions will be implemented. The results are reported for the mid-April to mid-October (2014) as that is when water temperature changes are expected to be greatest due to seasonal variation in solar radiation and hydrologic (flow) conditions.

The results indicate that water temperature moving downstream through the temporary inundation area as exhibited by the difference (green line) between Segment 44 (blue line) and Segment 111 (red line) as shown in Figure 15, Figure 16, and Figure 17[8]. This seasonal variation is expected as water temperature increases in the spring and early summer as the amount of solar radiation increases and the higher angle of the sun results in less shading. The water temperature declines in the late summer and early fall with the differences returning to near zero as the amount of daylight declines, low flow persists, and mixing occurs with the deeper pools in the river.

Figure 15 demonstrates that the updated baseline scenario under current conditions results in an approximate maximum water temperature difference of 1.4°C during the mid-summer period (July), returning to near zero by the fall (October).

[8] Figure 15, Figure 16, and Figure 17 show the 7-Day Average water temperature on the y-axis, over the time period from 4/25/14 to 10/22/2014 on the x-axis. Modeled water temperatures are plotted for Segment 44 (blue line) and Segment 111 (red line). The difference in water temperature between Segment 11 and Segment 44 (green line) is plotted to the 2nd y-axis "Temperature Difference".

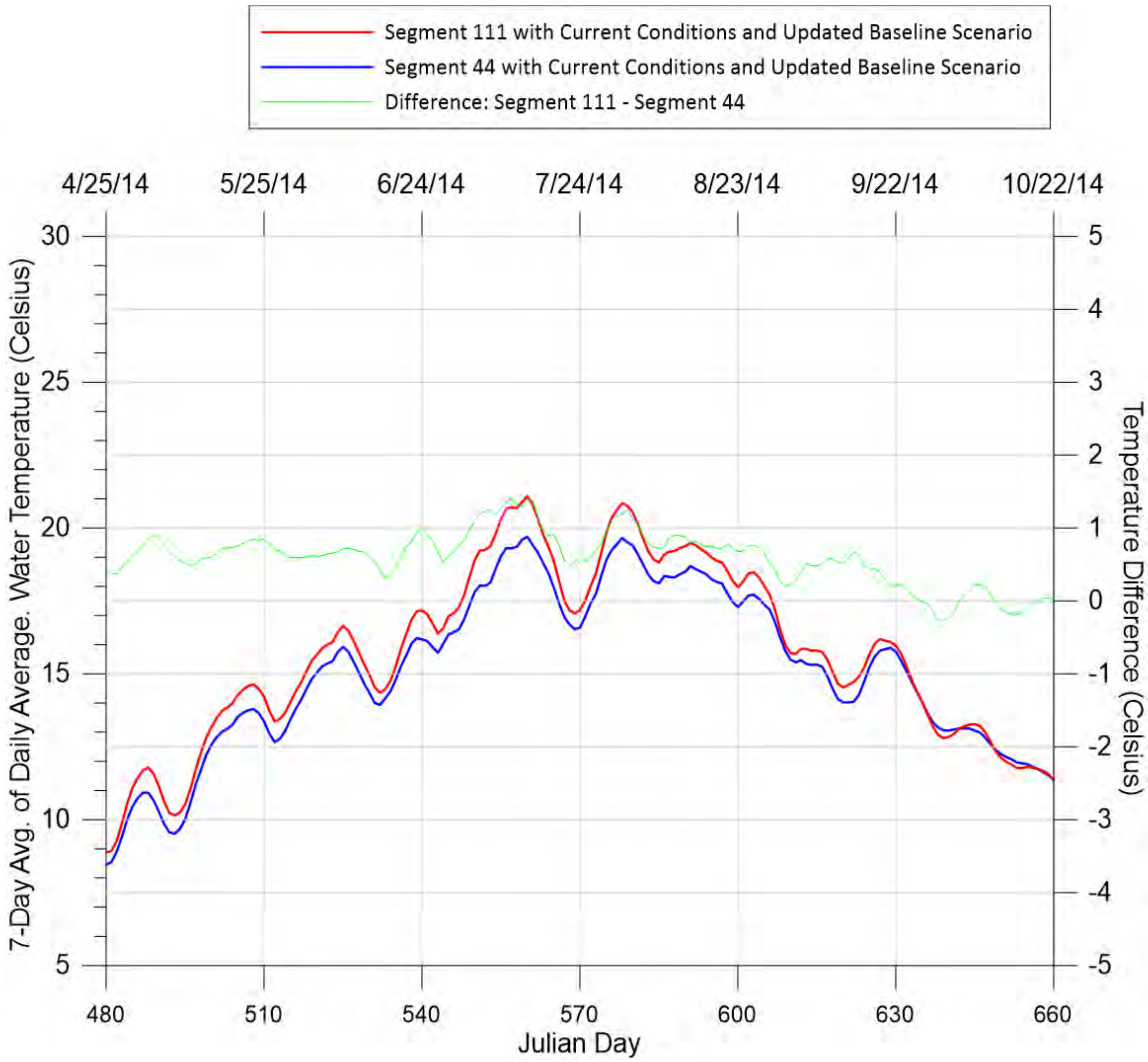

Figure 15. Comparison of Daily Average Water Temperature at Segment 44 (Upper Limit of Temporary Inundation Area) and Segment 111 (Proposed FRE Facility) with Updated Baseline Scenario under Current Conditions

Figure 16 demonstrates that with the high vegetation scenario under current conditions, the maximum water temperature difference between Segment 44 and Segment 111 increases to approximately 1.7°C in mid-summer (July). Figure 17 demonstrates that the low vegetation scenario under current conditions results in an increase to a maximum water temperature difference of approximately 2.5°C in mid-summer (July).

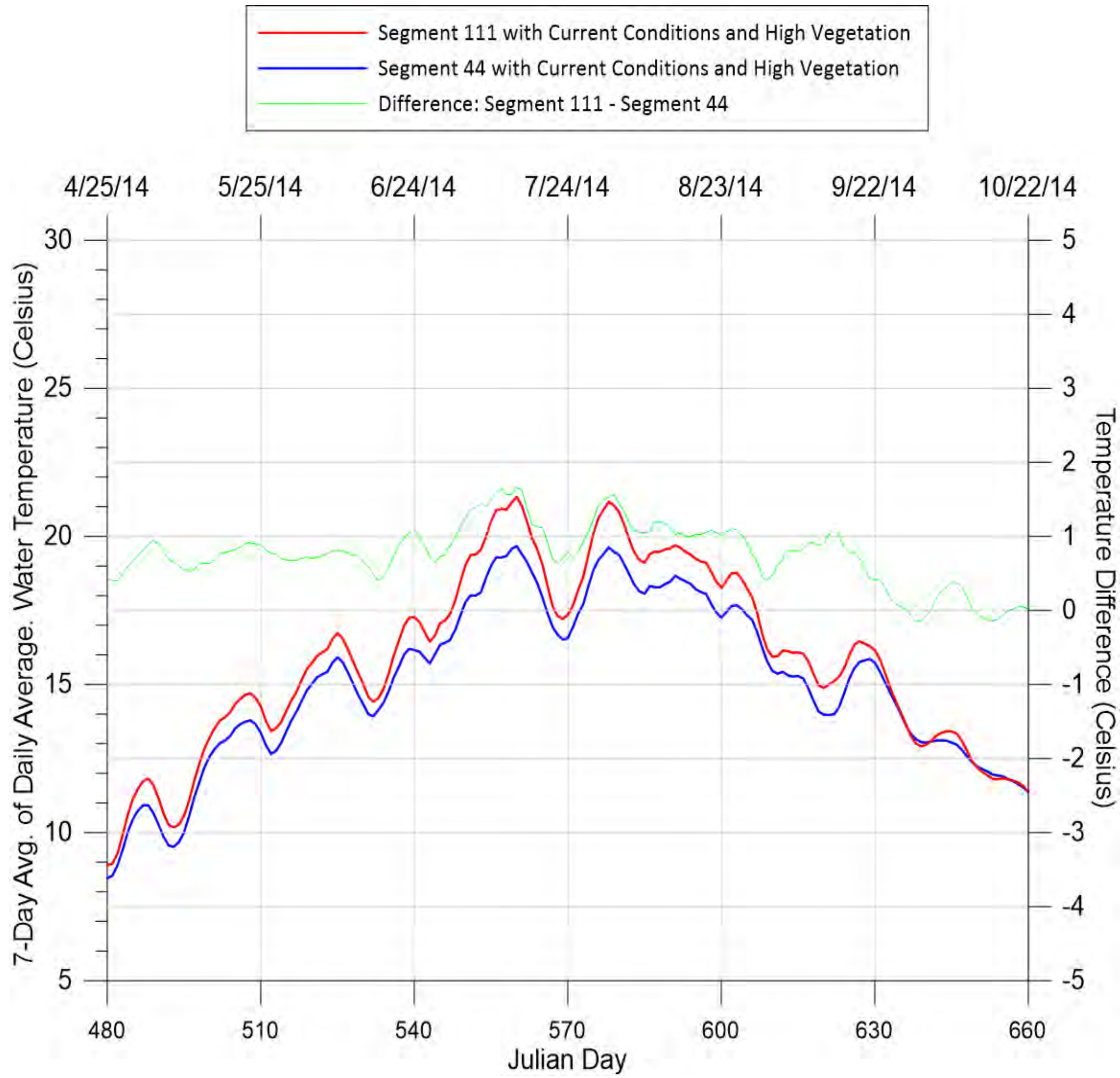

Figure 16. Comparison of Daily Average Water Temperature at Segment 44 (Upper Limit of Temporary Inundation Area) and Segment 111 (Proposed FRE Facility) with High Vegetation Scenario under Current Conditions

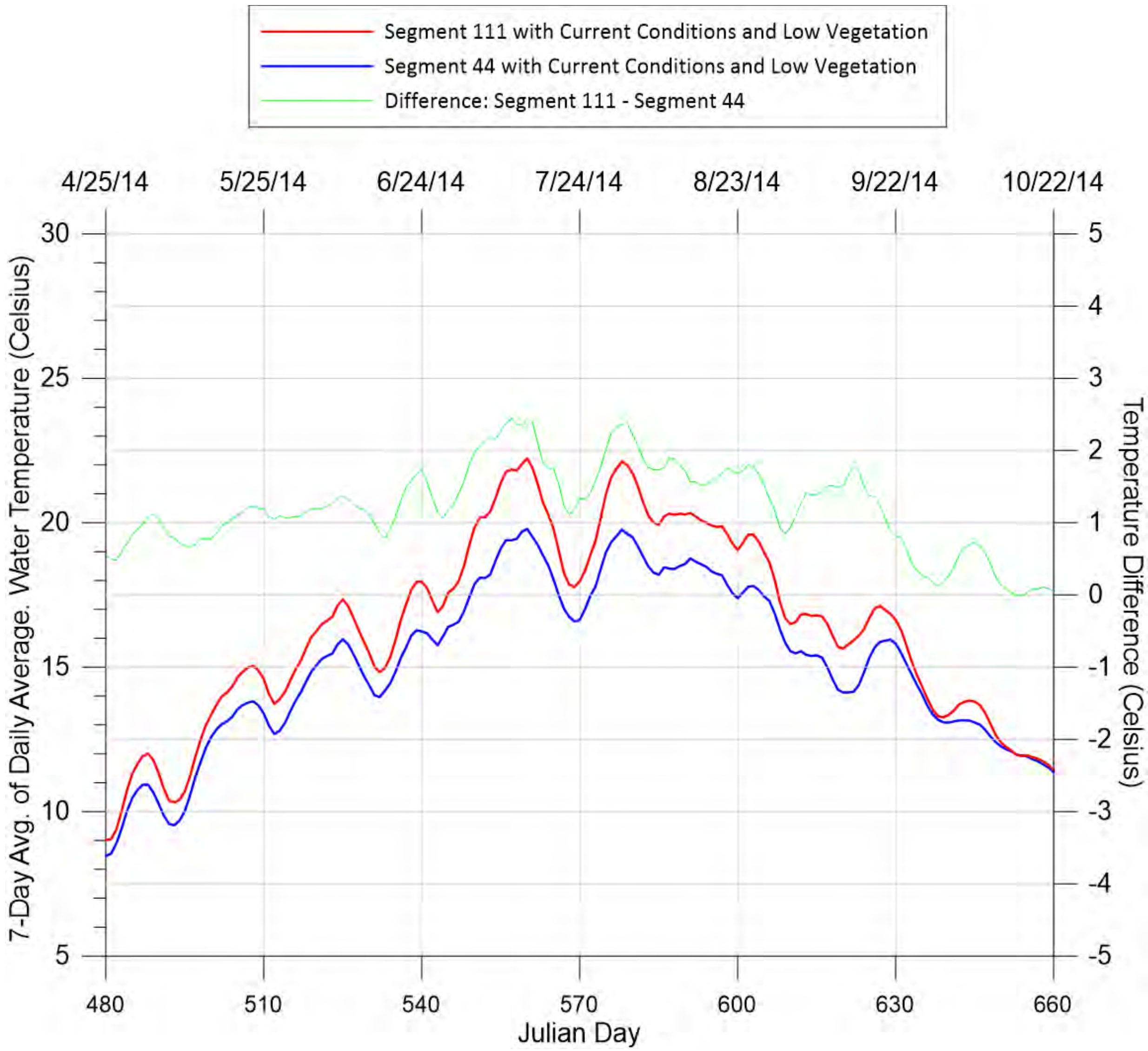

Figure 17. Comparison of Daily Average Water Temperature at Segment 44 (Upper Limit of Temporary Inundation Area) and Segment 111 (Proposed FRE Facility) with Low Vegetation Scenario under Current Conditions

Comparing the results between vegetation scenarios, the warming is greatest the lower the vegetation, as seen by the area between the blue and red lines, and the green difference line in Figure 15, Figure 16 and Figure 17. The largest differences occur in the summer when air temperature is highest, shading is the lowest, and the solar input is the greatest. These peaks align with those in Figure 11 through Figure 14 in Section 4.1, which indicates that vegetation conditions either at a single location or between locations show a similar pattern of seasonal variation from approximately April through October.

Figure 18 provides the water temperature differences between the high vegetation and updated baseline scenarios (black line), and the low vegetation and updated baseline scenarios (green line).[9] Figure 18 demonstrates that with the high vegetation scenario, the water temperature increases between the upper limit of the temporary inundation area (Segment 44) and the FRE facility (Segment 111) are not as great when compared to the low vegetation scenario. This result indicates that with the implementation of the VMP (high vegetation scenario), water temperature increases may be minimized.

