Appendix K
Discipline Report for Aquatic Species and Habitats

September 2020

Chehalis River Basin Flood Damage Reduction Project

NEPA Environmental Impact Statement

US Army Corps of Engineers®

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Discipline Report for Aquatic Species and Habitat

US Army Corps of Engineers

September 2020

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ACRONYMS AND ABBREVIATIONS

Applicant	Chehalis River Basin Flood Control Zone District
ASRP	Aquatic Species Restoration Plan
BMP	best management practice
CFR	Code of Federal Regulations
Chehalis Tribe	Confederated Tribes of the Chehalis Reservation
CHTR	Collection, Handling, Transfer, and Release
Corps	U.S. Army Corps of Engineers
CSSH	Core Summer Salmonid Habitat
CWA	Clean Water Act
DPS	distinct population segment
Ecology	Washington Department of Ecology
EDT	Ecosystem Diagnostic and Treatment
EFH	essential fish habitat
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
Fed. Reg.	Federal Register
FRE	Flood Retention Expandable
FRO	Flood Retention Only
HUC	Hydraulic Unit Code
LCC	Lewis County Code
LCM	Life Cycle Model
LWM	large woody material
mg/L	milligrams per liter
MSA	Magnuson-Stevens Act
NAVD88	North American Vertical Datum of 1988

NEPA	National Environmental Policy Act
NHD	National Hydrography Dataset
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OHWM	ordinary high-water mark
PHABSIM	physical habitat simulation
PHS	Priority Habitats and Species
PL	Public Law
RBF	Rainbow Falls
RCW	Revised Code of Washington
RM	river mile
SRM	Salmonid Spawning, Rearing, and Migration
SSIC	Supplemental Spawning and Incubation Criterion
TSS	total suspended solids
USC	United States Code
USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WNHP	Washington Natural Heritage Program
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation

EXECUTIVE SUMMARY

The Chehalis River Basin Flood Control Zone District (Applicant) is proposing the Chehalis River Basin Flood Damage Reduction Project (proposed project). The Applicant proposes to construct a flood retention facility with a temporary reservoir near the town of Pe Ell, Lewis County, Washington. Airport Levee Improvements would be constructed around the Chehalis-Centralia Airport in the city of Chehalis, Lewis County, Washington.

The purpose of this discipline report is to describe the affected environment and potential impacts of the National Environmental Policy Act Environmental Impact Statement (EIS) alternatives on aquatic species and habitat. Aquatic species include fish, shellfish, and plants, including special-status species (e.g., federally and state listed or candidate species). Marine mammals are addressed in this document if they depend on fish prey (e.g., Chinook salmon [*Oncorhynchus tshawytscha*]) likely to be affected by the alternatives. The habitat that could be affected by the alternatives includes instream habitat and nearby freshwater floodplain wetlands within the study area (Section 5.1). The nearby floodplain wetlands are hydraulically connected to the Chehalis River and provide habitat for fish. The study area is described in detail in Section 5.1. Fish habitat is described in terms of the key physical and biological attributes for aquatic species.

The alternatives considered include the following:

- No Action Alternative: This represents the conditions anticipated without the proposed flood retention facility or Airport Levee Improvements over the course of the analysis period from 2025 through 2080.
- Alternative 1 (Proposed Project): Flood Retention Expandable (FRE) Facility and Airport Levee Improvements. Alternative 1 is the Applicant's proposed project and includes the FRE Facility and Airport Levee Improvements. The FRE facility would include a foundation that allows for the future expansion of the flood retention structure to increase the storage capacity of the temporary reservoir.
- Alternative 2: Flood Retention Only (FRO) Facility and Airport Levee Improvements. Alternative 2 would be the same as Alternative 1, except that the flood retention facility would be built on a smaller foundation. The Alternative 2 facility, called an FRO facility, would not allow for potential future expansion of flood storage capacity.

For Alternatives 1 and 2, the impacts from construction and operation of the proposed flood retention facilities and Airport Levee Improvements were considered. The expected duration of the impacts (temporary versus permanent) were also determined. If permitted, the Applicant expects flood retention facility construction would begin in 2025 and operations in 2030, and construction of the Airport Levee Improvements would occur over a 1-year period between 2025 and 2030. The EIS analyzes probable impacts from the Proposed Project and alternatives for construction from 2025 to 2030 and for operations from 2030 to 2080.

For the purposes of analyzing the potential impacts of the alternatives, this report considered the effects in the context of four flood scenarios: a 2-year flood, a major flood, a catastrophic flood, and a back-to-back flood. A 2-year flood would occur approximately every other year and would not trigger operation of the proposed flood retention facility. Although a “major” flood is defined as one that would happen on average once every 7 years, modeling of major floods is based on flows that would occur on average once every 10 years. This is because the difference between 7-year flows and 10-year flows is small. For the purposes of this report, a major flood is represented by the 10-year flood and a catastrophic flood is represented by a 100-year flood. A back-to-back flood is where a major flood is followed by a catastrophic flood in the following year.

Table ES-1 summarizes the construction and operations impacts for Alternative 1 compared to the No Action Alternative. Alternative 1 impacts are also described below. The construction-related impacts of Alternative 2 would be similar to Alternative 1 but would result in lower impacts because of the reduced size of the flood retention facility and reduced construction duration. The operational impacts are expected to be the same as Alternative 1.

Impacts on Aquatic Habitat

Alternative 1 would result in low to high impacts on aquatic habitat. Potential impacts include high permanent losses and long-term degradation of aquatic habitat in the Chehalis River. Affected habitat includes the permanent loss of 2.05 acres of essential fish habitat (EFH) for coho salmon and Chinook salmon and Washington Department of Fish and Wildlife (WDFW) priority instream habitat (coho salmon, Chinook salmon, steelhead, and coastal cutthroat). There would also be additional low temporary losses of and impacts on aquatic habitat during the 5-year construction period.

Overall, construction of the FRE facility would result in high long-term impacts to aquatic habitat. This is mainly because of high permanent loss of EFH and spawning habitat from the FRE facility structure itself and high long-term temperature increases and dissolved oxygen decreases between river mile (RM) 114 and RM 100. Water quality impacts are expected because constructing the FRE facility would require the removal of 94 acres of riparian vegetation that would no longer provide shading to the Chehalis River. There would also be low impacts from increased turbidity and risks of spills and low to medium decreases in the supply of large woody material (LWM).

Alternative 1 operations would also result in high long-term impacts on aquatic habitat. Adverse effects would occur as the result of high levels of change to aquatic habitat over time. These changes would mainly affect the proposed footprint of the temporary reservoir and the area immediately below the proposed FRE facility. Impacts to aquatic habitat during operation would result from high losses of instream habitat, high increases in river temperature, decreases in dissolved oxygen, increased turbidity, and changes to habitat-forming processes. Changes in habitat-forming processes include changes in sediment amount, decreases in substrate size, decreases in the supply and transport of LWM, and reduced peak flows.

Construction and operation of the Airport Levee Improvements is not expected to affect aquatic habitat. Although the proposed improvements are within the Chehalis River 100-year floodplain, the Airport Levee Improvements project area is not connected to the floodplain. No streams, rivers, or drainages were identified in the Airport Levee Improvements project area (Anchor QEA 2018b).

Impacts on Aquatic Species

Construction and operations would also adversely affect aquatic species, including fish, plants, freshwater mussels, and marine mammals. Some construction impacts would be longer-lasting and would result in conditions that would continue over the entire time that the FRE facility was in operation. Some construction impacts would only last during the 5-year construction period.