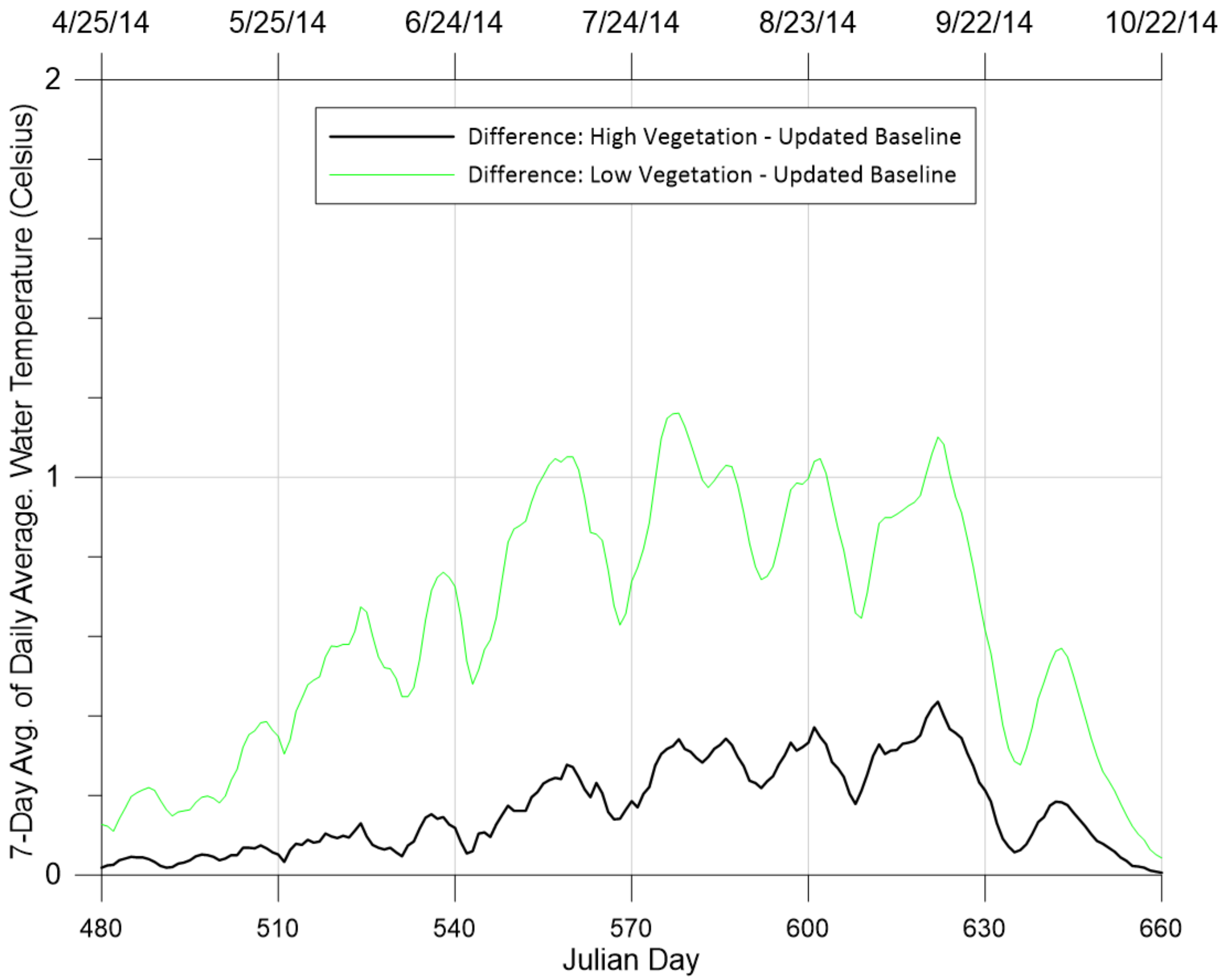

Figure 18: The Differences of Daily Average Water Temperature Differences between Segment 44 (Upper Limit of Temporary Inundation Area) and Segment 111 (Proposed FRE Facility) for the Low and High Vegetation Scenarios with respect to Current Vegetation

Table 5 below provides the statistical results of the water temperature change (using the 7-DADMax) for the high vegetation and low vegetation scenarios with respect to the updated baseline scenario that are

[9] Figure 18 shows the 7-Day Average water temperature on the y-axis, over the time period from 4/25/14 to 10/22/2014 on the x-axis. The differences between Segment 44 and Segment 11 and the modeled vegetation scenarios are plotted.

shown in Figure 18. The low vegetation scenario results in an approximately 0.6°C average water temperature increase, and 1.2°C maximum increase. The high vegetation scenario results in an approximately 0.2°C average water temperature increase, and 0.4°C maximum water temperature increase. The results indicate that the high vegetation scenario (implementation of the VMP) minimizes the water temperature increases that are expected to occur under the low vegetation scenario.

Table 5: Daily Average Water Temperature Differences between Segment 111 (Proposed FRE Facility) and Segment 44 (Upper Limit of Temporary Inundation Area) for the Low and High Vegetation Scenarios with respect to Updated Baseline Vegetation under Current Conditions between 4/25/2014 and 10/22/2014

Scenario	Water Temperature Change (°C)			
	Minimum	Median	Average	Maximum
Low Vegetation Scenario under Current Conditions minus Updated Baseline Scenario under Current Conditions	0.04	0.6	0.6	1.2
High Vegetation Scenario under Current Conditions minus Updated Baseline Scenario under Current Conditions	0.01	0.1	0.2	0.4

Note: Water temperature results from model calculated as 7-DADMax, difference calculated as Segment 111 minus Segment 44 for each scenario, and then difference between scenarios calculated for values shown.

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5 Discussion and Conclusions

The results of the sensitivity analysis indicate that the predictions for water temperature are sensitive to changes in shade parameters representing vegetation heights in the riparian area. This demonstrates that vegetation heights influence the predicted changes to water temperature. Successful management of vegetation, particularly vegetation of greater heights, in the riparian area creates shade, which can minimize increases to water temperature. Additionally, under climate change, the differences due to vegetation heights are estimated to remain similar to those under current conditions. Additional water temperature increases are due to climate change impacts on air and dewpoint temperature, hydrology, and upstream water temperature.

5.1 Water Quality Modeling Considerations

A primary purpose of the sensitivity analysis was to understand the influence of vegetation heights in the riparian area on water temperature as predicted by the Footprint Model used in the SEPA and NEPA DEISs. The sensitivity analysis presented here demonstrates that the modeling of water temperature is sensitive to changes to vegetation height. This finding suggests that with successful implementation of vegetation management actions, water temperature increases due to changes in riparian vegetation may be minimized.

As discussed in Section 2, the DEISs assumed vegetation heights that were a uniform 2 meters (6 feet, 7 inches) across the entire temporary inundation area. However, the District has developed a Conceptual VMP for management of vegetation within the temporary inundation area and will finalize the VMP with input from agency stakeholders prior to construction of the proposed FRE facility. Updating the assumptions for vegetation height in the water quality modeling based on the VMP provides a more accurate assessment of potential water temperature impacts.

Additional work to further refine the VMP may inform the selection of final tree heights to predict water temperature impacts under climate change. Furthermore, this modeling used recent LiDAR data for the updated baseline scenario. These recent data provide a more accurate baseline for assessing shade conditions along the mainstem Chehalis River within the temporary inundation area, compared to the approximated heights used for the water temperature analysis reported in the DEISs. This information is available for subsequent use in the development of the Final EISs.

5.2 Conceptual VMP Development and Implementation

Implementation of the VMP will aim to proactively establish flood-tolerant species of woody plants within the temporary inundation area for different flooding regimes, utilize large woody debris that needs to be removed in local mitigation actions, and establish appropriate habitat types that can be used for the impacts analysis of the proposed project. Furthermore, the VMP is intended to act as the basis for adaptive management within the temporary inundation area. It identifies the existing plant communities and proposes the type of vegetation that can be expected to survive temporary flooding conditions during proposed FRE facility operations. The review of the Mud Mountain Dam inundation zone validates many of the assumptions made within the VMP and refines the list of woody plants that are known to tolerate similar episodic temporary flooding in the region.

An important contribution of this sensitivity analysis is the review of the Mud Mountain regional example to inform vegetation height assumptions within the temporary inundation area of the proposed project. Review of the Mud Mountain analog, with consideration of the proposed vegetation management, indicates that taller vegetation would likely survive the flooding caused by the facility in the upper part of the basin affected by the inundation. The Mud Mountain regional example provides a reasonable pallet of vegetation species that can survive flooding at the depths and durations proposed during the operations of the proposed FRE facility. More direct comparisons between the two facilities' vegetation are not warranted because there are local conditions that influence growing conditions, including local geology, sediment transport, site aspect, soil types, and elevation. These and other factors are likely to determine which species can thrive within those local conditions independent of the flooding regime.

5.3 Climate Change Considerations

An additional value of the water quality sensitivity analysis is to segregate the influence of climate change from the influence of vegetation on water temperature. Climate change is projected to influence stream temperatures because of increases in air temperature and lower summer flows throughout Washington State including the Chehalis River (Isaak et al. 2011, Mauger et al. 2016). The SEPA DEIS included the influence of climate change in the analysis of the projects impacts on water temperature, however, it did not indicate what portion of the increase in water temperature is attributable to the vegetation management actions in the temporary inundation area of proposed project.

The sensitivity analysis documented in Section 4 included modeling scenarios under climate change. Climate change was represented by inputs that increased air and water temperature and shifted flow. The climate change inputs result in a water temperature that is 3 to 5°C higher than the respective scenarios under current conditions. This shift increasing water temperature from under current conditions to under climate change is seen in Figure 11 through Figure 14 in Section 4.1. Climate change results in an increase to water temperature irrespective of the vegetation and independent of the impacts of the proposed project.

Further, the shade inputs result in a water temperature that is 0.3°C higher with the high vegetation scenario and 1°C higher with the low vegetation scenario compared to the updated baseline scenario under both the current and climate change conditions. This increase to water temperature is seen in Table 3 and Table 4 in Section 4.1. The increase to water temperature due to vegetation height (shade) is irrespective of current or climate change conditions. In this case, it is known that the proposed project could affect shading through the removal of vegetation in the temporary inundation area, and as demonstrated through the water quality modeling presented in this report, the development and implementation of the VMP is necessary for minimizing impacts to water temperature.

5.4 Conclusions

The next phase of evaluating the impacts of the proposed project includes the development of Final EIS's by the USACE and Ecology. The final determinations of the proposed project's impacts to water quality (i.e., water temperature) should consider the following significant conclusions of this report:

1. Vegetation heights influence changes to water temperature as predicted in the CE-QUAL-W2 Footprint Model.
2. Shade inputs result in a water temperature that is 0.3°C higher with the high vegetation scenario and 1°C with the low vegetation scenario compared to the updated baseline scenario under both the current and climate change conditions (see Section 4.1).
3. Review of the Mud Mountain analog example confirms that higher vegetation heights then previously assumed in the SEPA and NEPA DEISs are highly likely to result from implementation of the VMP.
4. Higher riparian vegetation (see high vegetation scenario) will minimize water temperature increases in the temporary inundation area and downstream of the FRE facility.
5. Projected increases in water temperature in the Chehalis River due to climate change parameters are significantly greater than the increases in water temperature due to the proposed project.

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USACE-ERDC, Environmental Laboratory. 2019. Level II Habitat Survey & Wetland Identification: Howard Hanson Dam and Mud Mountain Dam, King and Pierce Counties, Washington. Vicksburg, MI 39180.

USDA, NRCS. 2021. The PLANTS Database (http://plants.usda.gov, 17 March 2021). National Plant Data Team, Greensboro, NC 27401-4901 USA.

Attachment A. Conceptual Vegetation Management Plan. Prepared by HDR for the Lewis County Flood Control Zone District. November 2020

Attachment B. GIS Data concerning Existing Vegetation at Project Reach (Digital copies available upon request)

Attachment C. GIS Data concerning Existing Vegetation at Mud Mountain (Digital copies available upon request)

Attachment D. Modelling Output Data (Digital copies available upon request)

Appendix E
Sediment Transport Dynamics

DRAFT

MEMORANDUM

Date: August 1, 2021
To: Chehalis River Basin Flood Control Zone District, Betsy Dillin
From: Kleinschmidt Team
Re: No Net Loss of Habitat Function

1.0 Introduction

The purpose of this technical memorandum is to conceptualize sediment dynamics as they would occur during future operations at the proposed Flood Retention – Expandable (FRE) facility. Kleinschmidt developed a qualitative conceptual site model (CSM) that identifies and describes the channel morphology, hydrology, hydraulics, and sediment dynamics within the Chehalis River corridor surrounding the proposed FRE. The study area for this evaluation includes approximately 8 miles of the Chehalis River channel upstream and 23 miles of the river channel extending downstream of the FRE to River Mile 85. The CSM will be used as a conceptual framework for developing a future quantitative modeling analysis to refine the characterization of ecological effects related to changes in sediment dynamics due to future FRE operations.

The CSM addresses three primary types of project effects related to sediment dynamics:

- Sediment deposition and reworking within the reservoir footprint will affect aquatic habitat within the river channel and adjacent overbank areas;
- Erosion of sediment deposited during a flood retention event will affect water quality by increasing turbidity out of phase with the flood hydrograph; and,
- Delay of fine sediment deliver downstream of the FRE structure may affect channel morphology and coarsen the riverbed sediment.

The CSM presented in this technical memorandum qualitatively describes these potential effects in the context of river hydraulics and sediment dynamics that would occur during FRE operations.

2.0 Background

The Chehalis River Basin Flood Control Zone District (CFCZD) is proposing construction of a new flood retention facility in the upper Chehalis watershed on the Chehalis River, near the city of Pe Ell, Washington. Figure 1 shows the project vicinity within the upper Chehalis River basin. Project elements include a Flood Retention Expandable (FRE) facility, a temporary reservoir, and levees (HDR 2017; HDR 2018; CFCZD 2019). The temporary reservoir would be located immediately upstream of the FRE. The project levees would be located approximately 35 river miles downstream of the FRE near the Chehalis-Centralia Airport.

2.1 Environmental Review Process

The project is currently under environmental review between draft and final environmental impacts statements (EIS). Washington State Department of Ecology (WDOE) published a draft EIS under Washington State Environmental Protection Act (SEPA) in February 2020. The U.S. Army Corps of Engineers (Corps) published a draft EIS under the National Environmental Protection Act (NEPA) in September 2020. Both documents reported that the project would have unavoidable impacts to regulated aquatic resources. Multiple stakeholders are engaged in the environmental planning process with the common goal to provide both flood control and basin-wide salmon recovery (OCB 2019).

Construction and operation of the FRE would have long-term effects on physical processes including hydrology, hydraulics, sediment transport dynamics, recruitment and transport of large woody debris, and geomorphology of the river channel and floodplain. Changes in these processes may produce both negative and beneficial effects on water quality, aquatic habitat, and terrestrial habitat on the floodplain, and thus indirectly cause long-term effects to aquatic, riparian, and floodplain-dependent species.

2.2 Previous Analysis of Hydrology, Hydraulics and Sediment Dynamics

The SEPA DEIS (WDOE, 2020) discusses sediment dynamics and related aquatic habitat impacts in Section 5.2 Earth and in Appendix F Earth Discipline Report. Additional technical studies that supported the SEPA DEIS with respect to hydraulics and sediment dynamics are listed below:

- Chehalis Basin Strategy – Geomorphology, Sediment Transport, and Large Woody Debris Report. Office of the Chehalis Basin (Watershed GeoDynamics and Anchor QEA LLC, 2017).
- HDR, 2017. Combined Dam and Fish Passage Design Conceptual Report (HDR, 2017).
- HDR, 2018. Chehalis River Basin Flood Control Combined Dam and Fish Passage Supplemental Design Report – FRE Dam Alternative (HDR, 2018).
- Chehalis River Basin Climate Change Flows and Flooding Results – Technical Memorandum (Anchor QEA, 2019).
- Chehalis River Existing Conditions RiverFlow2D Model Development and Calibration – Technical Memorandum (WSE, 2019a).
- WSE, 2019b. Chehalis River Basin Hydrologic Modeling – Technical Memorandum (WSE, 2019b).

3.0 Description of FRE Operations

Flood control operations at the FRE are expected to occur in response to an approximately 7-year recurrence interval flow event. For each event, the reservoir will temporarily hold water for up to 35 days. About 99 percent of the time, there would be no storage of water in the FRE reservoir, and the capacity of the river to transport sediment would not be affected.

The FRE is designed to capture floods on the rising limb of the flood hydrograph and then to release stored water on the falling limb of the flood hydrograph. To illustrate this process, the January 8, 2009 flood (50,700 cfs at Grand Mound gage) was selected. The storage and release of water during this flood can be analyzed from the rules of operation of the FRE, and implications for sediment transport will be discussed.

When a river enters a reservoir, the flow velocity and boundary shear stress will decrease, and incoming sediment will deposit in the reservoir. The larger, heavier sediment particles will fall out first, and the finer sediments will be transported further into the reservoir before they settle. Some of the sediment (especially the finer sediment particles) will be transported through the reservoir and downstream.

Turbidity currents may develop in some reservoirs when the incoming sediment-water mixture is denser than the sediment/water mixture stored in the reservoir. Density differences may be caused by differences in temperature or sediment concentration or both. The flood control operations are expected to have a duration of up to 35 days. That would not be enough time to develop appreciable differences in water temperature. Similarly, the incoming sediment/water mixture is not expected to be appreciably denser than the sediment/water mixture in the reservoir. Therefore, the formation of turbidity currents is not anticipated to occur in the FRE reservoir.

The flood that occurred on January 8, 2009, peaked at 50,700 cfs at 10:00PM in the Chehalis River near Grand Mound (USGS 12027500). Concurrent flow records are available at 15-minute intervals in the Chehalis River near Doty (USGS 12020000). To estimate flows in the Chehalis River at the FRE dam site, the flows measured near Doty were adjusted to account for the smaller drainage area at the dam site and an estimated 2-hr travel time between the dam site and the Doty gage.

Flood control operations at the FRE are initiated when the discharge in the Chehalis River near Grand Mound is forecasted to exceed 38,800 cfs in 48 hours. Historical flood forecast hydrographs were not available and the actual measured flows were used for this analysis. The discharge in the Chehalis River near Doty exceeded 38,800 cfs on January 8, 2009, at 10:30 AM. In this analysis it was assumed that flood control operations at the FRE would be initiated on January 6, 2009 at 10:30 AM (48 hours before the discharge in the Chehalis River near Grand Mound exceeded 38,800 cfs).

A sequence of operational triggers and conditions in the FRE reservoir are presented herein to illustrate the flood control processes and implications for sediment transport are discussed. The sequence of conditions when incoming water is accumulated in the FRE reservoir is shown in Figure 2 and the sequence of conditions when stored water is released is illustrated in Figure 3. Specific operational triggers are defined as:

1. **Operational Trigger 1** – the discharge in the Chehalis River near Grand Mound has been forecasted to exceed 38,800 cfs in 48 hours.

    Conditions just prior to initiation of flood control operations are shown in Figure 2 at 10:30 AM on January 6, 2009. There is no storage of water in the reservoir and the discharge just upstream from the dam (2,080 cfs) matches the discharge just downstream from the dam (also 2,080 cfs).

    Gates at the dam are closed to reduce outflow from the reservoir at a rate of 200 cfs per hour until the outflow reaches 300 cfs and then the outflow is maintained at this flow rate.

    Initially, accumulation of sediment in the reservoir would be focused near the dam (River Mile 108.2). As the reservoir fills, the upstream extent of sediment depositions would migrate upstream. Larger sediment particles would deposit when the river enters the reservoir and smaller sediment particles would deposit downstream from the large sediment particles.

    Inflow to the reservoir reaches a peak of 15,150 cfs at 1:00 AM on January 8, 2009. This would correspond with the largest rate of sediment transport and deposition of sediment particles would start with the larger particles near River Mile 113 (Figure 2). The storage in the reservoir is 23,200 acre-feet when the inflow to the reservoir peaks.

    This mode of operation continues until the discharge in the Chehalis River near Grand Rond reaches a peak at 10:00PM on January 8, 2009. The storage in the reservoir is 36,300 acre-feet when this occurs.

2. **Operational Trigger 2** - the discharge in the Chehalis River near Grand Mound reaches a peak (50,700 cfs) at 10:00 PM on January 8, 2009.

    When the discharge in the Chehalis River near Grand Mound peaks, flow releases from the FRE reservoir are initially 300 cfs and they are increased at a rate of 1,000 cfs per hour until the storage in the FRE reservoir reaches a peak. This occurs at 1:15 AM on January 9, 2009 (Figures 2 and 3).

    When this occurs, the upstream end of the extent of sediment deposition would be near River Mile 114.2.

3. **Operational Trigger 3** – the storage in the FRE reservoir reaches a peak of 36,700 acre-feet at 1:15AM on January 9, 2009 (Figures 2 and 3).

    The inflow to the reservoir matches the outflow from the reservoir at 3,550 cfs when the FRE reservoir reaches peak storage. Flow releases are then adjusted and regulated to draw the reservoir down at a rate of 10 feet per day. This rate was selected to prevent collapse of the side slopes at the reservoir shoreline.

    This mode of operation continues until the reservoir is drawn down to Elevation 528 feet (Figure 3). When this occurs, the reservoir storage is 8,400 acre-feet). The inflow to the reservoir is 642 cfs and the outflow from the reservoir is 3,840 cfs.

4. **Operational Trigger 4** – the water level in the FRE reservoir reaches Elevation 528 feet at 3:45AM on January 15, 2009 (Figure 3)

    When the water level in the reservoir reaches Elevation 528 feet, the outflow from the reservoir is adjusted and regulated to draw the reservoir down at a rate of 2 feet per day. This rate was selected to allow boats access to the reservoir to clean up floating debris.

    This mode of operation would continue until the water level in the reservoir reaches Elevation 500 feet (Figure 3). This would allow for two weeks for management of debris. The storage in the reservoir would be 4,000 acre-feet when this occurs. The inflow to the reservoir would be 216 cfs and the outflow from the reservoir would be 384 cfs.

5. **Operational Trigger 5** – the water level in FRE reservoir reaches Elevation 500 feet at 3:45AM on January 29, 2009 (Figure 3).

    When the water level in the reservoir reaches Elevation 500 feet, the outflow from the reservoir is adjusted and regulated to draw the reservoir down at a rate of 10 feet per day (to prevent collapse of the side slopes along the reservoir shoreline).

    The reservoir is drawn down until there is no stored water and normal operations are resumed. This would occur at 3:45 AM on February 6, 2009. In this example the inflow to the reservoir and the outflow from the reservoir would be 171 cfs when normal operations are resumed.

Operations of the FRE reservoir were analyzed using available information from the January 8, 2009 flood (50,700 cfs in the Chehalis River near Grand Mound). In this example is would take about 2.6 days to reach peak storage in the reservoir followed by about 28.1 days to draw the reservoir down and resume normal operations. This total duration of flood control operations would be one month for this example.

Sediment deposition would be initiated when the river enters the reservoir. This location would vary with the water level in the reservoir. At higher water levels, sediment deposition would initiate further upstream.

4.0 Conceptual Site Model

The description of FRE operations presented in the preceding section illustrates the temporal and spatial variability in hydraulics and sediment dynamics within the temporary reservoir and downstream of the FRE. Figure 4 shows the 100-year event inundation map for the FRE that corresponds to the maximum footprint of the temporary reservoir. Spatial variability may be illustrated by defining river reaches that correspond to spatial changes in sediment dynamics. Temporal variability may be evaluated by defining distinct operational phases of the FRE that correspond to different prevailing sediment dynamics across the river reaches.

4.1 River Reach Divisions for Sediment Dynamics

Spatial variability of sediment dynamics may be organized by dividing the study area into the following four reaches referenced to the River Miles (RM) shown on Figure 4:

Reach 1 Upstream of the reservoir inundation footprint – Reach 1 extends upstream of RM 114. The Chehalis River channel will experience little or no effects on sediment dynamics in Reach 1 due to FRE operations.

Reach 2 Primary deposition zone (upstream transition into the reservoir) – Reach 2 begins approximately at RM114 and extends downstream into the reservoir a distance that has not yet been determined. This zone represents the upstream transition into the reservoir. Bedload and sandy suspended sediments will settle to the bottom of the reservoir with the coarsest material settling fastest and settling rate decreasing in proportion to grain size. Fine silt and clay-sized sediments will remain suspended longer and be deposited more broadly around the reservoir.

Reach 3 Secondary transport zone (from primary deposition zone to FRE) – Reach 3 is defined as the river channel between the primary deposition zone and the FRE at RM 108. This river segment would experience physical effects resulting from secondary reworking and transport of the Reach 2 sediments during and after evacuation of the reservoir.

Reach 4: Downstream of FRE – Reach 4 extends downstream of the FRE a distance that has not yet been determined. The SEPA DEIS (WDOE, 2020) describes changes in riverbed storage patterns extending downstream of the FRE to RM 85. Changes to sediment dynamics within Reach 4 could result from delays in the timing of sediment delivery to this reach due to operation of the FRE. Future sediment transport modeling is planned to develop a sediment budget and evaluate the nature and extent of impacts to sediment dynamics.

4.2 Temporal Variability

Temporal variability in sediment dynamics related to operation of the FRE was described in Section 2.3 and illustrated on Figures 2 and 3. Temporal variability in sediment dynamics may be conceptualized and evaluated by considering existing conditions as a baseline and comparing sediment dynamics during three phases of FRE operation of the FRE as described below.

Period 1 FRE activated and reservoir filling – This period coincides with the rising limb of a flood hydrograph and active sediment transport. As the temporary reservoir fills, the pool expands upstream to inundate 6 miles of the Chehalis River. Bedload entering the reservoir quickly settles to the riverbed. Coarse-grained (sandy) suspended sediment also settles and is deposited as flow velocity decelerates. Silt and clay-sized sediment would remain suspended for longer and would be distributed more broadly throughout the reservoir. The finest material may remain in suspension long enough to be transported downstream during draining of the reservoir.

Period 2 FRE activated and reservoir draining – The temporary reservoir begins to drain during the falling limb of the flood hydrograph. While the flood hydrograph typically lasts for up to a week, evacuation of the reservoir may take up to 35 days. Sediment transport and deposition within the reservoir continues during much of the falling limb of the hydrograph. As the water surface falls, sediment deposited within the primary deposition zone (Reach 2) may be eroded and transported downstream into the receding pool. The progressive flushing of fine sediment as the reservoir drains would increase turbidity during this period.

Period 3 Intermediate period between flood events – The FRE is open during the intermediate period between flood events, and water and sediment may move freely down the river channel. Sediment deposited during the preceding FRE operation event is reworked by small and moderate flow events and transported downstream. Erosion and transport of fine sediment deposits within the temporary reservoir may cause changes in the timing and severity of turbidity downstream of those deposits.

4.3 Applications of the Conceptual Site Model

This technical memorandum presents a qualitative CSM that conceptualizes sediment dynamics for defined river reaches and distinct operational phases of the FRE. Operation of the proposed FRE will result in changes to sediment dynamics that may in turn affect aquatic species and their habitats. The CSM provides a conceptual framework that could support future quantitative modeling analysis to refine the characterization of ecological impacts related to changes in sediment dynamics due to FRE operations.

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Figure 1
Project Vicinity

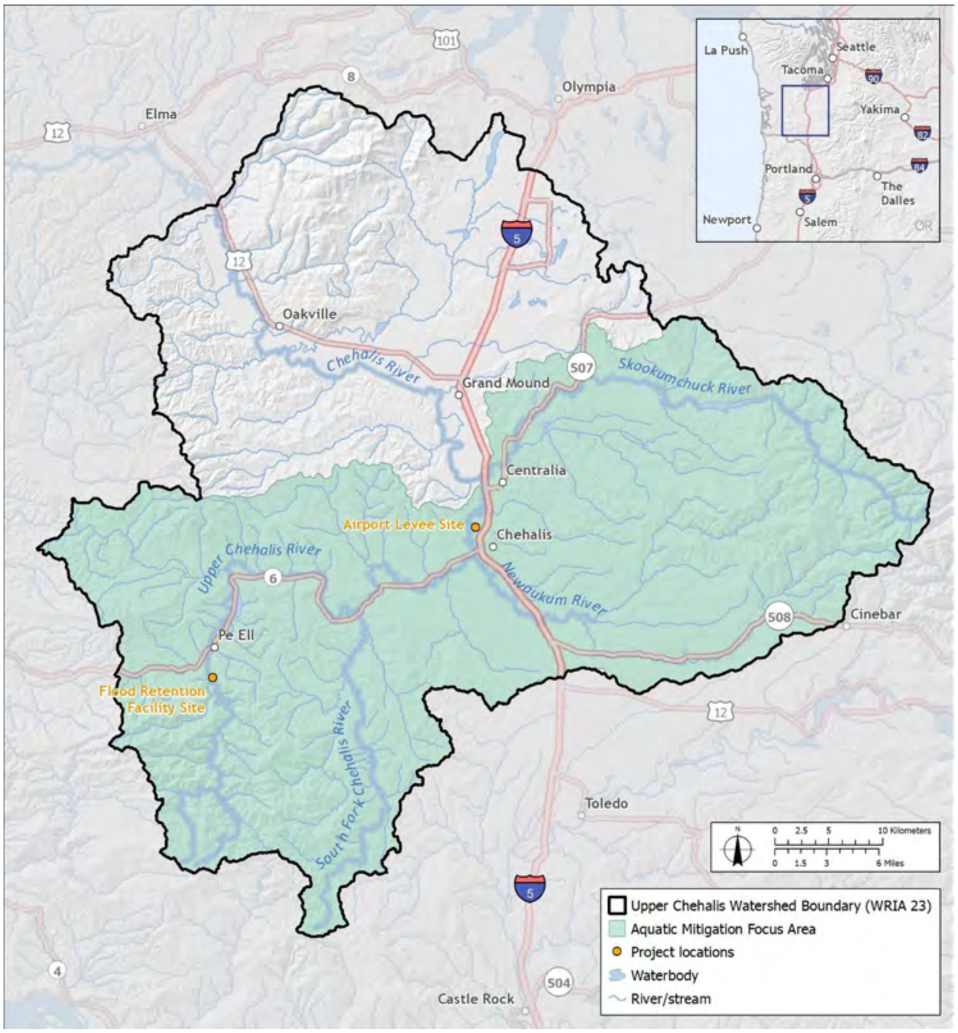


Figure 2
Accumulation of stored water at flood control reservoir based on January 2009 flood.

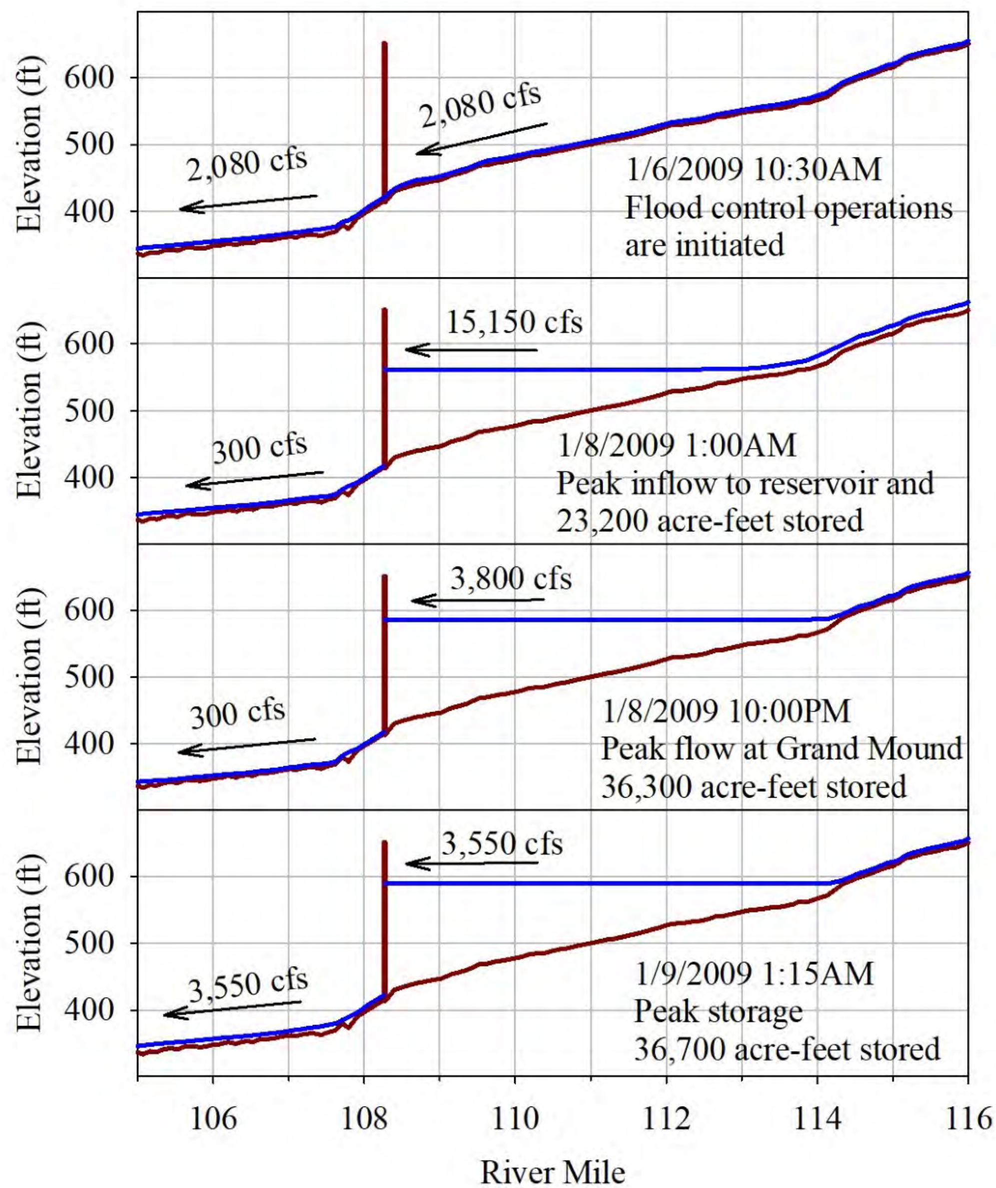


Figure 3
Release of stored water at flood control reservoir based on January 2009 flood.