High long-term construction impacts were predicted to affect spring-run Chinook salmon, fall-run Chinook salmon, coho salmon, and steelhead. The potential impacts on these four species were modeled. There would also be the potential for high long-term impacts on other non-modeled salmonids, lamprey, and other native fish species. Species that would be affected include those that may be present in the reservoir footprint and downstream of the FRE facility to RM 100. Of these species, spring-run and fall-run Chinook salmon, steelhead, Pacific lamprey, western brook lamprey, western ridged mussel, and western pearlshell mussel are special-status. High long-term impacts would occur mainly as a result of reduced fish passage and from impacts to water quality. Primary water quality impacts would include increased water temperatures and decreased dissolved oxygen as a result of pre-construction vegetation removal.

During the construction period, there would also be a potential for low to medium impacts on aquatic species from increased risk of mortality or injury during construction. This could occur from the placement of fill, increased underwater noise or vibration levels from construction activities, and increased risk of entrainment or stranding of fish during dewatering. In addition, construction would result in a low to medium temporary increase in turbidity and risk of spills and leaks. Construction may also result in low impacts from an increase in the risk of spreading invasive species that could compete with native species.

Long-term operation of the FRE facility would result in low to high impacts on the four modeled salmonid species. High adverse impacts would affect all four species in the area above and below the proposed FRE facility. There would be high impacts on steelhead, medium impacts on spring-run and fall-run Chinook salmon, and low impacts on coho salmon in the area downstream of the proposed FRE facility (to RM 100). At the scale of the Chehalis Basin, the potential impacts would be high for spring-run Chinook salmon and low for fall-run Chinook salmon, coho salmon, and steelhead. Potential impacts are mainly because of decreased water quality, including increased temperature and decreased dissolved oxygen, changes to habitat-forming processes (i.e., increases in fine sediment, decreases in substrate size, decreases in the supply and transport of LWM, and reduced peak flows), reduced supply of prey resources, increase in non-native species, and reduced fish passage. Operations would also adversely affect the following species:

- High decrease in habitat potential for non-salmon fish species above and below the flood retention facility because of impacts to aquatic habitat that are similar to impacts to salmon.
- Medium impact on native fish species from increased risk of the spread of non-native fish species. The increase in water temperature could expand the range of warm water predators into the flood retention facility project area and immediately downstream of the facility to RM 100.
- Medium impact on plants down to RM 100, especially bryophytes, during 2-year flows from increased water temperature and increased exposure to sunlight because of the loss of overwater shading from tree removal within the temporary reservoir footprint.
- High impact on aquatic plants from increased sediment deposition in the flood retention facility project area. Any aquatic plants in the temporary reservoir footprint could be covered with sediment during and after impoundment.
- Medium impact on native aquatic plant species from increased risk of the spread of non-native aquatic plant species. The increase in water temperature in the temporary reservoir footprint down to RM 100 during 2-year flows could expand the range of warm-water species.
- High impact on freshwater mussels from increased sediment deposition in the flood retention facility project area. Any mussels or plants in the temporary reservoir footprint could be covered with sediment during and after impoundment.
- Medium impact from increased temperatures on freshwater mussel larvae. Distribution of mussels could be altered as host fish distributions change from increased water temperature in the temporary reservoir footprint down to RM 100.
- Low impacts on marine mammals as the result of decreased spring-run Chinook salmon prey at the basin scale during impoundment. No impact on marine mammals when the flood retention facility is not impounding water because there are no predicted changes in salmonid abundance at the Chehalis Basin scale for this condition.

In addition to the overall impacts of FRE facility operations, the analysis of modeled salmonids considered potential impacts that could occur when the FRE facility was impounding water. This analysis shows a snapshot in time in terms of four different flow levels. This included 2-year river flows when the FRE facility would not operate, and three floods, when the FRE facility would operate. The floods that were considered included a 10-year flood, a 100-year flood, and a back-to-back flood. These impacts would occur approximately once every 7 years.

This analysis found that habitat potential for the four modeled salmonid species decreased significantly relative to the No Action Alternative. When the FRE facility was not operating (most of the time), the adverse impacts on habitat were less than during impoundment, but the impacts were still high for all modeled species.

Below the FRE facility (in the Chehalis River 100-year floodplain study area between RM 108 and RM 98), potential changes to habitat were both positive and negative compared to the No Action Alternative. Whether habitat was improved or worsened depended on the species and specific modeled metrics considered. Overall, when considering impacts both during impoundment events and when the river is free flowing, impacts were found to be high for steelhead, medium for spring-run and fall-run Chinook salmon, and low for coho salmon. There were instances when Alternative 1 was predicted to improve habitat potential as the result of an impoundment. This was because the related reduction in floods was predicted to reduce bed scour. Impacts at the Chehalis Basin scale would be high for spring-run Chinook salmon and low for the other three modeled species.

Table ES-1

Aquatic Species and Habitat Potential Impacts

ALTERNATIVE 1 (PROPOSED PROJECT): FLOOD RETENTION EXPANDABLE (FRE) FACILITY AND AIRPORT LEVEE IMPROVEMENTS		
RESOURCE AREA	**CONSTRUCTION**	**OPERATIONS**
Aquatic Habitat	**Flood Retention Facility Project Area** • High permanent loss of 2.05 acres of EFH for coho salmon and Chinook salmon and WDFW priority instream habitat (coho salmon, Chinook salmon, steelhead, coastal cutthroat) from construction of the flood retention structure and related facilities. These impacts would occur mainly in the mainstem Chehalis River, but also in unnamed intermittent streams. • High permanent impairment of habitat function because of increased water temperatures and decreased dissolved oxygen from pre-construction vegetation removal and reduced shading from riparian vegetation. • Low impairment in habitat function from increases in fine sediment (TSS/turbidity) and increased risk of construction spills and leaks during construction. Water quality impacts could be greater if a larger storm event (i.e., greater than 3-year) occurred during the 5-year construction period. • Low impairment of habitat-function from decreased transport of LWM because of the diversion tunnel. • Low temporary loss of 2.77 acres of EFH (Chinook salmon and coho salmon) and WDFW priority instream habitat (coho salmon, Chinook salmon, steelhead, coastal cutthroat trout) from dewatering the construction site and placement of cofferdams and staging areas during construction, These impacts would occur mainly in the mainstem Chehalis River, but also in unnamed intermittent streams.	**Flood Retention Facility Project Area** • Permanent impairment of habitat function because of high increases in water temperature and medium reductions in dissolved oxygen within the temporary reservoir footprint (RM 108 to RM 114 [Above Crim Creek]) during 2-year flows because of continued vegetation management practices. • Low impairment of habitat function from an increase in turbidity during 2-year flows during the first non-impoundment storm following an impoundment event and medium impairment of habitat function from increased turbidity during impoundment and when water is released during drawdown. • Low impairment of habitat function from an increase in turbidity during 2-year flows during the first non-impoundment storm following an impoundment event and medium impairment of habitat function from increased turbidity during impoundment and when water is released during drawdown. • High changes to habitat-forming processes, including an increase in fine sediment accumulation of up to 240,000 tons, reductions in the supply of LWM, and various impacts because of reduced peak flows in the footprint of the temporary reservoir. • High impact on EFH (spring and fall run Chinook salmon) and WDFW priority habitat (coho salmon, Chinook salmon, steelhead, coastal cutthroat trout) in the footprint of the temporary reservoir (RM 108 to RM 114 [Above Crim Creek]) from the loss of spawning and rearing habitat when the FRE facility is impounding water (predicted to be up to 32 days every 7 years).