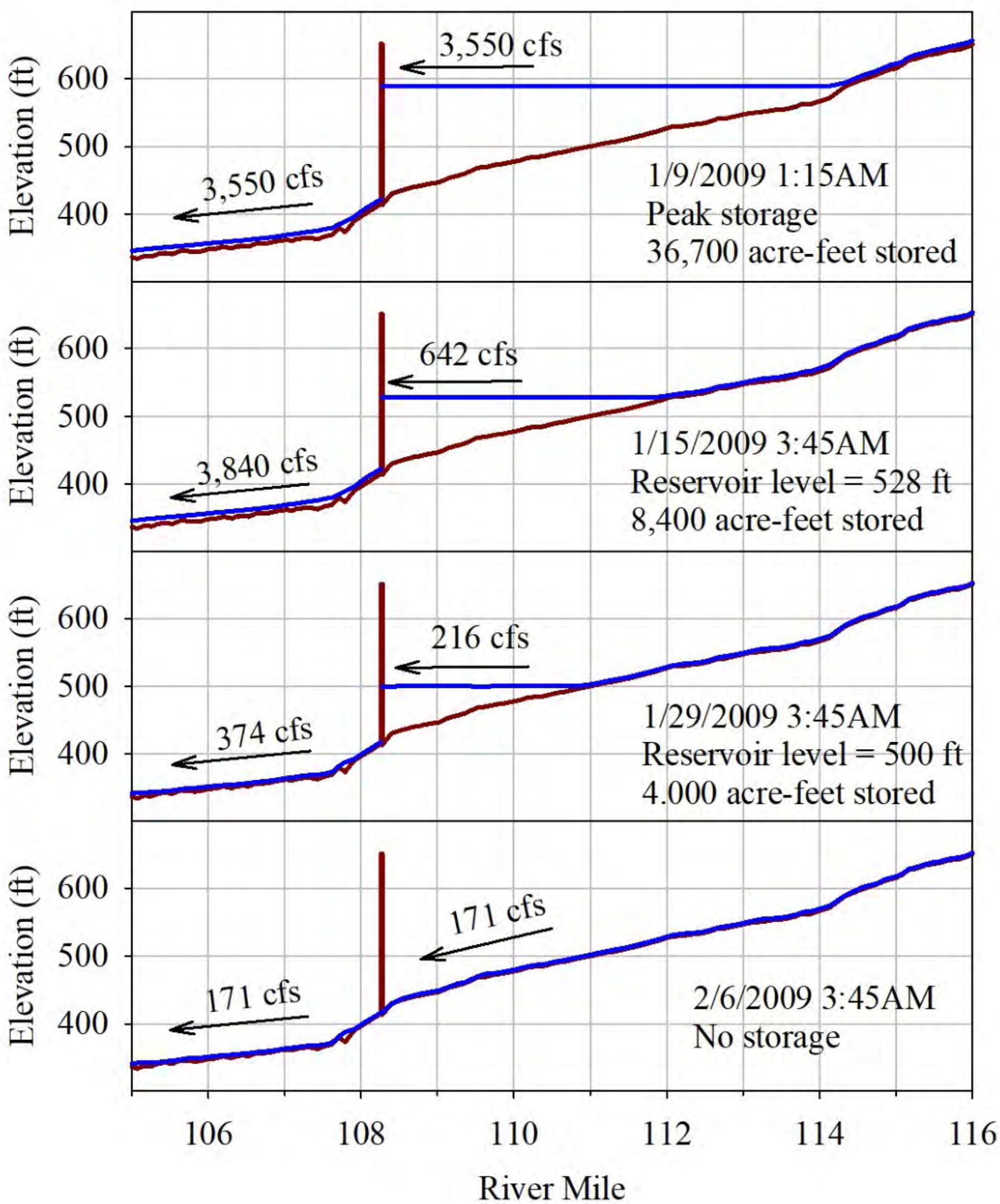
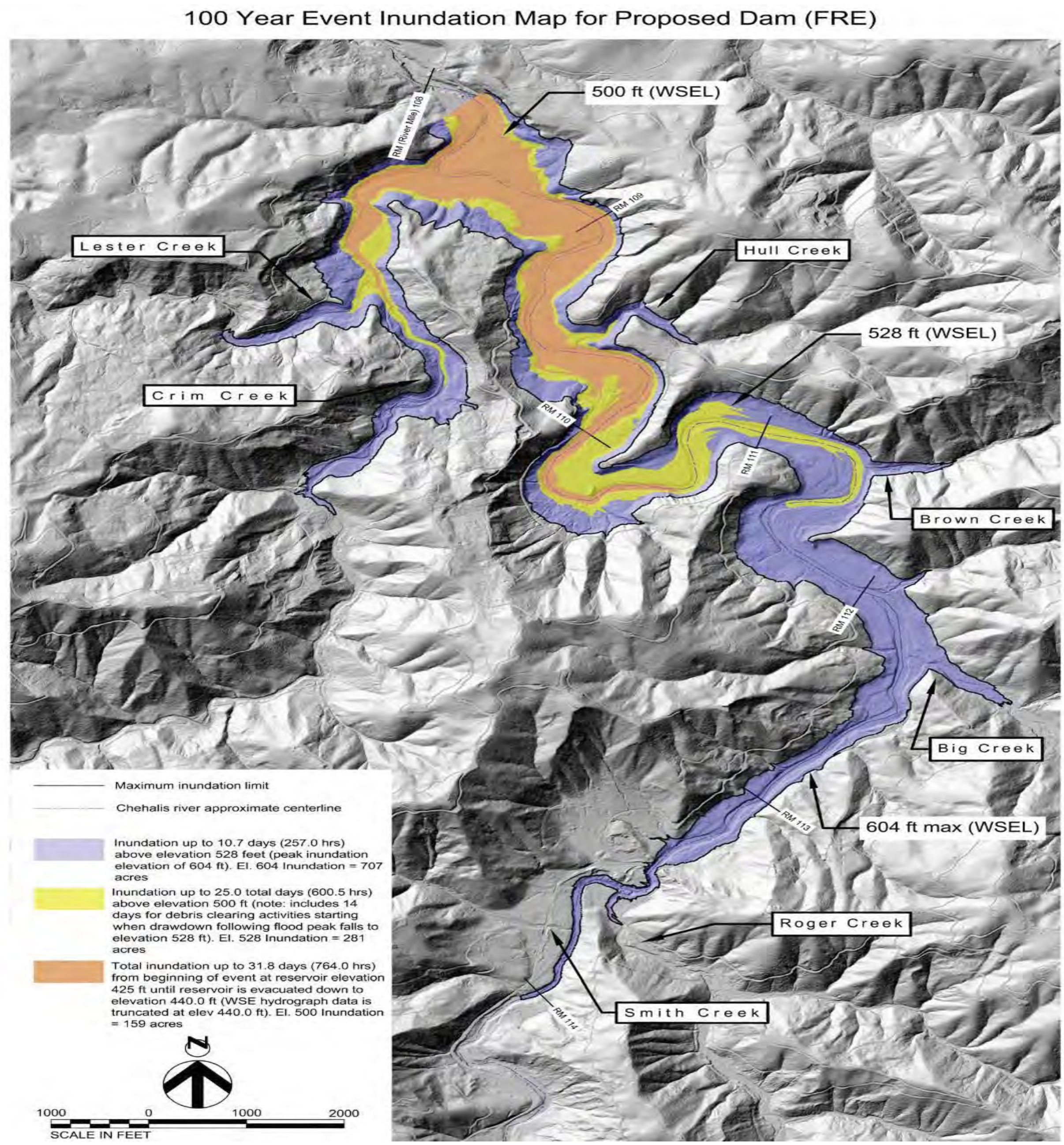
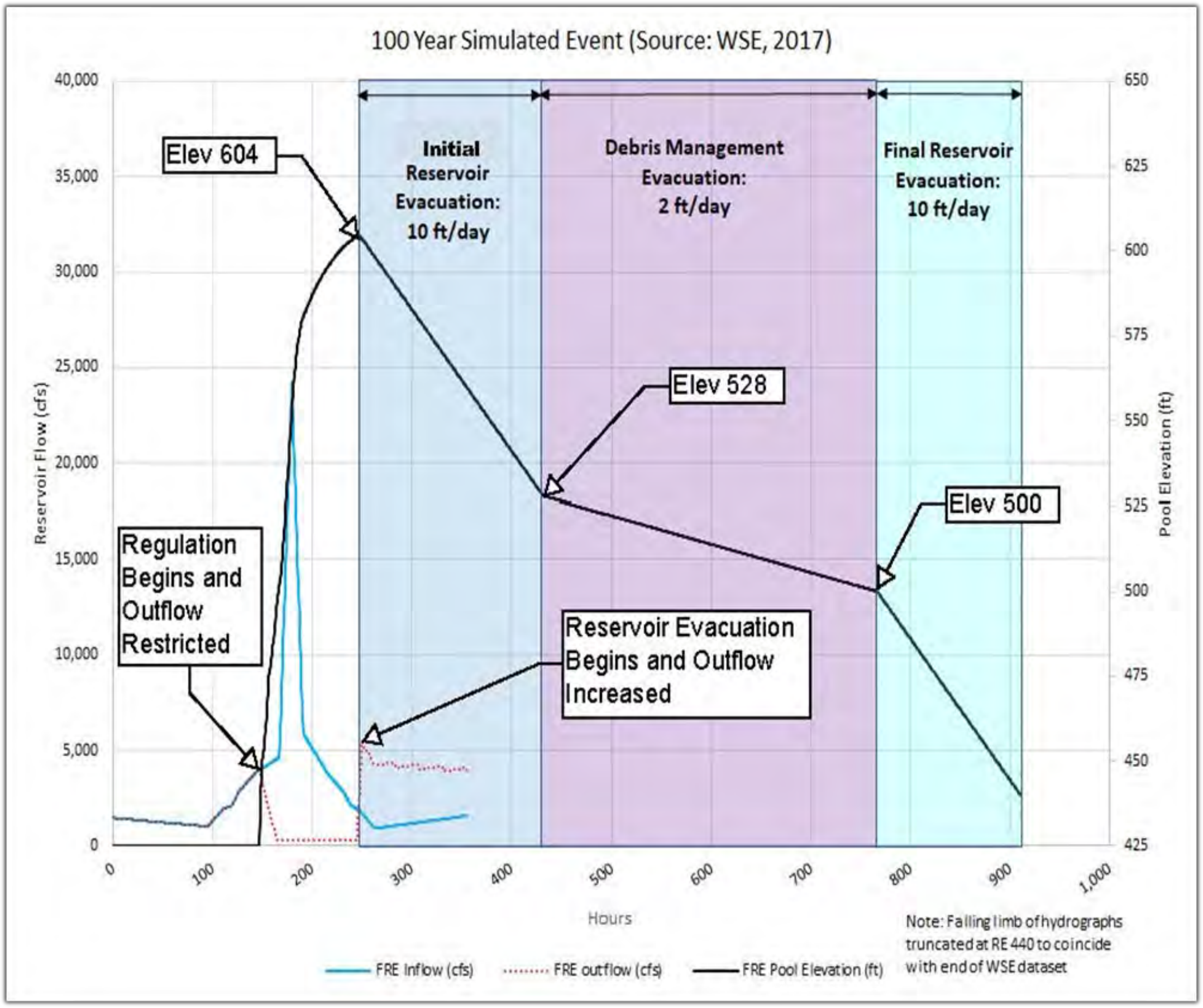


Figure 4
FRE Temporary Reservoir Footprint and Management Zones



Source: HDR, Inc. 2021 used by permission.

Figure 5
FRE Temporary Reservoir Evacuation Curve



Source: HDR, Inc.2021 used by permission.

Appendix F
Construction Best Management Practices

GENERAL CONSTRUCTION BEST MANAGEMENT PRACTICES

At a minimum, BMPs and other resource protection actions for general construction would include:

- In locating construction access and staging areas the applicate will avoid of regulatory waterbodies including stream and stream buffers and will use existing forest roads.
- Marbled Murrelet Protection Measures.
  - Nesting habitat suitability surveys for marbled murrelets, and timing restrictions for tree removal in or near suitable nesting habitat.
- The Applicant would conduct pre-construction marbled murrelet nesting habitat suitability surveys in all forested areas in which tree removal is proposed, and in the disturbance-based threshold distance of 328 feet (for noise disturbance) from tree removal activities. This includes the FRE facility construction footprint, access roads (temporary and permanent), staging areas, quarry site development areas, Pe Ell water system corridor, debris removal yard, and proposed areas of selective tree removal in the temporary reservoir under the VMP.
  - If the marbled murrelet nesting habitat suitability survey identifies any suitable nesting trees that are scheduled for removal, these trees, and those within 150 feet, would be removed outside of the marbled murrelet nesting season (i.e., no tree removal between April 1 and September 23).
  - Forested areas that are deemed unsuitable for marbled murrelet nesting habitat would not have seasonal restrictions on tree removal (i.e., tree removal may occur year-round). However, tree removal within 478 feet (328 feet + 150-foot buffer) of suitable nesting trees would be subject to daily limiting operating procedures (LOP) during the nesting season (April 1-September 23). LOP would restrict tree removal activities to avoid sensitive diurnal periods: tree removal in these areas would not begin until two hours after sunrise and would cease two hours before sunset.
- All new and improved road construction would conform to regulatory guidelines applying to each set of roads at the time of permitting. In some cases, Washington State Forest Practices Rules standards (Title 222 WAC) would apply to road construction. When applicable, these standards would be considered by the Applicant in the future design of permanent and temporary access roads, or existing road improvements.
- Installation of high visibility fence to define construction limits.
- Placement of all spoils in approved, upland locations. Any spoils (from river or upland excavation) beyond what could be accommodated in the identified spoils disposal areas would be taken off-site to approved locations.

- Maintenance and control of access to Proposed Action properties, as feasible, by installing signs, marking detour routes, hanging flagging, and providing information to the public, including advanced notification of construction activities.
- Development of a traffic control plan, if necessary.
- Stabilization of construction entrances.
- Development and implementation of a Spill Prevention Control and Countermeasures (SPCC) Plan for temporary fuel tanks, construction equipment, and on-site diesel generators, including identified refueling locations, spill control measures, and necessary containment equipment and materials.
- Compliance with dust control policies and plans, including the use of water trucks.
- Stabilization of construction access roads and parking areas.
- Implementation of adaptive management for stormwater control during construction.
- Measurement of construction-related water quality parameters such as turbidity and pH throughout construction. Measurements would be taken at identified points as required for permit compliance, and both upstream and downstream measurements would be taken to determine construction-related changes.

EROSION CONTROL BMP DURING CONSTRUCTION

Construction would comply with the National Pollutant Discharge Elimination System (NPDES) permit, WAC 173-201A: Water Quality Standards for Surface Waters of the State of Washington, and other federal, state, and local codes and regulations. The Applicant would implement BMPs in accordance with Ecology's Stormwater Management Manual for Western Washington, current WSDOT Standard Specifications for Road, Bridge, and Municipal Construction and Standard Plans, and Lewis County standards.

As part of a construction contract, the Applicant would require the contractor to implement temporary erosion and sediment control (TESC) measures and prepare a TESC plan for all aspects of construction, including clearing and grading in the FRE facility construction footprint, temporary access roads, improvements to existing access roads (i.e., to selected quarry site). The TESC plan would also apply to the implementation of the VMP. Implementation of the TESC plan would minimize stormwater impacts such as storm flow runoff, soil erosion, waterborne sediment from exposed soils, and degradation of water quality from on-site pollutant sources. At a minimum, and for consideration as part of the

Proposed Action, the following BMPs would be implemented to minimize the potential for erosion and sediment production:

- Use of straw bales, silt fencing, vegetation strips, brush barriers, or other suitable sedimentation control or containment devices.
- Washing truck tires to reduce tracking of sediments and potential aquatic invasive species from construction sites.
- Covering exposed soil stockpiles and exposed slopes with mulch, nets and blankets, plastic coverings, temporary seeding and sodding, and compost blankets.
- Use of straw mulch (certified free of noxious weeds and seeds) and erosion control matting to stabilize graded areas as appropriate.
- Retaining vegetation where possible to minimize soil erosion.
- Seeding or planting appropriate vegetation on exposed areas as soon as possible after work is completed.
- Construction of temporary sedimentation ponds to detain runoff water as appropriate.
- Use of Baker tanks, sediment traps, flow control structures, oil/water separators, ditches, and level spreaders to control erosion.
- Use of berms, ditching, and other on-site measures to prevent soil loss.
- Monitoring downstream turbidity during construction to document the potential effectiveness of implemented measures.
- Visual monitoring for signs of erosion and implementation of additional erosion control measures, as required.
- Relative to excavated slopes that may be prone to bank instability during construction:
  - Excavation would begin from the upper portion of the slope first to avoid stability issues.
  - Steep rock slopes would include pattern rock bolts for stability.
  - To reduce the potential for landslides, over-steepened slopes included as part of the permanent design would be stabilized to meet slope design criteria by methods including:
    - Introduction of horizontal drainage into vulnerable slopes to improve stability.
    - Placement of berms at the toes of steep slopes.
    - Introduction of tieback walls to retain slopes.

In addition, the Applicant would comply with all permit requirements and would monitor erosion during construction.

SPECIFIC IN-WATER AND OVER-WATER BMP

The Applicant would employ the following measures during construction to prevent potential effects on receiving water:

- Stormwater Pollution Prevention Plan. Mitigation for potential stormwater potential effects would be provided by implementing a stormwater pollution prevention plan and TESC plan during construction.
- Spill Response Plan. A spill response plan would be developed for construction. This plan would outline measures and procedures for response to hazardous material spills and entry of spilled substances to any receiving waters.
- Construction Water Management. Dewatering of areas behind cofferdams would be necessary. If surface water or groundwater were encountered during excavation, the water would be pumped out of the work area and settled prior to discharge.

Typical construction BMPs for working in, over, and near water include:

- Checking equipment for leaks and other problems that could result in the discharge of petroleum-based products or other material into receiving waters.
- Corrective actions, including those listed below, would be taken in the event of any discharge of oil, fuel, or chemicals into the water:
  - In the event of a spill, containment and cleanup efforts would begin immediately and be completed in an expeditious manner in accordance with all local, state, and federal regulations; these efforts would take precedence over normal work. Cleanup would include proper disposal of any spilled material and used cleanup material.
  - The cause of the spill would be assessed, and appropriate action taken to prevent further incidents or environmental damage.
  - Spills would be reported to the Washington State Department of Ecology Southwest Regional Spill Response Office at (360) 407-6300.
- Excess or waste materials would not be disposed of or abandoned waterward of the OHWM or allowed to enter waters of the state.
- Waste materials would be disposed of in an appropriate landfill.
- Demolition and construction materials would not be stored where wave action or upland runoff could cause materials to enter surface waters.
- Oil-absorbent materials would be stored on-site during construction in the event of a spill, or if any oil product is observed in the water.
- During construction, the Applicant would require the contractor to prevent or minimize potential adverse potential effects on groundwater quality from inadvertent spills by using construction BMPs, such as good housekeeping, proper storage of hazardous materials and petroleum products, and implementation of an SPCC plan.

- To limit the impact of construction-related noise on the environment, the proposed work would comply with applicable noise regulations by restricting construction activities to daytime hours.
- The Applicant would require the contractor to adhere to the following when pouring wet concrete for FRE facility-related infrastructure:
  - Wet concrete would be poured "in the dry" behind isolation cofferdams and would not be allowed to meet surface waters.
  - Forms for any concrete structure would be constructed and kept in place until the concrete is cured to prevent leaching.
  - During in-water concrete pouring for the FRE facility foundations, the contractor would test the pH of the water immediately downstream of the construction cofferdam to ensure there are no detrimental potential effects on water quality. If high pH readings are measured, concrete pouring would cease immediately, and the contractor would identify the source of contamination. Concrete pouring would not commence again until the issue was resolved. In addition, the contractor would test seepage water that may be present behind the cofferdam. If high pH readings are measured, seepage water would be pumped from the isolation structure to land for upland containment and disposal.
- Small pumps would be available on-site to capture seepage water from behind isolation cofferdams. Seepage water would be routed to a settling basin (sandbags filled with clean gravel or Baker tank, as appropriate), prior to discharge back to the temporary reservoir.
- Compost berms or socks would be available to protect the work area from seepage or erosion.

CONSTRUCTION BMP FOR THE PROTECTION OF FISH

The contractor would be required to submit dewatering plans to the Applicant a minimum of 60 days prior to in-water work, and to agencies 30 days prior for regulatory review to ensure consistency with existing environmental authorizations.

In coordination with USFWS, NOAA, and WDFW, the Applicant would develop appropriate protective measures to avoid or mitigate any potential effect on fish. The Applicant would submit a fish rescue and salvage plan to WDFW no less than 60 days prior to the start of fish removal activities for each in-water work period. The plan would outline the sequential methods for removing fish from the work area. The plan would require secondary written approval by WDFW prior to implementation to ensure consistency with the permit and protections for fish life in the Mitigation Area. The Applicant would require the contractor to adhere to typical construction BMPs for the protection of fish including:

- Adherence to the agency-approved in-water work window.
- Coordination with agencies to implement fish salvage plans for each stage of in-water work.

  - Fish salvage would be conducted in accordance with WSDOT fish exclusion protocols (WSDOT 2016).
  - Electroshocking would occur in accordance with NOAA (2000) electrofishing guidelines.
  - All electrofishing would be conducted by a person with electrofishing training to direct all activities.
  - All captured and collected fish would be transported to the upstream end of the work area and released at a suitable location for recovery and re-orientation (slow-moving pool habitat).
- Monitoring of temperature and dissolved oxygen during operations and subsequent refill periods.
- Screening of intakes – screens must have enough surface area to ensure that the through-screen velocity is less than 0.4 feet per second.
- Maintenance of fish screens to prevent injury or entrapment of fish.

IMPACT PILE DRIVING, BLASTING, AND QUARRY OPERATIONS BMPS

The Applicant would construct and operate the selected quarry under the regulation of an NPDES Sand and Gravel Permit issued by Ecology. For all blasting activities, the Applicant would require the contractor to prepare a blasting and debris management plan for agency submittal and approval a minimum of 60 days prior to blasting activities. Specific blasting minimization measures are defined below.

Impact Pile Driving and Blast Timing Restrictions

Impact pile driving and blast timing restrictions would be implemented to protect marbled murrelet during upland and in- or near-channel blasting. Although not surveyed, LiDAR and aerial vegetation analyses indicate that pockets of nesting habitat potentially suitable for marbled murrelets may be present near the proposed FRE facility site and candidate quarry sites. The USFWS considers all un-surveyed suitable habitats to be occupied. Accordingly, for areas within ¼ mile of the selected quarry site, and within ¼ mile of the FRE facility foundation and tunnel blasting locations, the Applicant would commit to the following:

- Pre-construction surveys within ¼ mile of all impact pile driving and blasting locations to identify suitable nesting trees for marbled murrelets.
- Within ¼ mile of all suitable nesting trees, all impact pile-driving and blasting would adhere to LOP during the murrelet nesting season (April 1-September 23). Therefore, impact pile driving

and blasting during the murrelet nesting season would only be authorized from two hours after official sunrise through two hours prior to official sunset.

- Outside of the murrelet nesting season (September 24-March 31), no impact pile-driving or blast timing restrictions would be required.

Blasting in Uplands

Controlled blasting would be required to comply with anticipated regulatory requirements and measures for the protection of personnel and property. Blasting in uplands more than 200 feet from active river flow would be accomplished using BMPs that would include:

- Test-blasting to be conducted to determine the minimum explosive charge weight required to satisfactorily excavate the bedrock for the bypass tunnel or quarry site.
- If test-blasting shows that debris is ejected to an unacceptable distance away from demolition, or dust generation is unacceptable, the contractor would be required to use blast mats or overburden cover to contain debris and dust.

Blasting In and Adjacent to the Chehalis River or Bypass Tunnel

No blasting would occur in the active river channel (i.e., with water flowing). Blasting for the FRE structure foundation excavation would occur while the river is diverted into the diversion tunnel. Such blasting would be conducted “in the dry,” with a minimum 25-foot-wide dry working space buffer between the blast site and the cofferdam isolating the in-water work area from active river flow.

To reduce or eliminate potential effects on fish, or to keep fish out of areas of harmful blasting pressure, the selected contractor would be required to attenuate vibration transference when blasting close to the active flow in the Chehalis River or its tributaries. Attenuation measures would include:

- Maintaining a dry in-water work area in this zone using sheet piling as cofferdams.
- Additional attenuation measures such as bubble curtains directly waterward of blast locations that would be applied if future blasting plans (to be developed as part of the construction contract) determine that explosive charge sizes exceed those typical for trenching.
- Selecting the minimum size charge and type of explosives necessary to accomplish the excavation.
- If buffer distances are not defined by the governing jurisdictions, buffer distances identified in industry standards and by other government entities would be considered and employed, such as the Alaska Department of Fish and Game’s Blasting Standards for the Protection of Fish (ADFG 1991) which recommends at 50-foot buffer distance for use of the 1-2 pound explosive charges typically used for trenching excavation. Larger buffer distances may be required for larger explosive charges.

Prior to rock blasting, the contractor would be required to provide a rock blasting plan for review. In addition to the requirements above, the contractor would be required to follow local, state, federal, and industry standards for safety and environmental protection during blasting, including:

- Safety procedures that minimize the potential for human presence in the blasting area and flyrock zone (the area in which blast-induced rockfall could occur) during the blasting period;
- Compliance with codes and permit requirements governing noise levels;
- Compliance with codes and permit requirements governing the times and locations of blasting, and avoidance of blasting during identified blast timing restrictions for wildlife protection, to the extent possible;
- Use of blast curtains and other debris containment practices to control debris produced by blasting activities;
- Monitoring of blast activities and limiting peak particle velocities induced by blasting operations; and
- Use of water spray or other best management practices to control the dust produced from blasting activities.

Finally, Kolden (2013) reviewed blasting mitigation requirements for several projects requiring a Hydraulic Project Approval (HPA) from WDFW and noted several measures that have been required to minimize the potential effects of blasting on aquatic species. In addition to conducting all blasting "in the dry" behind dewatered cofferdams, the Applicant would require the selected contractor to implement the following measures during in-channel or near-channel blasting:

- Charges shall be no larger than necessary to accomplish the task and shall be set in a manner (timing, frequency, location) such that instream concussion is minimized. Timing shall include microsecond delays to minimize the potential effect on fish.
- All blast material shall be removed and deposited in an approved upland disposal site so it would not re-enter the stream.
- Methods (blasting mats, sandbag berms, etc.) to contain and control slide debris resulting from blasting shall be in place prior to any blasting.

Appendix G
Mitigation Capacity Memo

MEMORANDUM

Date: February 26, 2021
To: Chehalis River Basin Flood Control Zone District, Betsy Dillin
From: Kleinschmidt Team
Re: Mitigation Capacity and Species Benefits

Introduction

The purpose of this Technical Memorandum is to provide updated mitigation related information on two important areas related to the Draft Environmental Impact Statement findings of the Flood Retention Expandable (FRE) Facility project for the Chehalis Basin. The first section of the memorandum addresses mitigation capacity on the landscape and the second section is focused on potential per-species benefits from the mitigation actions presented in the July 2020 Draft Mitigation Opportunities Report (Kleinschmidt 2020).

Capacity to Mitigate Additional Impacts

This section of the memorandum considers the capacity of the mitigation opportunities study area to provide additional compensatory aquatic habitat mitigation if future impact assessments indicate mitigation needs that exceed the functional improvement from opportunities and actions identified in the July 2020 Draft Mitigation Opportunities Report (Kleinschmidt 2020).

The work presented in this memorandum and in the July 2020 Draft Mitigation Opportunities Report represents one component of the process of evaluating whether sufficient mitigation opportunity exists within the upper Chehalis Basin. This work focuses on estimated quantities of defined habitat types for both impacts and mitigation at a coarse level of detail consistent with the impact descriptions published in the SEPA DEIS (Ecology 2020). This work was performed to provide a basis for a preliminary assessment of mitigation opportunities and potential costs. The mitigation action types used for this analysis serve as a coarse resolution proxy for a future more detailed analysis of impacts and mitigation evaluated based on ecological functions and aquatic species and life stages that are impacted or benefited.

In addition to a direct comparison of habitat quantities between impacts and mitigation, evaluation of mitigation sufficiency will need to consider the spatial and temporal context of the watershed, population dynamics and trends for affected aquatic species, limiting factors for species productivity and survival, and the cumulative effects of the project combined with other actions that affect aquatic species and their habitats. Regulatory agencies will make the determination of mitigation sufficiency and efficacy in consultation with tribes. This information is provided by the District to support early coordination with agencies and tribes regarding mitigation opportunities.

The July 2020 Draft Mitigation Opportunities Report (Kleinschmidt 2020) described a pool of 355 aquatic and terrestrial habitat mitigation sites that were identified in the initial feasibility assessment. Section 4.4 of the July 2020 draft report noted that total length of stream and river channel potentially available for compensatory mitigation for some action types may be considerably more extensive than shown. The extent of mitigation site availability is re-examined herein to document the expanded capacity of identified mitigation opportunities that would be available to address potential impacts to aquatic species not yet determined.

An additional 49 sites have been identified since the July 2020 draft report. At these additional candidate sites, there are 93 potential mitigation actions that may be applied. Many (n=34) of the additional sites are located on the upper mainstem Chehalis River between Pe Ell (Stowe Cr. confluence) and the South Fork Chehalis River. Nine of the new sites are located between the FRE site and Pe Ell and six are within the estimated FRE 10-year event inundation zone. Figure 1 is a revised version of Figure 3 from the July 2020 Draft Mitigation Opportunities Report showing aquatic habitat candidate site pool locations summed by sub-watershed.

Table 5 in the Draft Mitigation Opportunities Report presented a comparison estimated mitigation needs to a snapshot of the available sites identified at that time. Mitigation sites for action types such as riparian buffer expansion, instream modification, gravel retention jams, and off-channel modification sites had been primarily identified only in conjunction with other action types, or as examples of their type, magnitude, and extent of suitable landscape settings. For particular mitigation action types (e.g., riparian buffer expansion, instream modification, gravel retention jams, upland conservation/enhancement), the potential pool of additional sites within the geographic focus area for on-site and off-site mitigation is extensive and unlikely to be limited by availability on the landscape within the range of distribution of anadromous salmonid and lamprey in the upper Chehalis Basin. This will enable the addition, removal, shrinking, or expansion of those types of proposed sites as needed to match impacts. These adjustments can be made during the mitigation planning and design processes based on refinement of project impact analyses, predicted functional maturity timeframes, and degree of certainty of site performance. Such adjustments could also be made in an adaptive management fashion based on monitoring of post-construction project effects and mitigation site performance.

Figure 1: Updated aquatic habitat candidate site pool locations summed by sub-watershed (Revised Figure 3 from July 2020 Draft Mitigation Opportunities Report, updated to include additional sites).

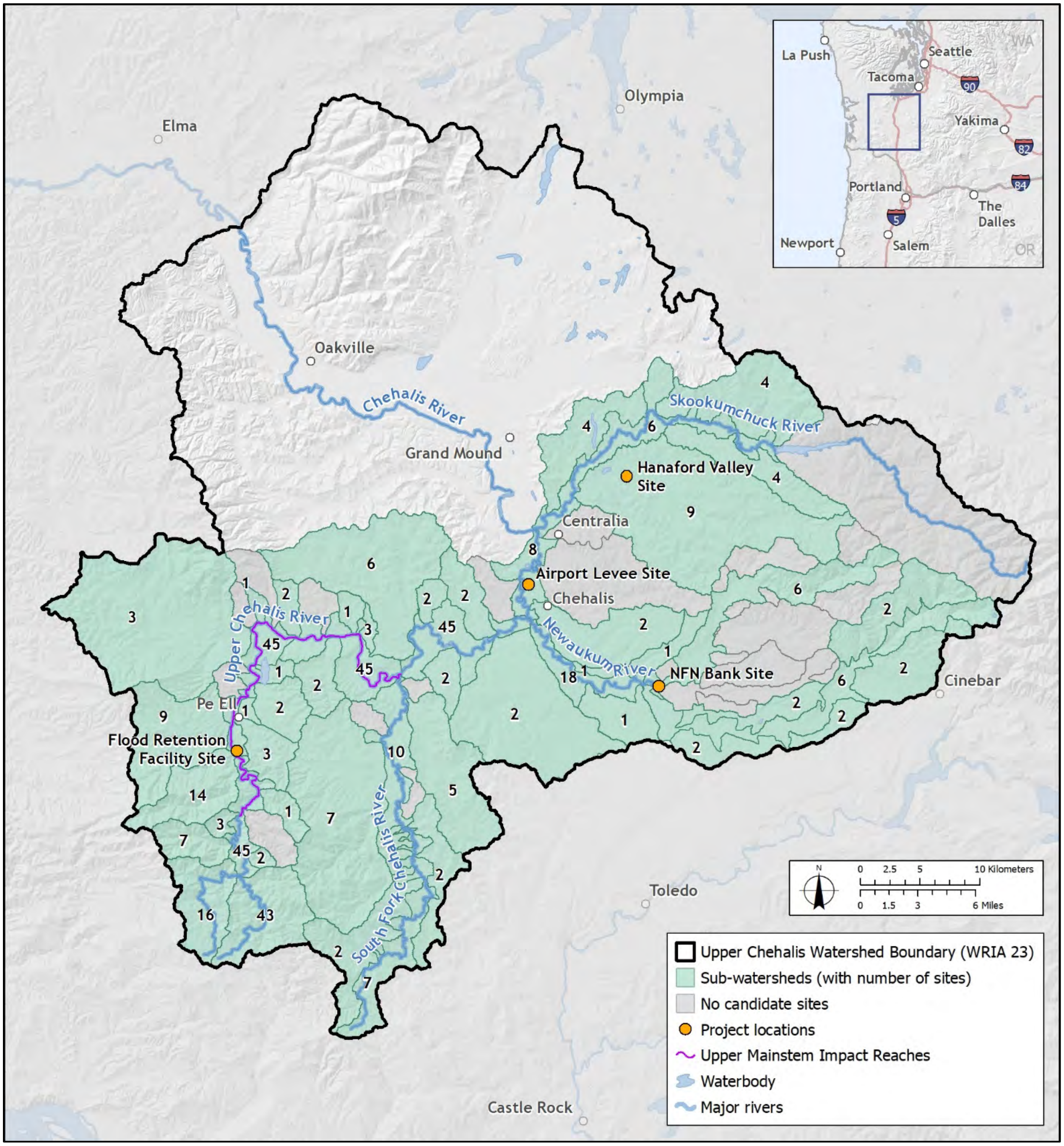


Table 1 is an update of Table 5 in the July 2020 Draft Mitigation Opportunities Report. Estimated mitigation need is verbatim from that report and is subject to revision according to ongoing effects analyses. As in the July 2020 draft report, “identified availability” is not intended to be a comprehensive sum of total availability of suitable sites in the study area. Notes for each mitigation action type outline the maximum theoretical extent of land available for each within their criteria. Additional selection methods are discussed below.