ALTERNATIVE 1 (PROPOSED PROJECT): FLOOD RETENTION EXPANDABLE (FRE) FACILITY AND AIRPORT LEVEE IMPROVEMENTS		
RESOURCE AREA	**CONSTRUCTION**	**OPERATIONS**
	Chehalis River 100-Year Floodplain Study Area • High permanent impairment of habitat function because of increased water temperatures and decreased dissolved oxygen below the proposed flood retention facility to RM 100 from pre-construction vegetation removal and reduced shading from riparian vegetation. • Low impairment in habitat function from decreased water quality immediately downstream of the flood retention facility. This would occur as the result of increases in fine sediment (TSS/turbidity) and increased risk of spills and leaks during construction. Water quality impacts could be greater if a larger storm event (i.e., greater than 3-year) occurred during the 5-year construction period. • Low temporary impairment of habitat function from decreased transport of LWM because of the diversion tunnel.	**Chehalis River 100-Year Floodplain Study Area** • High permanent impairment of habitat function because of increases in water temperatures (RM 108 to RM 100 near the Elk Creek confluence) from ongoing vegetation management. These increases would occur between May and October during 2-year flow conditions. • High permanent impairment of habitat function because of increases in water temperatures (RM 108 to RM 100 near the Elk Creek confluence) from ongoing vegetation management. These increases would occur between May and October during 2-year flow conditions. • High impairment of habitat function because of an increase in water temperature from on-going vegetation management during temporary reservoir drawdown only if impoundment occurs in the fall for major or greater floods. • High long-term impairment of habitat function because of reductions in dissolved oxygen levels corresponding to temperature increases to RM 100 during 2-year flow conditions. • Low to medium short-term impairment of habitat function from temporary turbidity increases when the temporary reservoir is releasing water and briefly during the first storm event following reservoir operations. • Medium to high impairment of habitat function because of changes in habitat-forming processes including an overall reduction in the amount of accumulated sediment (i.e., spawning material) to RM 80, increase in fine sediment to RM 86, decreased supply and transport of LWM to RM 75, and various changes because of reduced peak flows. • Negligible impacts farther downstream of RM 75 because of the extent of the changes to habitat-forming processes being negligible beyond this point.

ALTERNATIVE 1 (PROPOSED PROJECT): FLOOD RETENTION EXPANDABLE (FRE) FACILITY AND AIRPORT LEVEE IMPROVEMENTS		
RESOURCE AREA	**CONSTRUCTION**	**OPERATIONS**
Fish	**Flood Retention Facility Project Area** • High impact on spring-run Chinook salmon, fall-run Chinook salmon, coho salmon, and steelhead from the modeled decrease in the species' habitat potential because of pre-construction vegetation removal (i.e., increased water temperatures and decreased dissolved oxygen), decrease in the supply of prey resources, loss of LWM supply, loss of rearing and spawning habitat, and reduced fish passage. • High impacts on other salmonids, lamprey, and other native fish species because of impacts on habitat functions similar to modeled salmonids. • Medium impact on native fish species from increased risk of the spread of non-native fish species. The increase in water temperature could expand the range of warm water predators into this area. • Low impact on aquatic species as the result of construction work within or near the river after the implementation of best management practices. This would include increased risk of mortality or injury from turbidity, construction spills and leaks, entrainment or stranding of fish, and increased underwater noise or vibration levels. Water quality impacts could be greater if a larger flood (i.e., greater than 3-year) occurred during the 5-year construction period.	**Flood Retention Facility Project Area** • High long-term modeled decrease in habitat potential for spring- and fall-run Chinook salmon, coho salmon, and steelhead because of changes in habitat function, reduced supply of prey resources, and reduced fish passage. • High decrease in habitat potential for other salmonids, lamprey, and other native fish species because of impacts to habitat function that are similar to impacts to modeled salmonids. • Medium impact on native fish species from increased risk of the spread of non-native fish species. The increase in water temperature could expand the range of warm water predators into the flood retention facility project area and immediately downstream of the facility to RM 100.

ALTERNATIVE 1 (PROPOSED PROJECT): FLOOD RETENTION EXPANDABLE (FRE) FACILITY AND AIRPORT LEVEE IMPROVEMENTS		
RESOURCE AREA	**CONSTRUCTION**	**OPERATIONS**
	Chehalis River 100-Year Floodplain Study Area • High modeled decrease in the habitat potential of steelhead, medium modeled decrease in habitat potential of spring-run Chinook salmon and fall-run Chinook salmon, and low to medium decrease in habitat potential of coho salmon in the immediate vicinity of the proposed FRE facility to Rainbow Falls near RM 98. These impacts are mainly because of pre-vegetation removal (i.e., increased water temperatures and decreased dissolved oxygen), and loss of LWM recruitment. • Medium impacts on other salmonids, lamprey, and other native fish species from decreased habitat potential similar to impacts on modeled salmonids in the immediate vicinity of the proposed FRE facility to RM 98. • Medium impact on native fish species from increased risk of the spread of non-native fish species. The increase in water temperature could expand the range of warm water predators in the immediate vicinity of the proposed FRE facility to RM 100. • Low impact on aquatic species as the result of construction work within or near the river after the implementation of best management practices. This would include increased risk of mortality or injury from turbidity and construction spills and leaks in the immediate vicinity of the proposed FRE facility. Water quality impacts could be greater if a larger flood (i.e., greater than 3-year) occurred during the 5-year construction period.	**Chehalis River 100-Year Floodplain Study Area** • High long-term modeled decrease in habitat potential for steelhead, medium decreases for spring-run and fall-run Chinook salmon, and low decrease for coho salmon downstream of the flood retention facility to Rainbow Falls (RM 98). • Medium long-term decrease in habitat potential expected for spring-run and fall-run Chinook salmon, low decrease in habitat potential for steelhead, and a negligible decrease in habitat potential for coho salmon downstream of Rainbow Falls down to RM 75. • Low to high decrease in habitat potential for other salmonid fish species because of impacts to habitat function that are similar to impacts to modeled salmonids down to RM 98 over the life of the proposed project. • Low to medium decrease in habitat potential for other non-salmonid native fish species that have a preference for habitat and greater numbers near and below RM 98 because of impacts to habitat function over the life of the proposed project. • Medium decrease in habitat potential for non-salmonid native fishes because of changes in habitat-forming processes between RM 98 and RM 75 over the life of the proposed project. • Low to medium decrease in habitat potential for salmonids between RM 98 and RM 75 because most salmonid spawning habitat occurs upstream of RM 98. • Medium impact on native fish species from increased risk of the spread of non-native fish species. The increase in water temperature could expand the range of warm water predators in the immediate vicinity of the proposed FRE facility to RM 100.

ALTERNATIVE 1 (PROPOSED PROJECT): FLOOD RETENTION EXPANDABLE (FRE) FACILITY AND AIRPORT LEVEE IMPROVEMENTS		
RESOURCE AREA	**CONSTRUCTION**	**OPERATIONS**
	Chehalis Basin Scale (Modeled Salmonids) • High decrease in habitat potential for spring-run Chinook salmon, and low decrease in habitat potential for fall-run Chinook salmon, coho salmon, and steelhead.	**Chehalis Basin Scale (Modeled Salmonids)** • High long-term decrease in habitat potential of spring-run Chinook salmon and low decrease in habitat potential for fall-run Chinook salmon, coho salmon, and steelhead.
Aquatic Plants	**Flood Retention Facility Project Area** • Low impact on aquatic plants, after considering construction BMPs, from increased risk of killing them from placement of fill. • Medium impact on aquatic plants, especially bryophytes, from increased water temperature and increased exposure to sunlight because of the loss of overwater shading from tree removal. • Low impact on aquatic plants from increased potential for sediment deposition in the flood retention facility project area. • Medium impact on native aquatic plant species from increased risk of the spread of non-native aquatic plant species. The increase in water temperature could expand the range of warm water species.	**Flood Retention Facility Project Area** • Medium impact on aquatic plants, especially bryophytes, during 2-year flows from increased water temperature and increased exposure to sunlight because of the loss of overwater shading from tree removal. • High impact on aquatic plants from increased sediment deposition in the flood retention facility project area. Any aquatic plants in the temporary reservoir footprint could be covered with sediment during and after impoundment. • Medium impact on native aquatic plant species from increased risk of the spread of non-native aquatic plant species. The increase in water temperature during 2-year flows could expand the range of warm water species.
	Chehalis River 100-Year Floodplain Study Area • Medium impact on aquatic plants, especially bryophytes, from increased water temperature to RM 100. • Medium impact on native aquatic plant species from increased risk of the spread of non-native aquatic plant species in the immediate vicinity of the flood retention facility to RM 100. The increase in water temperature could expand the range of warm water species.	**Chehalis River 100-Year Floodplain Study Area** • Medium impact on aquatic plants, especially bryophytes, from increased water temperature to RM 100 during 2-year flows. • Medium impact on native aquatic plant species from increased risk of the spread of non-native aquatic plant species in the immediate vicinity of the flood retention facility to RM 100. The increase in water temperature could expand the range of warm water species.