Table 1. Revised comparison of Estimated Mitigation Needs to Opportunities by Action Type

MITIGATION ACTION TYPES	ESTIMATED NEED (JULY 2020)	ESTIMATED AVAILABILITY (JULY 2020)	ADDITIONAL IDENTIFIED AVAILABILTY (FEBRUARY 2021)	NOTES
Riparian Buffer Expansion	17 miles	53 miles	5.6 miles (17 added sites)	Mainstem and tributary sites are available. May include complete reforestation, expanded forested widths, and/or management of existing full-width riparian forest in perpetuity for riparian function. Maximum theoretical extent of potential length would include all channels capable of supporting riparian vegetation in the study area that are not of optimal width, native vegetation community, and/or conservation status.
Hyporheic Exchange Enhancements	9,000 ft	28,500 ft	2700 ft (9 added sites)	Availability is controlled by valley form.
Cold-water Retention Structures	1,000 ft	18,000 ft	1250 ft (5 added sites)	Availability is controlled by hillslope topography and geology.
Instream Modifications	17,500 ft	89,000 ft	23,500 ft (47 added sites)	Maximum theoretical extent of potential length would include all fish-bearing channels in the study area that do not conform to all preference criteria of target species.
Off-channel Modifications	8,000 ft	220,000 ft	4000 ft (2 added sites)	Availability is controlled by valley form.
Gravel Retention Jams	13,500 ft	18,000 ft	10,800 ft (12 added sites)	Maximum theoretical extent of potential length would include all identified spawning reaches in the study area that do not conform to all preference criteria of target species.
Fish Passage	5 barriers	23 barriers	n/a	Availability is controlled by number of existing/inventoried barriers. Some private road crossing barriers may be missing from inventories. Additional opportunities may also include funding second-tier State of WA agency-owned or other barriers.
Wetland Enhancement	1 location (3 acres)	34 locations	1 added site	Availability is controlled by valley form, soils, and hydrology. See Wetland Mitigation Assessment.

MITIGATION ACTION TYPES	ESTIMATED NEED (JULY 2020)	ESTIMATED AVAILABILITY (JULY 2020)	ADDITIONAL IDENTIFIED AVAILABILTY (FEBRUARY 2021)	NOTES
Upland Conservation and Enhancement	2 locations (50 acres each)	10 locations (variable size >50 acres)	n/a	Maximum theoretical extent of potential area would encompass nearly all non-urban lands in the study area except those already in conservation land use type.

Selection Methods for Added Candidate Mitigation Sites

Mitigation action descriptions, site selection criteria, and average site size assumptions for the 49 additional unique sites discussed here were identical to those used in the July 2020 Draft Mitigation Opportunities Report. As in the July 2020 draft report, sub-watersheds mapped in Figure 1 are the same as used in the EDT model (McConnaha et al., 2017). Sites were selected with consideration of equipment and material accessibility.

For this effort, emphasis was placed on identifying additional sites that may be suitable for Hyporheic Exchange Enhancements (n=9), Off-channel Modifications (n=2), and Gravel Retention Jams (n=12). Twenty-five additional sites focused on Instream Modifications and one Riparian Expansion site were also added. Reflecting an emphasis on sites that may provide multiple functional benefits to multiple species and lifestages, 32 of the newly identified sites were identified as having potential for two or more mitigation action types. For each newly identified candidate site, one or more secondary potential mitigation actions (e.g., Riparian Expansion, Cold Water Retention, Instream Modification elements) were assigned where site conditions and morphology provided the opportunity. In this manner, 93 potential mitigation actions were identified that could be applied to the 49 added candidate sites.

Summed additional lengths for each mitigation action type were derived by multiplying the number of identified sites by the per-site extent assumptions in Table 2. These same assumptions were used for the July 2020 draft report.

“Identified availability” numbers are intended to be illustrative, not comprehensive: they represent only mitigation opportunities identified to date. In most cases, the process of identifying opportunities was paused for an action type when it was determined that the pool was of a sufficient magnitude to substantially exceed the estimated effects of the proposed project. For identified mitigation opportunities, the potentially available quantities for each mitigation action type exceed the estimated need by a factor ranging from 3.4 to 35 times the estimated need. These sums are not intended to provide a comprehensive inventory of total availability of suitable sites in the study area. As discussed in Table 1, within specified constraints, additional sites of each type are likely available beyond the pool identified to-date in the July 2020 Draft Mitigation Opportunities Report and in this memorandum. The theoretical maximum extents of land or channel available for each mitigation action type outlined in

Table 1 are based on the geological, biological, and land use variables that control the occurrence of areas that fit the criteria for each action type. For example, as described in Appendix B of the Draft Mitigation Opportunities Report, hyporheic exchange of the type and magnitude envisioned for enhancement occurs in specific valley forms that host alluvial channels with suitable planform geometry and adjacent terraces. Similarly, candidate locations for off-channel habitat modifications could only be sited in relatively unconfined channels in valley bottoms wide enough to possess floodplains, but without critical infrastructure. The siting of cold-water retention structures or alcoves designed to slow mixing of relatively colder local inflows is also determined by valley form: they could be sited where groundwater seeps join perennial fish-bearing channels (mostly found higher in the study area in steeper, more constrained channels) and at the downstream end of hyporheic enhancement sites (found at lower elevations in the study area) to capture hyporheic outflows for the creation of local temperature refugia.

Table 2. Assumed Typical Site Quantities for Each Mitigation Action Type (verbatim from Table 4 in July 2020 Draft Mitigation Opportunities Report)

MITIGATION ACTION TYPE	DESCRIPTION	QUANTITY FOR A TYPICAL SITE	UNIT OF EXTENT
Riparian Buffer Expansion	Reforestation of riparian buffers along channel margins	0.33	Length (miles)
Hyporheic Exchange Enhancements	Hyporheic exchange enhancements at selected riverbends	300	Length (feet)
Groundwater Retention Structures	Structures, side channels, or alcoves that intercept groundwater and form cool water pockets for thermal refugia	250	Length (feet)
Instream Modifications	Construction of habitat features within the perennial wetted channel for several purposes	500	Length (feet)
Off-channel Modifications	Off-channel habitat enhancements including side channel and floodplain actions	2000	Length (feet)
Gravel Retention Jams	Large wood and rock structures that provide roughness to retain salmonid spawning gravels.	900	Length (feet)
Fish Passage	Fish passage improvements including replacing fish passage barrier culverts with passable crossings.	1	Each
Wetland Enhancement	Enhancement, restoration, or expansion of wetlands to benefit wildlife species.	2	Area (acre)

MITIGATION ACTION TYPE	DESCRIPTION	QUANTITY FOR A TYPICAL SITE	UNIT OF EXTENT
Upland Conservation and Enhancement	Conservation and enhancement of specific habitats matching the requirements of focal wildlife species.	10	Area (acre)

<u>Potential Per-Species Benefits from Mitigation Actions</u>

This section provides a framework to cross-reference potential ecological function benefits of each mitigation action type with life stages of five target aquatic species. Table 3 summarizes these benefit types for spring-run Chinook Salmon, fall-run Chinook Salmon, Coho Salmon, Steelhead, and Pacific Lamprey. Life history characteristics of Chehalis Basin fish species were derived from the summaries in Appendix K of the NEPA DEIS (USACE 2020). This memorandum presumes that mitigation planning and design will be conducted using a process-based rather than form-based approach to select actions that match site potential and maximize long-term functioning to support fish population resilience. To ensure that mitigation projects function as intended and benefit the selected target species and lifestages, watershed position, reach and site geomorphology, hydrology, hydraulics, human constraints, and biological factors must shape mitigation planning and the specifics of each design.

The five target species considered here have overlapping habitat requirements and geographic distributions, but they differ in ways that may affect how their populations respond to habitat mitigation actions. These differences will lead to varying benefits depending on mitigation action type, location, and technical specifications. For example, spring Chinook adults' earlier freshwater entrance and longer holding periods make them particularly susceptible to pre-spawn mortality associated with summertime high water temperatures. Mitigation actions that lead to local and/or overall improvements to water temperature conditions at and downstream of spawning reaches could therefore offer relatively greater benefits to spring Chinook populations compared to species with later adult arrival in the Chehalis River. The spatial distribution of life stages also varies: coho and steelhead spawning extends higher in the basin than does Chinook (Ronne et al. 2020). The relative distribution of benefits may, in part, be managed via mitigation siting and design if emphasis on particular species or life stages is desired. The differentiating factors that will guide selection of which local habitat-forming processes (e.g., pool scour, substrate sorting, sediment transport, solar inputs, nutrient retention, surface-groundwater exchange, bank erosion, etc.) to manipulate are rooted in the distinct selective pressures that shaped the evolution of each species or stock. Compared to Chehalis Basin spring Chinook, the following general types of differences in life history and habitat needs are assumed:

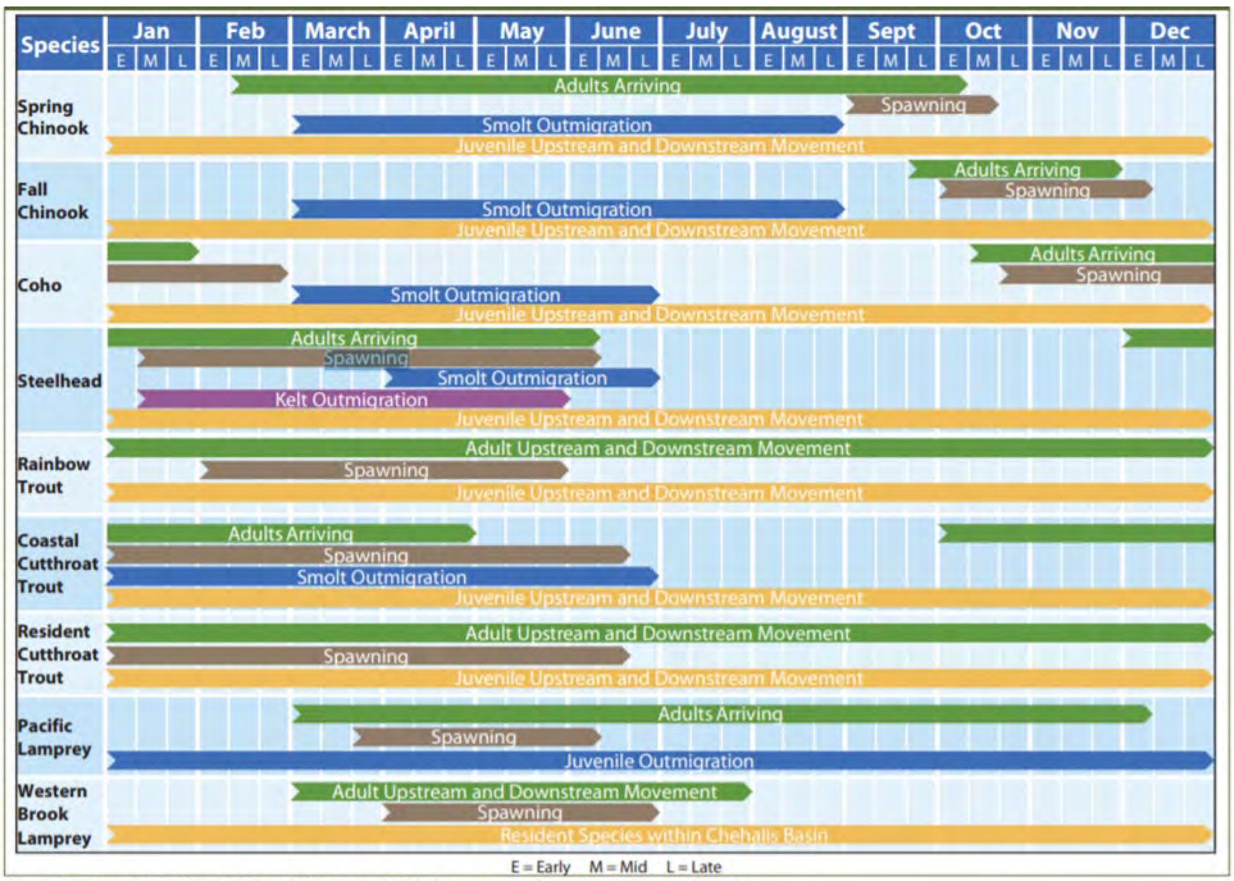
- Fall Chinook: Later adult migration, shorter holding, and later spawning timing; different spawning and rearing distribution
- Coho: Later adult migration, shorter holding, and later/longer spawning timing; different spawning and rearing distribution; smaller spawning substrate preference range; lower rearing

velocities; higher winter use of off-channel rearing habitats; shorter juvenile outmigration period; different fish passage criteria: slightly lower burst speeds and jumping abilities

- Steelhead: Later adult migration and holding timing; later and longer spawning timing; different spawning and rearing distribution; smaller spawning substrate preference range; more diverse juvenile rearing strategies (timing and locations); kelt (post-spawn adult) downstream migration; different fish passage criteria: higher burst speeds and jumping abilities
- Pacific lamprey: Longer adult migration and holding periods; earlier spawning timing; different spawning and rearing distribution; smaller spawning substrate preference range; need for fine sediments for larval rearing; no natal fidelity; continuous juvenile outmigration; different fish passage criteria (no jumps or sharp angles, but can climb vertical wetted surfaces)

Figure 2 is a fish periodicity chart from the Draft SEPA EIS that illustrates timing differences between the target fish species.

Figure 2 Anticipated migration periods of selected fish species and life stages (Figure E-4 from 2020 SEPA DEIS).



Source: Data from Wydoski and Whitney 2003 and Holt 2019; figure adapted from Figure 2-1 in CBS 2018b.

Mitigation site selection will be guided, in part, by known population limiting factors and habitat-forming processes that are likely to be affected by the FRE project. Geomorphological potential and constraints will also guide the process of matching actions to sites. Mitigation actions will be designed according to their location in regard to the life stages that use (or could use) the reach and the associated habitat processes that will support the site's suitability for those life stages. As an example, for a site on the upper mainstem Chehalis River above Doty, the design may emphasize processes that capture, retain, and sort spawning gravels and provide rearing habitat with suitable depth, complexity, and velocities across a range of seasonal flows. A site in the middle reaches of the upper mainstem Chehalis River may emphasize floodplain reconnection and hyporheic enhancement to provide increased forage, high flow refuge, off-channel overwintering habitat, nutrient flux, adult holding water, and temperature moderation. A site on the South Fork may emphasize the creation of seasonal non-natal rearing opportunities and riparian enhancements to reduce summer thermal load contribution and support other habitat improvements.