ALTERNATIVE 1 (PROPOSED PROJECT): FLOOD RETENTION EXPANDABLE (FRE) FACILITY AND AIRPORT LEVEE IMPROVEMENTS		
RESOURCE AREA	**CONSTRUCTION**	**OPERATIONS**
Freshwater Mussels	**Flood Retention Facility Project Area** • Low impact on freshwater mussels, after considering construction BMPs, from increased risk of killing them from placement of fill. • Unknown impact from increased temperatures on freshwater mussel larvae. Distribution of mussels could be altered as host fish distributions change from increased water temperature. • Low impact from increased sediment deposition in the flood retention facility project area.	**Flood Retention Facility Project Area** • High impact on freshwater mussels from increased sediment deposition in the flood retention facility project area. Any mussels or plants in the temporary reservoir footprint could be covered with sediment during and after impoundment. • Medium impact from increased temperatures on freshwater mussel larvae. Distribution of mussels could be altered as host fish distributions change from increased water temperature.
	Chehalis River 100-Year Floodplain Study Area • Medium impact from increased temperatures on freshwater mussel larvae in the immediate vicinity of the flood retention facility to RM 100. Distribution of mussels could be altered as host fish distributions change from increased water temperature.	**Chehalis River 100-Year Floodplain Study Area** • Medium impact from increased temperatures on freshwater mussel larvae in the immediate vicinity of the flood retention facility to RM 100. Distribution of mussels could be altered as host fish distributions change from increased water temperature.
Marine Mammals	**Chehalis Basin** • Low impact on marine mammals as the result of no substantial changes in abundance for all modeled species, which are prey for marine mammals.	**Chehalis Basin** • Low impact on marine mammals as the result of decreased spring-run Chinook salmon abundance during impoundment. No impact on marine mammals when the flood retention facility is not impounding water because of no decreases in abundance compared to the No Action Alternative.

1 INTRODUCTION

The Chehalis River Basin Flood Control Zone District (Applicant) is proposing to construct the Chehalis River Basin Flood Damage Reduction Project (proposed project) in Lewis County, Washington (Figure 1-1). Project construction would require a Department of the Army Permit under Section 404 of the Clean Water Act (CWA) (proposed action). On January 31, 2018, the Seattle District of the U.S. Army Corps of Engineers (Corps) determined that the proposed project may have significant individual and/or cumulative impacts on the human environment. An environmental impact statement (EIS) will be prepared in accordance with the National Environmental Policy Act (NEPA).

The purpose of this discipline report is to describe the existing conditions and potential impacts of the NEPA EIS alternatives on aquatic species and habitat that could be affected by potential changes to aquatic habitat. Aquatic habitat that could be impacted and may affect aquatic species includes instream habitat, nearby freshwater floodplain wetlands that fish can access via hydraulic connections to the Chehalis River, and special-status habitat. Special-status habitat includes habitats occurring within the study area that are defined at the federal and state level as follows:

- Critical habitat is a federally recognized term under the Endangered Species Act (ESA). Critical habitat is the specific geographic areas and features that are essential to the conservation of a listed species (threatened or endangered). Critical habitat may also include areas that are not currently occupied by the species, but that would be necessary for the species to recover. Critical habitat has been defined for less than 50% of ESA listed species (USFWS 2020).
- Essential fish habitat (EFH) is defined by the Magnuson-Stevens Act (MSA; 50 Code of Federal Regulations [CFR] 600.905-930) as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity” and is designated for federally managed groundfish, Pacific salmon, and coastal pelagic species. The consultation requirements of Section 305(b) of the MSA direct federal agencies to consult with the National Marine Fisheries Service (NMFS) on all actions, or proposed actions, that may adversely affect EFH. Adverse effects include the direct or indirect physical, chemical, or biological changes to the water column and/or substrate. Adverse effects also include the loss of, or injury to, benthic organisms, prey species and their habitat, and other aquatic habitat components, if such changes reduce the quality or quantity of EFH.
- Washington Department of Fish and Wildlife (WDFW) priority habitats are defined at the state level as habitat types or elements that provide value (either unique or significant) to many species.

Aquatic species that could be impacted by changes in aquatic habitat include fish, freshwater mussels, aquatic plants and special-status aquatic species. Special-status aquatic species are plant and animal species that are identified for protection as follows:

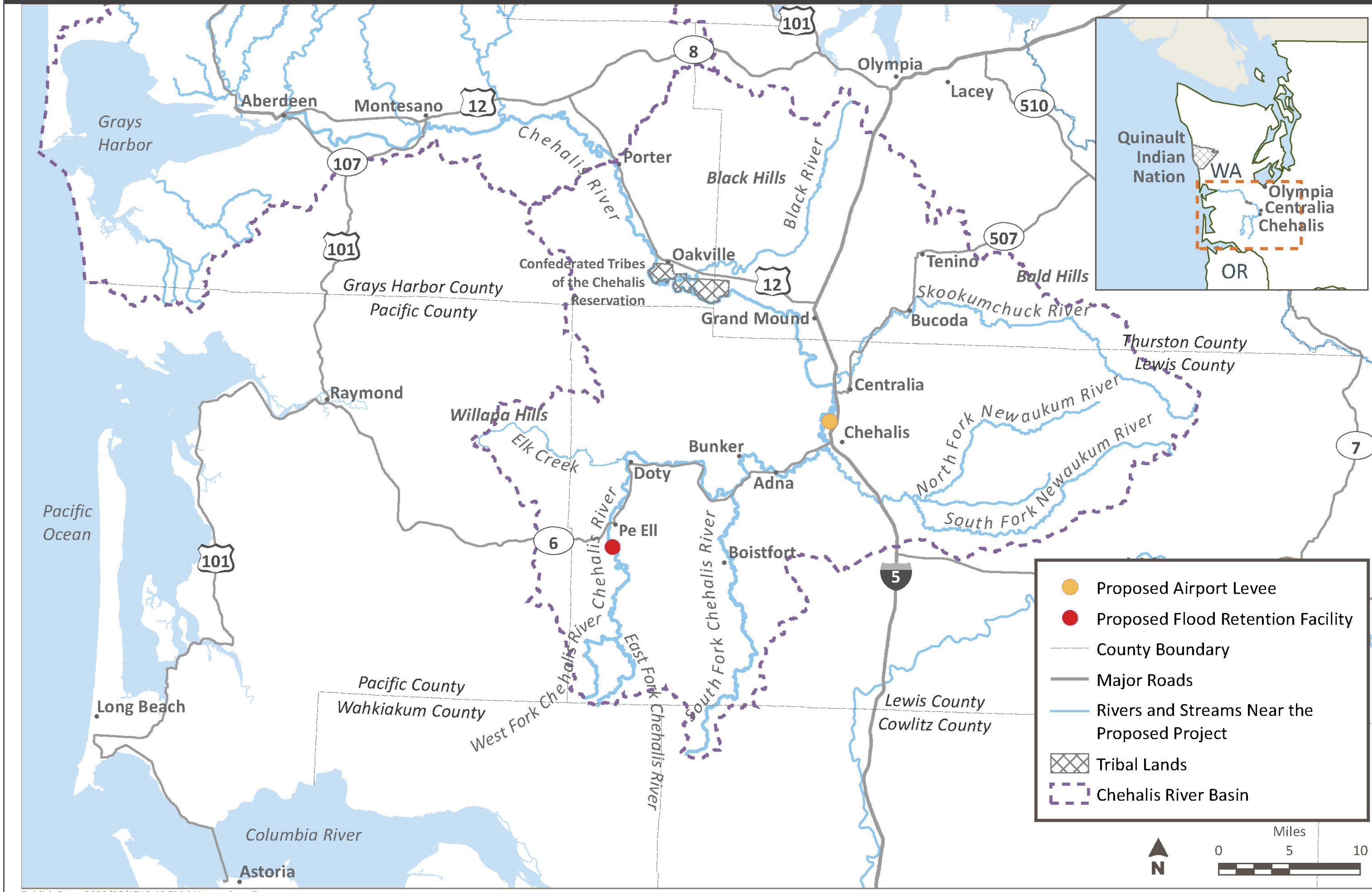
- Federal protected species include plants and animals classified as endangered or threatened under the ESA. Candidate species have no statutory protection under the ESA. However, conservation efforts are voluntary and encouraged by NMFS and the U.S. Fish and Wildlife Service (USFWS).
- State protected species include state endangered, threatened, sensitive, and candidate species under Washington Administrative Code [WAC] 220-610-110. All these categories are described as state species of concern. All species of concern are automatically listed on the State Priority Habitats and Species (PHS) List.
- WDFW priority species are those fish and wildlife that require specific management actions and/or other protective measures to ensure their survival. To be listed as a state priority species, one or more of the following criteria must be met: 1) the species is a state-listed or candidate species (WAC 232-12-014 and 232-12-011); 2) the species is part of a vulnerable aggregation (e.g., heron rookeries, fish spawning areas); or 3) the species is of recreational, commercial, or tribal importance. PHS are prioritized for conservation and management when land use plans and decisions are made or updated.
- Washington Natural Heritage Program (WNHP) rare plant and animal species are identified through the Washington Department of Natural Resources (WDNR). The rare species list supports conservation planning, funding, and research.

This discipline report addresses submerged, vascular and non-vascular, rooted and non-rooted aquatic plant species. Wetlands are addressed in the *NEPA Discipline Report for Wetlands and Other Waters* (Corps 2020a) and wetland-dependent plants and animals (including amphibians) are addressed in the *NEPA Discipline Report for Terrestrial Species and Habitat* (Corps 2020b).

Non-native fish species are stocked in the Chehalis River for recreational fishing and are analyzed in terms of their role in recreational fisheries and their adverse effects on native fish species. There are also non-native fish species that have not been stocked that are considered invasive species that could impact native fish species.

Marine mammals do not occur in the study area (Section 5.1), but are addressed in this document if they depend on fish prey (e.g., Chinook salmon [*Oncorhynchus tshawytscha*]) that are likely to be affected by the alternatives.

Figure 1-1
Project Vicinity Map



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2 PROPOSED ACTION AND ALTERNATIVES

Three alternatives are evaluated in this report: two action alternatives and a No Action Alternative. Additional details about these alternatives are documented in a memorandum on NEPA EIS alternatives (Anchor QEA 2019a). The alternatives are as follows:

- No Action Alternative. This represents the conditions anticipated without the proposed project over the course of the analysis period from 2025 through 2080.
- Alternative 1 (Proposed Project): Flood Retention Expandable (FRE) Facility and Airport Levee Improvements. Alternative 1 is the Applicant's proposed project and includes the FRE facility and Airport Levee Improvements. The FRE facility would include a foundation that allows for the future expansion of the flood retention structure to increase the storage capacity of the temporary reservoir.
- Alternative 2: Flood Retention Only (FRO) Facility and Airport Levee Improvements. Alternative 2 would be the same as Alternative 1 except that the flood retention facility would be built on a smaller foundation. The Alternative 2 facility, called an FRO facility, would not allow for potential future expansion of flood storage capacity.

3 REGULATORY CONTEXT AND DEFINITIONS

3.1 Regulatory Context

Table 3-1 provides the regulations, statutes, and guidelines that apply to aquatic species and habitat.

Table 3-1
Regulations, Statutes, and Guidelines

REGULATION, STATUTE, OR GUIDELINE	DESCRIPTION
FEDERAL	
Clean Water Act (33 USC 1251 et seq.)	The CWA establishes the basic structure for the U.S. Environmental Protection Agency to regulate discharges of pollutants into the waters of the United States and regulates water quality standards for surface waters. Section 303(d) includes a requirement for states to identify and list waters where current water pollution control regulations and controls alone cannot meet the water quality standards set for those waters. Section 401 (water quality certification) requires Water Quality Certification from the state for activities requiring a federal permit or license to discharge pollutants into a water of the United States. Certification attests the state has reasonable assurance the proposed activity will meet state water quality standards. Section 402 (33 USC 1342) establishes the National Pollutant Discharge Elimination System program, under which certain discharges of pollutants into waters of the United States are regulated. Section 404 regulates the discharge of dredged or fill material into waters of the United States, including jurisdictional wetlands.
Endangered Species Act (16 USC 1531–1544)	Provides for the conservation of species listed as threatened or endangered and the habitat upon which they depend. Section 7 of the ESA requires federal agencies to consult with USFWS and/or NMFS to ensure a federal action is not likely to jeopardize the continued existence of any threatened or endangered species or result in the destruction or adverse modification of designated critical habitat.
Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (PL 104-267)	Requires fishery management councils to include descriptions of EFH and potential threats to EFH in all federal fishery management plans. Also requires federal agencies to consult with NMFS on activities that may adversely affect EFH. EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" and is designated for groundfish, Pacific salmon, and coastal pelagic composites. EFH includes coral reefs, kelp forests, bays, wetlands, rivers, and areas of the deep ocean that are

REGULATION, STATUTE, OR GUIDELINE	DESCRIPTION
	necessary for fish reproduction, growth, feeding, and shelter (NOAA 2019d).
Fish and Wildlife Coordination Act (16 USC 661-667[e])	Protects fish and wildlife when federal actions result in the control or modification of a natural stream or body of water. The Fish and Wildlife Coordination Act provides the basic authority for the involvement of USFWS in evaluating impacts to fish and wildlife from proposed water resource development projects, to take action to prevent loss or damage to these resources, and to provide for the development and improvement of these resources. The Fish and Wildlife Coordination Act requires that wildlife conservation be given equal consideration to other features of water-resource development programs through planning, development, maintenance, and coordination of wildlife conservation and rehabilitation.
Marine Mammal Protection Act of 1972, Amended 1994 (16 USC 1361)	Prohibits activities that harass, hunt, capture, collect, or kill marine mammals, such as whales, dolphins, seals, and manatees. “Harass” means any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild; or has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering. In order to pursue activities that may incidentally (unintentionally but not unexpectedly) harm marine mammals, private entities or government agencies must apply for a permit. The Marine Mammal Protection Act also requires permit holders to monitor the damage they cause and implement mitigation measures. To engage in multi-year activities that may harass, injure or kill marine mammals, an entity must obtain a letter of authorization from NOAA.
Chehalis Tribal Code Quinault Indian Nation Tribal Code	The Chehalis Tribe and Quinault Indian Nation retain sovereign rights that are guaranteed under treaties and federal laws. For activities on tribal lands, tribal laws may require critical area permits and approvals. As a signatory of the Treaty of Olympia (1856), the Quinault Indian Nation has treaty-reserved rights that reserve the rights to “taking fish, at all usual and accustomed fishing grounds and stations” and the privilege of hunting and gathering, among other rights, in exchange for ceding lands over which it historically roamed freely (Sharp 2016). As a treaty tribe, the Quinault manage their fisheries and are responsible for regulating tribal fishers both on and off the reservation. The Quinault Indian Nation is a co-manager with WDFW for salmon, steelhead, white sturgeon, and Dungeness crab. The Chehalis River and all its tributaries empty into Grays Harbor and are within the Quinault Indian Nation’s usual and accustomed fishing areas (Sharp 2016).

REGULATION, STATUTE, OR GUIDELINE	DESCRIPTION
	Because the Chehalis Tribe is a non-treaty tribe, their fisheries are limited to the portion of the rivers on the reservation, and their harvest is a portion of the non-treaty allowable harvest. The Chehalis Tribe's portion of the non-treaty harvest is based on a sharing formula between the state of Washington and the Chehalis Tribe.
STATE	
Washington State Hydraulic Code (RCW 77.55; WAC 220-660)	Issued by WDFW for projects with elements that may affect the bed, bank, or flow of a water of the state or productive capacity of fish habitat. Considers effects on riparian and shoreline/bank vegetation in issuance and conditions of the permit, including for the installation of piers, docks, pilings and bank armoring and crossings of streams and rivers (including culverts).
Washington State Water Pollution Control Law (RCW 90.48)	Grants Ecology the jurisdiction to control and prevent the pollution of streams, lakes, rivers, ponds, inland water, saltwaters, water courses, and other surface and groundwater in the state.
Washington Department of Ecology Code (WAC 173)	**Chapter 201A:** Establishes water quality standards for surface waters, implementing RCW 90.48, Water Pollution Control Act. Freshwater designated uses and associated criteria are specifically identified in WAC 173-201A-200. **Chapter 204:** Establishes sediment management standards to reduce and ultimately eliminate adverse effects on biological resources and significant threats to human health from surface sediment contamination.
Water Resources Act of 1971 (RCW 90.54)	Sets forth fundamental policies for the state to ensure that waters of the state are protected and fully utilized for the greatest benefit.
Washington State Growth Management Act (RCW 36.70A)	Defines a variety of critical areas, which are designated and regulated at the local level under city and county critical areas ordinances. These critical areas may include shorelines or portions of fish habitat.
Shoreline Management Act (RCW 90.58)	Regulates and manages the use, environmental protection, and public access of the state's shorelines. The Shoreline Management Act was passed by the Washington State Legislature in 1971 and adopted in 1972. Ecology is the agency responsible for enforcing the Shoreline Management Act.
WDFW State and Protected Species (WAC 220-610)	The Washington State and Protected Species legislation defines species listed under the federal ESA within the state and prohibits fishing for or possessing fish that are federally listed as threatened or endangered. This legislation defines endangered, threatened, and sensitive wildlife species within the state of Washington.
Washington State Wildlife Action Plan Fish and Wildlife (RCW 77)	Plan to help guide implementation of policies and goals related to Washington state wildlife, fish, and wildlife and fish habitat as set forth by RCW 77, Fish and Wildlife.

REGULATION, STATUTE, OR GUIDELINE	DESCRIPTION
Invasive/Non-Native Species (WAC 220-640)	Washington state legislation on invasive and non-native species applies to all non-native aquatic animal species except those in ballast water. This legislation requires the state to define standards for invasive risk levels and criteria for determining environmental impacts, list prohibited and regulated species, and require a permit for possession of listed species.
Rivers and Habitat Open Space Program (WAC 222-23)	The Rivers and Habitat Open Space Program allows Washington State Departments to acquire conservation easements on forest lands within unconfined channel migration zones and forest lands containing a critical habitat for threatened or endangered species.
Washington Department of Natural Resources Natural Heritage Program	The WNHP has been connecting conservation science with conservation action since its establishment in 1977. The WNHP catalogs the plants, animals, and ecosystems of Washington and prioritizes their conservation needs, helping guide conservation funding in the state and providing the framework for the statewide system of natural areas.
LOCAL	
Lewis County Shoreline Permit and Shoreline Master Program	The Lewis County Shoreline Permit is issued in compliance with the Lewis County Shoreline Master Program and covers all work that occurs landward within 200 feet of the ordinary high-water mark of waters of the state and the wetlands associated with these stream segments.
Lewis County Critical Areas Ordinance (LCC 17.35A.685[3])	Provides standards for instream structures, including dams other than those regulated exclusively by the Federal Energy Regulatory Commission. Such structures shall be permitted only when multiple public benefits are provided and ecological impacts are fully mitigated, and instream structures on shorelines of the state shall be regulated in accordance with the Lewis County shoreline master program.
City of Chehalis Critical Areas Ordinance (Ordinance 849-B, Section 4, Title 17.21)	Provides development standards and requirements for projects that occur in critical areas including fish and wildlife habitat areas. Describes allowed and prohibited uses in such areas and the details the requirements for buffer establishment around habitats known to support special-status species. Provides the permitting process and mitigation requirements for projects that affect designated fish and wildlife habitat areas.

3.2 Flood Definitions

For the purposes of analyzing the potential impacts of the alternatives over time, this report considers the effects in the context of four flood scenarios: a 2-year flood, a major flood, a catastrophic flood, and a back-to-back flood where a major flood is followed by a catastrophic flood in the following year. Table 3-2 defines Chehalis River flows associated with the floods considered in this report. A 2-year flood has an approximately 50% chance of occurring each year and would not trigger operation of the proposed flood retention facility. Although a "major" flood is defined as the 7-year recurrence interval flood, the 10-year flood was used as a substitute for the 7-year flood during the analysis because their modeled inundation areas are similar. The 10-year is also a more commonly modeled flood and has an approximately 10% chance of occurring each year. For the purposes of this report, a major flood is represented by the 10-year flood and a catastrophic flood is represented by a 100-year flood. A catastrophic flood has an approximately 1% chance of occurring each year. The chance of back-to-back major and catastrophic floods would be less than 1%.

Table 3-2
Definition of Chehalis River Floods

FLOOD	FLOOD OCCURRENCE INTERVAL	PEAK FLOW MEASUREMENT
2-Year	2-year	25,659 cubic feet per second at Grand Mound
Major	7-year	38,800 cubic feet per second at Grand Mound
Catastrophic	100-year	75,100 cubic feet per second at Grand Mound

Note:
Source: Anchor QEA 2017a

4 INFORMATION SOURCES

This section provides the sources used to describe the existing conditions and expected future conditions within the study area (see Section 5.1) to support the impact analysis.