While some mitigation concepts will be designed specific to species and life stage needs, most mitigation concepts and locations discussed in the July 2020 Draft Mitigation Opportunities Assessment could benefit any of the five target species to some degree due to overlapping spatial distributions and habitat requirements. Table 4 and Table 5 summarize, per target species and life stage, which of the functional benefit types summarized in Table 3 would be expected to be derived from elements of two of the conceptual examples in the Mitigation Opportunities Assessment, demonstrating the application of a variety of mitigation action types across multiple sites within a reach. Those conceptual examples were for hypothetical reaches (based on actual locations within the study area), so Table 4 and Table 5 assume the presence of each of the life stages of the five target species within each reach, with habitat use partitioned in time and space. Actual benefits to fish species will depend on selected locations and designs: actions may benefit species and lifestages unequally. An upper river mitigation site offering enhanced summer rearing habitat could benefit juvenile coho and steelhead more than Chinook due to the ocean-type juvenile Chinook migration strategy observed in the Chehalis by Winkowski et al. (2018), but the same mitigation actions applied further downstream could bias benefits toward Chinook. Mitigation site size and complexity will also influence benefits: smaller sites are more likely to precisely target and benefit a narrower range of species and lifestages per location, but larger sites that are located within overlapping species ranges and designed with diverse and complex habitat features that function across a range of seasonal flow stages will benefit a wider range of species and lifestages. During later mitigation planning and design processes, Table 3 may be refined to indicate selection of targeted limiting factors (e.g., summer rearing habitat and temperature, per Winkowski et al. [2018]), and the checkmarks in Table 4 and Table 5 may be replaced with more detailed site-specific descriptions or quantifications of applicable functional benefits per species and life stage.

Table 3: Potential functional benefits assigned to mitigation action type per target species and life stage.

SPECIES	LIFE STAGE	ACTION TYPES							
		RIPARIAN BUFFER EXPANSION	HYPORHEIC EXCHANGE ENHANCEMENTS	COLD WATER RETENTION STRUCTURES	INSTREAM MODIFICATIONS	OFF-CHANNEL MODIFICATIONS	GRAVEL RETENTION JAMS	FISH PASSAGE	WETLAND ENHANCEMENT
SPRING CHINOOK	Adult migration and holding	Shade to reduce warming; water quality filtration; LWD recruitment for cover and holding pool structure and cover.	Local temperature refuge and buffering	Local temperature refuge	Increased holding pool depth and cover		Increased holding pool depth and cover	Increased access to holding and spawning habitats	Water quality filtration; temperature buffering; reduced PSM risk
	Spawning	Where excess bank or riparian soil erosion is occurring, revegetation may reduce erosion that leads to gravel embeddedness; increased overhanging cover.	Increased quantity or quality of attractive spawning habitat		Increased suitable spawning area; increased substrate sorting; increased cover. Where excess bank or riparian soil erosion is occurring, wood structures may reduce erosion that leads to embeddedness.		Increased suitable spawning area; increased substrate sorting	Increased access to spawning habitat	Floodplain wetlands capture and retain fine sediments that can otherwise lead to gravel embeddedness.
	Incubation	Where excess bank or riparian soil erosion is occurring, revegetation may reduce erosion that leads to egg suffocation.	Moderation of incubation temperatures		Localized reduction of redd scour by increasing hydraulic roughness. Where excess bank or riparian soil erosion is occurring, wood structures may	Reach-scale reduction of redd scour by reducing scour forces at high flows	Localized reduction of redd scour		Floodplain wetlands capture and retain fine sediments that can otherwise lead to egg suffocation.

SPECIES	LIFE STAGE	ACTION TYPES							
		RIPARIAN BUFFER EXPANSION	HYPORHEIC EXCHANGE ENHANCEMENTS	COLD WATER RETENTION STRUCTURES	INSTREAM MODIFICATIONS	OFF-CHANNEL MODIFICATIONS	GRAVEL RETENTION JAMS	FISH PASSAGE	WETLAND ENHANCEMENT
					reduce erosion that leads to egg suffocation.				
	Rearing	Shade to reduce warming; water quality filtration; CPOM nutrient inputs; invertebrate forage; LWD recruitment for hiding and water velocity heterogeneity	Local temperature refuge and buffering	Local temperature refuge	LWD for cover and water velocity heterogeneity; substrate sorting; pool formation	Low-velocity rearing and refuge	LWD for cover and water velocity heterogeneity; substrate sorting; pool formation	Access to non-natal rearing habitats	Water quality filtration; temperature buffering; invertebrate forage if in floodplain
	Outmigration				Refuge from predation	Refuge from predation	Refuge from predation	Access to non-natal rearing habitats	Water quality filtration; invertebrate forage if in floodplain
FALL CHINOOK	Adult migration and holding	Shade to reduce warming; water quality filtration; LWD recruitment for cover and holding pool structure and cover	Local temperature refuge and buffering	Local temperature refuge	Increased holding pool depth and cover		Increased holding pool depth and cover	Increased access to holding and spawning habitats	Water quality filtration; temperature buffering; reduced PSM risk
	Spawning	Where excess bank or riparian soil erosion is occurring, revegetation may reduce erosion that	Increased quantity or quality of attractive spawning habitat		Increased suitable spawning area; increased substrate sorting; increased cover. Where excess bank or riparian soil		Increased suitable spawning area; increased substrate sorting	Increased access to spawning habitat	Floodplain wetlands capture and retain fine sediments that can otherwise lead to gravel embeddedness.

SPECIES	LIFE STAGE	ACTION TYPES							
		RIPARIAN BUFFER EXPANSION	HYPORHEIC EXCHANGE ENHANCEMENTS	COLD WATER RETENTION STRUCTURES	INSTREAM MODIFICATIONS	OFF-CHANNEL MODIFICATIONS	GRAVEL RETENTION JAMS	FISH PASSAGE	WETLAND ENHANCEMENT
		leads to gravel embeddedness; increased overhanging cover.			erosion is occurring, wood structures may reduce erosion that leads to embeddedness.				
	Incubation	Where excess bank or riparian soil erosion is occurring, revegetation may reduce erosion that leads to egg suffocation.	Moderation of incubation temperatures		Localized reduction of redd scour by increasing hydraulic roughness. Where excess bank or riparian soil erosion is occurring, wood structures may reduce erosion that leads to egg suffocation.	Reach-scale reduction of redd scour by reducing scour forces at high flows	Localized reduction of redd scour		Floodplain wetlands capture and retain fine sediments that can otherwise lead to egg suffocation.
	Rearing	Shade to reduce warming; water quality filtration; CPOM nutrient inputs; invertebrate forage; LWD recruitment for hiding and water velocity heterogeneity	Local temperature refuge and buffering	Local temperature refuge	LWD for cover and water velocity heterogeneity; substrate sorting; pool formation	Low-velocity rearing and refuge	LWD for cover and water velocity heterogeneity; substrate sorting; pool formation	Access to non-natal rearing habitats	Water quality filtration; temperature buffering; invertebrate forage if in floodplain
	Outmigration				Refuge from predation	Refuge from predation	Refuge from predation	Access to non-natal rearing habitats	Water quality filtration; invertebrate forage if in floodplain
COHO	Adult migration and holding	Shade to reduce warming;	Local temperature refuge and buffering	Local temperature refuge	Increased holding pool depth and cover		Increased holding pool depth and cover	Increased access to holding and	Water quality filtration; temperature

SPECIES	LIFE STAGE	ACTION TYPES							
		RIPARIAN BUFFER EXPANSION	HYPORHEIC EXCHANGE ENHANCEMENTS	COLD WATER RETENTION STRUCTURES	INSTREAM MODIFICATIONS	OFF-CHANNEL MODIFICATIONS	GRAVEL RETENTION JAMS	FISH PASSAGE	WETLAND ENHANCEMENT
		water quality filtration; LWD recruitment for cover and holding pool structure						spawning habitats	buffering; reduced PSM risk
	Spawning	Where excess bank or riparian soil erosion is occurring, revegetation may reduce erosion that leads to gravel embeddedness.			Increased suitable spawning area; increased substrate sorting. Where excess bank or riparian soil erosion is occurring, wood structures may reduce erosion that leads to embeddedness.		Increased suitable spawning area; increased substrate sorting	Increased access to spawning habitat	Floodplain wetlands capture and retain fine sediments that can otherwise lead to gravel embeddedness.
	Incubation	Where excess bank or riparian soil erosion is occurring, revegetation may reduce erosion that leads to egg suffocation.			Localized reduction of redd scour by increasing hydraulic roughness. Where excess bank or riparian soil erosion is occurring, wood structures may reduce erosion that leads to egg suffocation.	Reach-scale reduction of redd scour by reducing scour forces at high flows	Localized reduction of redd scour		Floodplain wetlands capture and retain fine sediments that can otherwise lead to egg suffocation.
	Rearing	Shade to reduce warming; water quality filtration; CPOM nutrient inputs;	Local temperature refuge and buffering	Local temperature refuge	LWD for cover and water velocity heterogeneity; substrate sorting; pool formation	Low-velocity rearing and refuge	LWD for cover and water velocity heterogeneity; substrate sorting; pool formation	Access to non-natal rearing habitats	Water quality filtration; temperature buffering; invertebrate forage if in floodplain

SPECIES	LIFE STAGE	ACTION TYPES							
		RIPARIAN BUFFER EXPANSION	HYPORHEIC EXCHANGE ENHANCEMENTS	COLD WATER RETENTION STRUCTURES	INSTREAM MODIFICATIONS	OFF-CHANNEL MODIFICATIONS	GRAVEL RETENTION JAMS	FISH PASSAGE	WETLAND ENHANCEMENT
		invertebrate forage; LWD recruitment for hiding and water velocity heterogeneity							
	Outmigration				Refuge from predation	Refuge from predation	Refuge from predation	Access to non-natal rearing habitats	Water quality filtration; invertebrate forage if in floodplain
STEELHEAD	Adult migration and holding; kelt migration	Shade to reduce warming; water quality filtration; LWD recruitment for cover and holding pool structure	Local temperature refuge and buffering	Local temperature refuge	Increased holding pool depth and cover		Increased holding pool depth and cover	Increased access to holding and spawning habitats	Water quality filtration; temperature buffering; reduced PSM risk and lower kelt mortality from stormwater contaminants
	Spawning	Where excess bank or riparian soil erosion is occurring, revegetation may reduce erosion that leads to gravel embeddednes s.			Increased suitable spawning area; increased substrate sorting. Where excess bank or riparian soil erosion is occurring, wood structures may reduce erosion that leads to embeddedness.		Increased suitable spawning area; increased substrate sorting	Increased access to spawning habitat	Floodplain wetlands capture and retain fine sediments that can otherwise lead to gravel embeddedness.
	Incubation	Where excess bank or riparian soil erosion is occurring, revegetation may reduce			Localized reduction of redd scour by increasing hydraulic roughness. Where excess bank or riparian soil	Reach-scale reduction of redd scour by reducing scour forces at high flows	Localized reduction of redd scour		Floodplain wetlands capture and retain fine sediments that can otherwise lead to egg suffocation.

SPECIES	LIFE STAGE	ACTION TYPES							
		RIPARIAN BUFFER EXPANSION	HYPORHEIC EXCHANGE ENHANCEMENTS	COLD WATER RETENTION STRUCTURES	INSTREAM MODIFICATIONS	OFF-CHANNEL MODIFICATIONS	GRAVEL RETENTION JAMS	FISH PASSAGE	WETLAND ENHANCEMENT
		erosion that leads to egg suffocation.			erosion is occurring, wood structures may reduce erosion that leads to egg suffocation.				
	Rearing	Shade to reduce warming; water quality filtration; CPOM nutrient inputs; invertebrate forage; LWD recruitment for hiding and water velocity heterogeneity	Local temperature refuge and buffering	Local temperature refuge	LWD for cover and water velocity heterogeneity; substrate sorting; pool formation	Low-velocity rearing and refuge	LWD for cover and water velocity heterogeneity; substrate sorting; pool formation	Access to non-natal rearing habitats	Water quality filtration; temperature buffering; invertebrate forage if in floodplain
	Outmigration				Refuge from predation	Refuge from predation	Refuge from predation	Access to non-natal rearing habitats	Water quality filtration; invertebrate forage if in floodplain
PACIFIC LAMPREY	Adult migration and holding	Shade to reduce warming; water quality filtration; LWD recruitment for cover and holding pool structure	Local temperature refuge and buffering	Local temperature refuge	Increased holding pool depth and cover		Increased holding pool depth and cover	Increased access to holding and spawning habitats	Water quality filtration; temperature buffering
	Spawning	Where excess bank or riparian soil erosion is occurring, revegetation			Increased suitable spawning area; increased substrate sorting.		Increased suitable spawning area; increased substrate sorting	Increased access to spawning habitat	Floodplain wetlands capture and retain fine sediments that can otherwise

SPECIES	LIFE STAGE	ACTION TYPES							
		RIPARIAN BUFFER EXPANSION	HYPORHEIC EXCHANGE ENHANCEMENTS	COLD WATER RETENTION STRUCTURES	INSTREAM MODIFICATIONS	OFF-CHANNEL MODIFICATIONS	GRAVEL RETENTION JAMS	FISH PASSAGE	WETLAND ENHANCEMENT
		may reduce erosion that leads to gravel embeddednes s.			Where excess bank or riparian soil erosion is occurring, wood structures may reduce erosion that leads to embeddedness.				lead to gravel embeddedness.
	Incubation	Where excess bank or riparian soil erosion is occurring, revegetation may reduce erosion that leads to egg suffocation.			Localized reduction of redd scour by increasing hydraulic roughness. Where excess bank or riparian soil erosion is occurring, wood structures may reduce erosion that leads to egg suffocation.	Reach-scale reduction of redd scour by reducing scour forces at high flows	Localized reduction of redd scour		Floodplain wetlands capture and retain fine sediments that can otherwise lead to egg suffocation.
	Rearing	Shade to reduce warming; water quality filtration; CPOM nutrient inputs; LWD recruitment for hiding and water velocity heterogeneity	Local temperature refuge and buffering	Local temperature refuge	LWD for cover and water velocity heterogeneity; substrate sorting; pool formation	Increased rearing habitat and capacity due to local fine sediment accumulation for larva burrowing	LWD for cover and water velocity heterogeneity; substrate sorting; pool formation		Water quality filtration; temperature buffering
	Outmigration				Refuge from predation	Refuge from predation	Refuge from predation		Water quality filtration

Table 4: Potential functional benefits of conceptual examples per target species and life stage for Example Conceptual Design Group #2, a hypothetical location on the mainstem Chehalis River from the July 2020 Draft Mitigation Opportunities Assessment.

SPECIES	LIFE STAGE	ACTION TYPES: EXAMPLE CONCEPTUAL DESIGN GROUP #2 (MAINSTEM CHEHALIS RIVER)							
		RIPARIAN BUFFER EXPANSION	HYPORHEIC EXCHANGE ENHANCEMENTS	COLD WATER RETENTION STRUCTURES	INSTREAM MODIFICATIONS	OFF-CHANNEL MODIFICATIONS	GRAVEL RETENTION JAMS	FISH PASSAGE	WETLAND ENHANCEMENT
		Riparian reforestation and protection	*Hyporheic forcing structures and bank treatments*	*Groundwater refugia creation* *Alcove creation and expansion*	*Large wood installations*	*Floodplain reconnection* *Paleo channel enhancement*	*Large wood structures*		*Floodplain wetlands enhancement, creation, and/or reconnection*
SPRING CHINOOK	Adult migration and holding	+	+	+	+		+	+	+
	Spawning				+		+	+	
	Incubation				+	+	+		
	Rearing	+	+	+	+	+	+	+	+
	Outmigration				+	+	+	+	+
FALL CHINOOK	Adult migration and holding	+	+	+	+		+	+	+
	Spawning				+		+	+	
	Incubation				+	+	+		
	Rearing	+	+	+	+	+	+	+	+
	Outmigration				+	+	+	+	+
COHO	Adult migration and holding	+	+	+	+		+	+	+
	Spawning				+		+	+	
	Incubation				+	+	+		
	Rearing	+	+	+	+	+	+	+	+
	Outmigration				+	+	+	+	+
STEELHEAD	Adult migration and holding	+	+	+	+		+	+	+
	Spawning				+		+	+	
	Incubation				+	+	+		

SPECIES	LIFE STAGE	ACTION TYPES: EXAMPLE CONCEPTUAL DESIGN GROUP #2 (MAINSTEM CHEHALIS RIVER)							
		RIPARIAN BUFFER EXPANSION	HYPORHEIC EXCHANGE ENHANCEMENTS	COLD WATER RETENTION STRUCTURES	INSTREAM MODIFICATIONS	OFF-CHANNEL MODIFICATIONS	GRAVEL RETENTION JAMS	FISH PASSAG E	WETLAND ENHANCEMENT
	Rearing	+	+	+	+	+	+	+	+
	Outmigration				+	+	+	+	+
PACIFIC LAMPREY	Adult migration and holding	+	+	+	+		+	+	+
	Spawning				+		+	+	
	Incubation				+	+	+		
	Rearing	+	+	+	+	+	+		+
	Outmigration				+	+	+		+