4.1 Aquatic Habitats

This section lists the information sources used to define the existing conditions and perform the impact analysis for aquatic habitats. The aquatic habitats located in the study area are described and quantified using the following resources:

- National Oceanic and Atmospheric Administration (NOAA) online information sources, including National Marine Fisheries Service Habitat Conservation Mapper (NOAA 2019b) and Understanding Essential Fish Habitat (NOAA 2019d)
- U.S. Fish and Wildlife Service (USFWS) online information sources, including Endangered Species Information (USFWS 2019a) and IPaC (USFWS 2019b)
- WDFW online information sources, including the PHS List (WDFW 2008), Threatened and Endangered Species search tool (WDFW 2019a), PHS mapper (WDFW 2019b), and ScoRE Interactive map (WDFW 2019c)
- Ongoing aquatic habitat monitoring studies conducted by WDFW (e.g., Hayes et al. 2018, Hayes et al. 2019, Henning et al. 2006, Henning et al. 2007, Kendall and Zimmerman 2018, Winkowski et al. 2018a, Winkowski et al. 2018b, Winkowski and Zimmerman 2019)
- General aquatic habitat information (e.g., Caldwell et al. 2004, NOAA 1999, Normandeau 2012, Simon and Peoples 2006, Smith and Wenger 2001, USFWS 2004, Wydoski and Whitney 2003)
- Previous aquatic habitat modeling and monitoring studies conducted for the Chehalis Basin Strategy:
  - Physical Habitat Simulation study of changes in fish habitat with changes in flow, temperature (Normandeau 2012; Beecher 2015; Pacheco 2019)
  - Memorandum: Chehalis River Existing Conditions RiverFlow2D Model Development and Calibration (Elliot et al. 2019)
  - Memorandum: Chehalis River Basin Hydrologic Modeling (WSE 2019)
  - *Procedure for Rating Water Temperature in the Chehalis ASRP EDT Model* (ICF 2019)
- Other documents completed for the Chehalis Basin Strategy:
  - *The Chehalis Basin Salmon Habitat Restoration and Preservation Strategy for WRIA 22 and 23* (GHLE 2011)
- Other Discipline Reports supporting the NEPA EIS:
  - *NEPA Discipline Report for Wetlands and Other Waters* (Corps 2020a)
  - *NEPA Discipline Report for Terrestrial Species and Habitat* (Corps 2020b)
  - *NEPA Discipline Report for Water Quantity and Quality* (Corps 2020c)
  - *NEPA Discipline Report for Geomorphology* (Corps 2020d)

4.2 Aquatic Species

This section lists the information sources used to define the existing conditions and perform the impact analysis for aquatic species. Appendix A presents relevant information on fish modeling that was used in the development of this discipline report. The general and special-status aquatic species that are known or likely to occur in or use the study area were identified using the following resources:

- NOAA online information sources, including West Coast Salmon and Steelhead Listing (NOAA 2019a), National Marine Fisheries Service (NMFS) Habitat Conservation Mapper (NOAA 2019b), Green Sturgeon Overview (NOAA 2019c), and Understanding Essential Fish Habitat (NOAA 2019d)
- USFWS online information sources, including Endangered Species Information (USFWS 2019a), Information for Planning and Conservation (IPaC; USFWS 2019b), and Freshwater Fish of America (USFWS 2019f)
- WDFW online information sources, including the PHS List (WDFW 2008), Threatened and Endangered Species search tool (WDFW 2019a), PHS mapper (WDFW 2019b), and Salmon Conservation and Reporting Engine (ScoRE) Interactive map (WDFW 2019c)
- WDNR Natural Heritage Program lists, including List of Animal Species with Ranks (WDNR 2017) and 2019 Washington Vascular Plant Species of Special Concern List (WDNR 2019)
- Ongoing aquatic species monitoring studies conducted by the U.S. Geological Survey (e.g., Liedtke et al. 2016)
- Ongoing aquatic species monitoring studies conducted by WDFW (e.g., Brown et al. 2017, Edwards and Zimmerman 2018, Hayes et al. 2019, Kendall and Zimmerman 2018, Langness et al. 2018, Ronne et al. 2018, Ronne 2019, Seamons et al. 2017, Seamons et al. 2019, Winkowski et al. 2016, Winkowski et al. 2018a, Winkowski et al. 2018b, Winkowski and Kendall 2018, Winkowski and Zimmerman 2019, Winkowski et al. 2019a, Winkowski et al. 2019b)
- General fish references for the state of Washington (e.g., Wydoski and Whitney 2003)
- Species-specific fish, invertebrate, and aquatic plant studies (e.g., Caldwell et al. 2004, Gadomski et al. 2001, Keefer et al. 2010, Lindley et al. 2011, NOAA 2010, Ostberg et al. 2018, Pearson 2004, Poytress et al. 2015, Prybil et al. 2004, Simon and Peoples 2006, Steel et al. 2019, Thompson et al. 2019a, Thompson et al. 2019b, Thompson et al. 2019c, USFWS 1983, USFWS 2004)
- Species-specific publications (e.g., Blevins 2018, Cascadia 2018, Ecology 2006, Ecology 2019a, Nedeau et al. 2009, Rieman and McIntyre 1993, Troffe 1999, USDA 2011, USFWS 2008, 75 Federal Register [Fed. Reg.] 63898; USFWS 2010, USFWS 2019e, WDNR 2005, Weichmann 2018)
- State and federal fish passage design guidelines (NMFS 2011; WDFW 2013)
- Ongoing fish passage monitoring and management studies (e.g., Ferguson et al. 2007)

- Previous fish passage design reports completed for the Chehalis Basin Strategy:
  - Memorandum: Spawning Distribution of Chehalis Spring-Run Chinook Salmon and Application to Modeling (Lestelle et al. 2019)
- Other documents completed for the Chehalis Basin Strategy:
  - *Chehalis Basin Strategy Final Programmatic EIS* (Ecology 2017)
  - *Aquatic Species Enhancement Plan* (ASEPTC 2014)

5 AFFECTED ENVIRONMENT

5.1 Study Area

The study area for aquatic species and habitat is defined as the aquatic environments with the potential to be affected by construction and operation of the alternatives. This study area was divided into three distinct areas based on the potential for impacts (Figure 5.1-1):