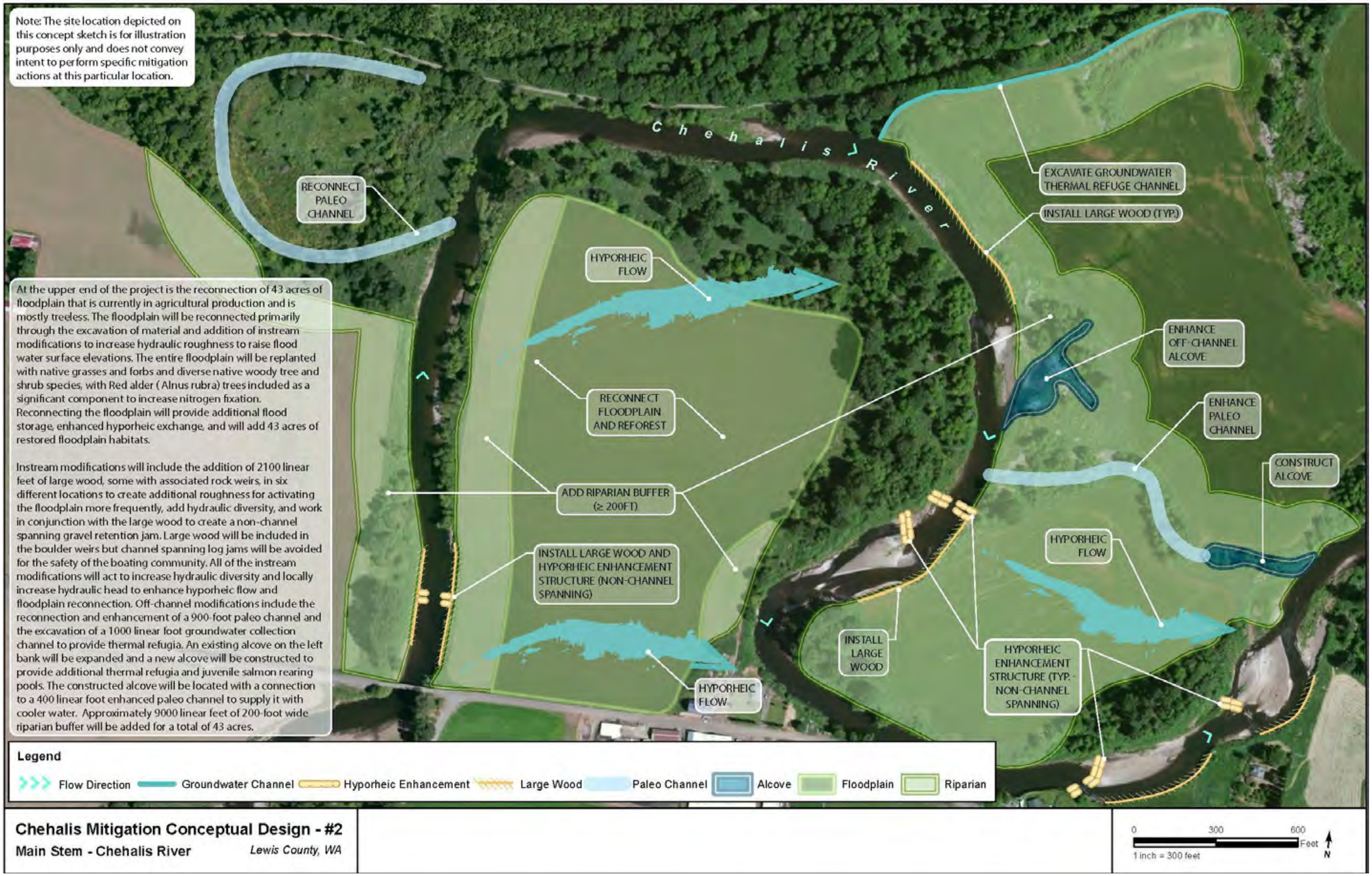
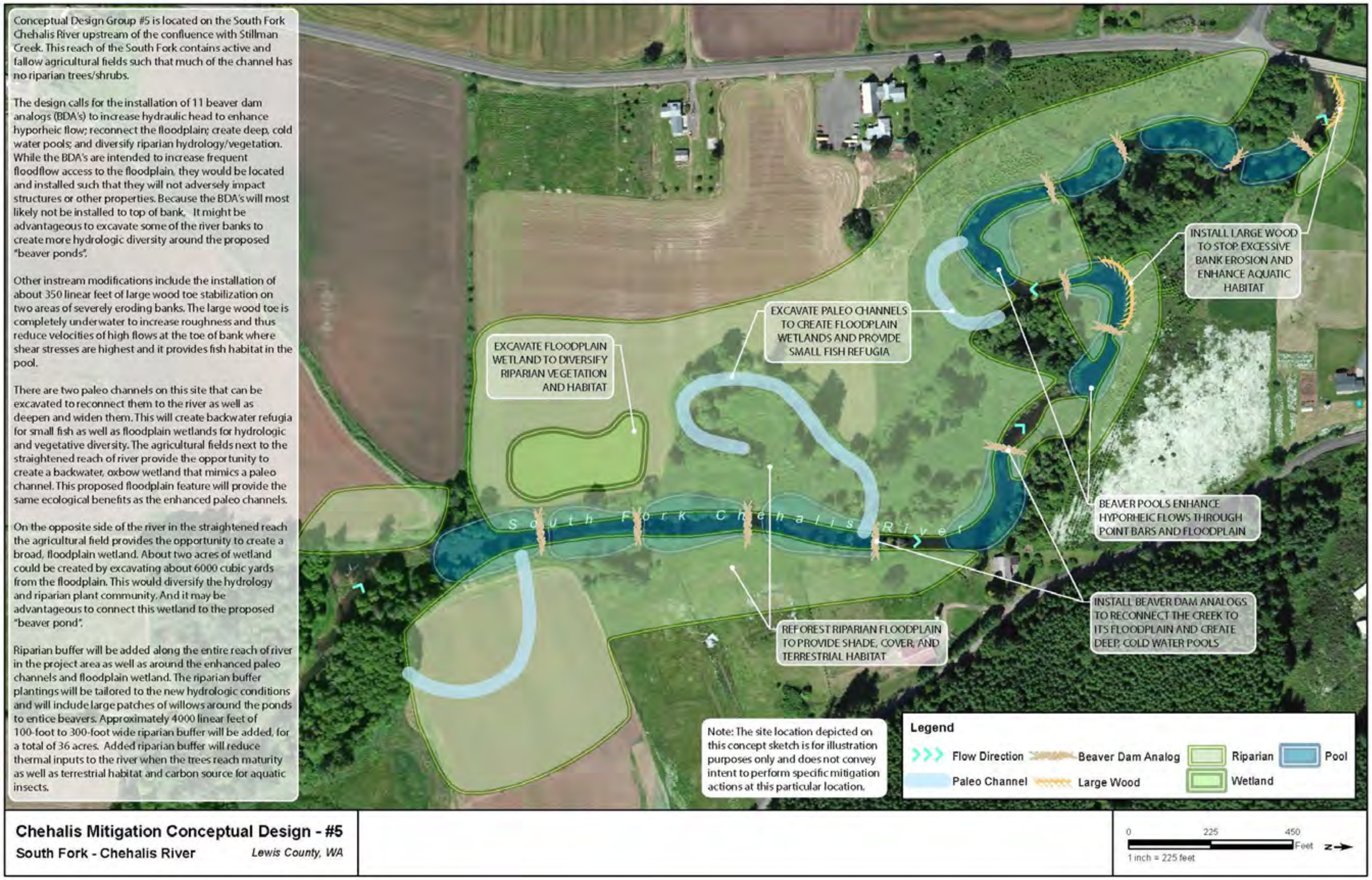

Note: The site location depicted on this concept sketch is for illustration purposes only and does not convey intent to perform specific mitigation actions at this particular location.
Chehalis River
RECONNECT PALEO CHANNEL
HYPORHEIC FLOW
EXCAVATE GROUNDWATER THERMAL REFUGE CHANNEL
INSTALL LARGE WOOD (TYP.)
ENHANCE OFF-CHANNEL ALCOVE
ENHANCE PALEO CHANNEL
RECONNECT FLOODPLAIN AND REFOREST
CONSTRUCT ALCOVE
ADD RIPARIAN BUFFER (≥ 200FT)
HYPORHEIC FLOW
INSTALL LARGE WOOD AND HYPORHEIC ENHANCEMENT STRUCTURE (NON-CHANNEL SPANNING)
INSTALL LARGE WOOD
HYPORHEIC ENHANCEMENT STRUCTURE (TYP. - NON-CHANNEL SPANNING)
HYPORHEIC FLOW
At the upper end of the project is the reconnection of 43 acres of floodplain that is currently in agricultural production and is mostly treeless. The floodplain will be reconnected primarily through the excavation of material and addition of instream modifications to increase hydraulic roughness to raise flood water surface elevations. The entire floodplain will be replanted with native grasses and forbs and diverse native woody tree and shrub species, with Red alder (Alnus rubra) trees included as a significant component to increase nitrogen fixation. Reconnecting the floodplain will provide additional flood storage, enhanced hyporheic exchange, and will add 43 acres of restored floodplain habitats.
Instream modifications will include the addition of 2100 linear feet of large wood, some with associated rock weirs, in six different locations to create additional roughness for activating the floodplain more frequently, add hydraulic diversity, and work in conjunction with the large wood to create a non-channel spanning gravel retention jam. Large wood will be included in the boulder weirs but channel spanning log jams will be avoided for the safety of the boating community. All of the instream modifications will act to increase hydraulic diversity and locally increase hydraulic head to enhance hyporheic flow and floodplain reconnection. Off-channel modifications include the reconnection and enhancement of a 900-foot paleo channel and the excavation of a 1000 linear foot groundwater collection channel to provide thermal refugia. An existing alcove on the left bank will be expanded and a new alcove will be constructed to provide additional thermal refugia and juvenile salmon rearing pools. The constructed alcove will be located with a connection to a 400 linear foot enhanced paleo channel to supply it with cooler water. Approximately 9000 linear feet of 200-foot wide riparian buffer will be added for a total of 43 acres.
Legend
Flow Direction
Groundwater Channel
Hyporheic Enhancement
Large Wood
Paleo Channel
Alcove
Floodplain
Riparian
Chehalis Mitigation Conceptual Design - #2
Main Stem - Chehalis River
Lewis County, WA
0
300
600
Feet
1 inch = 300 feet
N

Table 5: Potential functional benefits of conceptual examples per target species and life stage for Example Conceptual Design Group #5, a hypothetical location on the South Fork Chehalis River from July 2020 Draft Mitigation Opportunities Assessment.

SPECIES	LIFE STAGE	ACTION TYPES: EXAMPLE CONCEPTUAL DESIGN GROUP #5 (SOUTH FORK CHEHALIS RIVER)							
		Riparian Buffer Expansion	Hyporheic Exchange Enhancements	Cold Water Retention Structures	Instream Modifications	Off-channel Modifications	Gravel Retention Jams	Fish Passage	**WETLAND ENHANCEMENT**
		Riparian reforestation and protection	*Hyporheic forcing structures and bank treatments*	*BDA structures at hyporheic return locations*	*Large wood installations for habitat and bank erosion protection*	*Floodplain reconnection* *Paleo channel enhancement, reconnection, and excavation*	*Large wood structures*		*Floodplain wetlands enhancement, creation, and/or reconnection*
SPRING CHINOOK	Adult migration and holding	+	+	+	+		+	+	+
	Spawning	+			+		+	+	
	Incubation				+	+	+		
	Rearing	+	+	+	+	+	+	+	+
	Outmigration				+	+	+	+	+
FALL CHINOOK	Adult migration and holding	+	+	+	+		+	+	+
	Spawning	+			+		+	+	
	Incubation				+	+	+		
	Rearing	+	+	+	+	+	+	+	+
	Outmigration				+	+	+	+	+
COHO	Adult migration and holding	+	+	+	+		+	+	+
	Spawning	+			+		+	+	
	Incubation				+	+	+		
	Rearing	+	+	+	+	+	+	+	+
	Outmigration				+	+	+	+	+
STEELHEAD	Adult migration and holding	+	+	+	+		+	+	+

SPECIES	LIFE STAGE	ACTION TYPES: EXAMPLE CONCEPTUAL DESIGN GROUP #5 (SOUTH FORK CHEHALIS RIVER)							
		Riparian Buffer Expansion	Hyporheic Exchange Enhancements	Cold Water Retention Structures	Instream Modifications	Off-channel Modifications	Gravel Retention Jams	Fish Passage	**WETLAND ENHANCEMENT**
		Riparian reforestation and protection	*Hyporheic forcing structures and bank treatments*	*BDA structures at hyporheic return locations*	*Large wood installations for habitat and bank erosion protection*	*Floodplain reconnection* *Paleo channel enhancement, reconnection, and excavation*	*Large wood structures*		*Floodplain wetlands enhancement, creation, and/or reconnection*
	Spawning	+			+		+	+	
	Incubation				+	+	+		
	Rearing	+	+	+	+	+	+	+	+
	Outmigration				+	+	+	+	+
PACIFIC LAMPREY	Adult migration and holding	+	+	+	+		+	+	+
	Spawning	+			+		+	+	
	Incubation				+	+	+		
	Rearing	+	+	+	+	+	+		+
	Outmigration				+	+	+		+


Conceptual Design Group #5 is located on the South Fork Chehalis River upstream of the confluence with Stillman Creek. This reach of the South Fork contains active and fallow agricultural fields such that much of the channel has no riparian trees/shrubs.
The design calls for the installation of 11 beaver dam analogs (BDA's) to increase hydraulic head to enhance hyporheic flow; reconnect the floodplain; create deep, cold water pools; and diversify riparian hydrology/vegetation. While the BDA's are intended to increase frequent floodflow access to the floodplain, they would be located and installed such that they will not adversely impact structures or other properties. Because the BDA's will most likely not be installed to top of bank, It might be advantageous to excavate some of the river banks to create more hydrologic diversity around the proposed "beaver ponds".
Other instream modifications include the installation of about 350 linear feet of large wood toe stabilization on two areas of severely eroding banks. The large wood toe is completely underwater to increase roughness and thus reduce velocities of high flows at the toe of bank where shear stresses are highest and it provides fish habitat in the pool.
There are two paleo channels on this site that can be excavated to reconnect them to the river as well as deepen and widen them. This will create backwater refugia for small fish as well as floodplain wetlands for hydrologic and vegetative diversity. The agricultural fields next to the straightened reach of river provide the opportunity to create a backwater, oxbow wetland that mimics a paleo channel. This proposed floodplain feature will provide the same ecological benefits as the enhanced paleo channels.
On the opposite side of the river in the straightened reach the agricultural field provides the opportunity to create a broad, floodplain wetland. About two acres of wetland could be created by excavating about 6000 cubic yards from the floodplain. This would diversify the hydrology and riparian plant community. And it may be advantageous to connect this wetland to the proposed "beaver pond".
Riparian buffer will be added along the entire reach of river in the project area as well as around the enhanced paleo channels and floodplain wetland. The riparian buffer plantings will be tailored to the new hydrologic conditions and will include large patches of willows around the ponds to entice beavers. Approximately 4000 linear feet of 100-foot to 300-foot wide riparian buffer will be added, for a total of 36 acres. Added riparian buffer will reduce thermal inputs to the river when the trees reach maturity as well as terrestrial habitat and carbon source for aquatic insects.
EXCAVATE FLOODPLAIN WETLAND TO DIVERSIFY RIPARIAN VEGETATION AND HABITAT
EXCAVATE PALEO CHANNELS TO CREATE FLOODPLAIN WETLANDS AND PROVIDE SMALL FISH REFUGIA
INSTALL LARGE WOOD TO STOP EXCESSIVE BANK EROSION AND ENHANCE AQUATIC HABITAT
South Fork Chehalis River
BEAVER POOLS ENHANCE HYPORHEIC FLOWS THROUGH POINT BARS AND FLOODPLAIN
INSTALL BEAVER DAM ANALOGS TO RECONNECT THE CREEK TO ITS FLOODPLAIN AND CREATE DEEP, COLD WATER POOLS
REFOREST RIPARIAN FLOODPLAIN TO PROVIDE SHADE, COVER, AND TERRESTRIAL HABITAT
Note: The site location depicted on this concept sketch is for illustration purposes only and does not convey intent to perform specific mitigation actions at this particular location.
Legend
Flow Direction
Beaver Dam Analog
Riparian
Pool
Paleo Channel
Large Wood
Wetland
Chehalis Mitigation Conceptual Design - #5
South Fork - Chehalis River
Lewis County, WA
0
225
450
Feet
1 inch = 225 feet

References

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