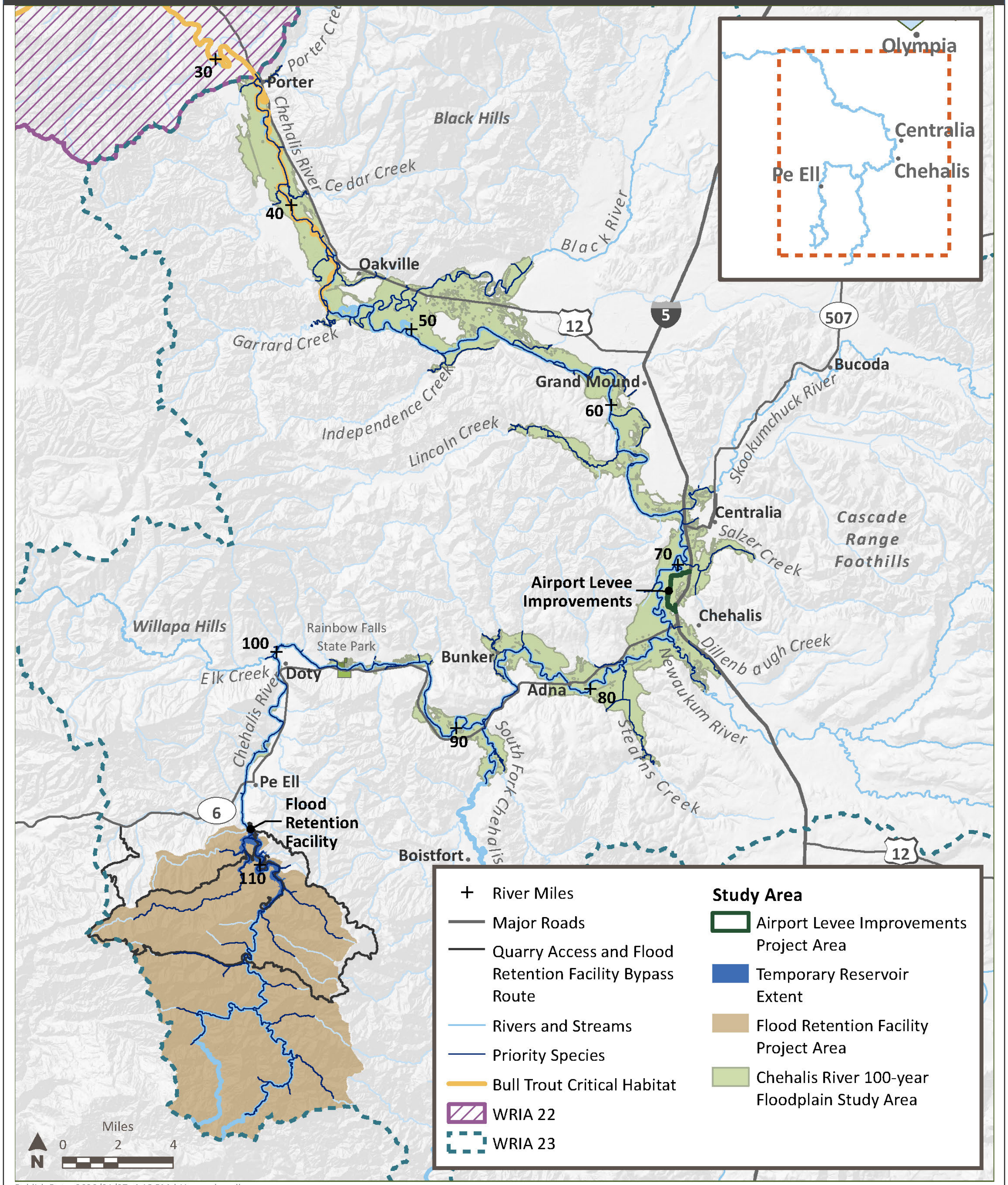
- Proposed flood retention facility project area
- Chehalis River 100-year floodplain (RM 33 to 108)
- Proposed Airport Levee Improvements project area

The study area is primarily in the upper Chehalis River Basin (Water Resource Inventory Area [WRIA] 23). However, information is included, and some impacts are evaluated, at the Chehalis Basin (WRIA 22/23) scale. This applies to the analysis of spring-run Chinook salmon, fall-run Chinook salmon, coho salmon, and steelhead. As discussed in greater detail in Section 6, this approach provides additional context for interpreting the results of the impact analysis.

5.1.1 Flood Retention Facility Project Area

The flood retention facility project area covers approximately 43,700 acres and is in Lewis County in the upper Chehalis River Basin in WRIA 23. This includes the location of the proposed flood retention facility at approximately RM 108 and the nine sub-basins above it, and any areas potentially affected by construction of the facility (Figure 5.1-2). This encompasses the site of the flood retention facility, including the full extent of the temporary reservoir, diversion tunnel site, construction staging and storage areas, quarries, improved access roads, bypass route, and spoil placement sites. The nine sub-basins upstream of the proposed flood retention facility are included because they contain anadromous fish that could be impacted by the proposed project. These sub-basins include the upper Chehalis, Crim Creek, Big Creek, Roger Creek, Alder Creek, Thrash Creek, Mack Creek, West Fork Chehalis River, and East Fork Chehalis River.

Figure 5.1-1
Study Area



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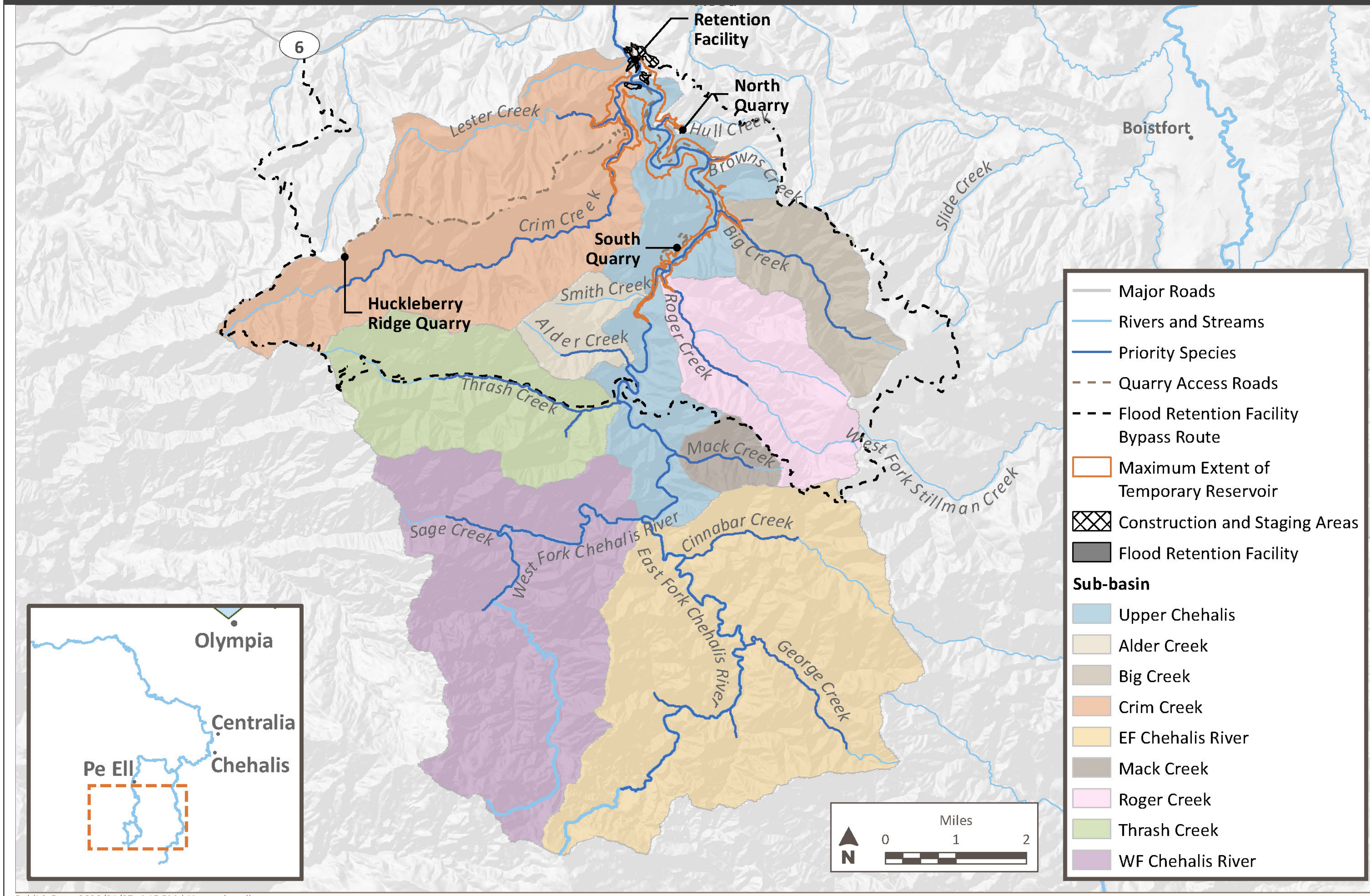
Filepath: \\orcas\gis\Jobs\WA_OFM_1023\NEPA\Maps\Discipline_Report\Aquatic_Species_and_Habitats\AQ_NEPA-EIS_ASH_A_Overall_Study_Area.mxd

Figure 5.1-2
Flood Retention Facility Project Area



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5.1.2 Chehalis River 100-Year Floodplain Study Area

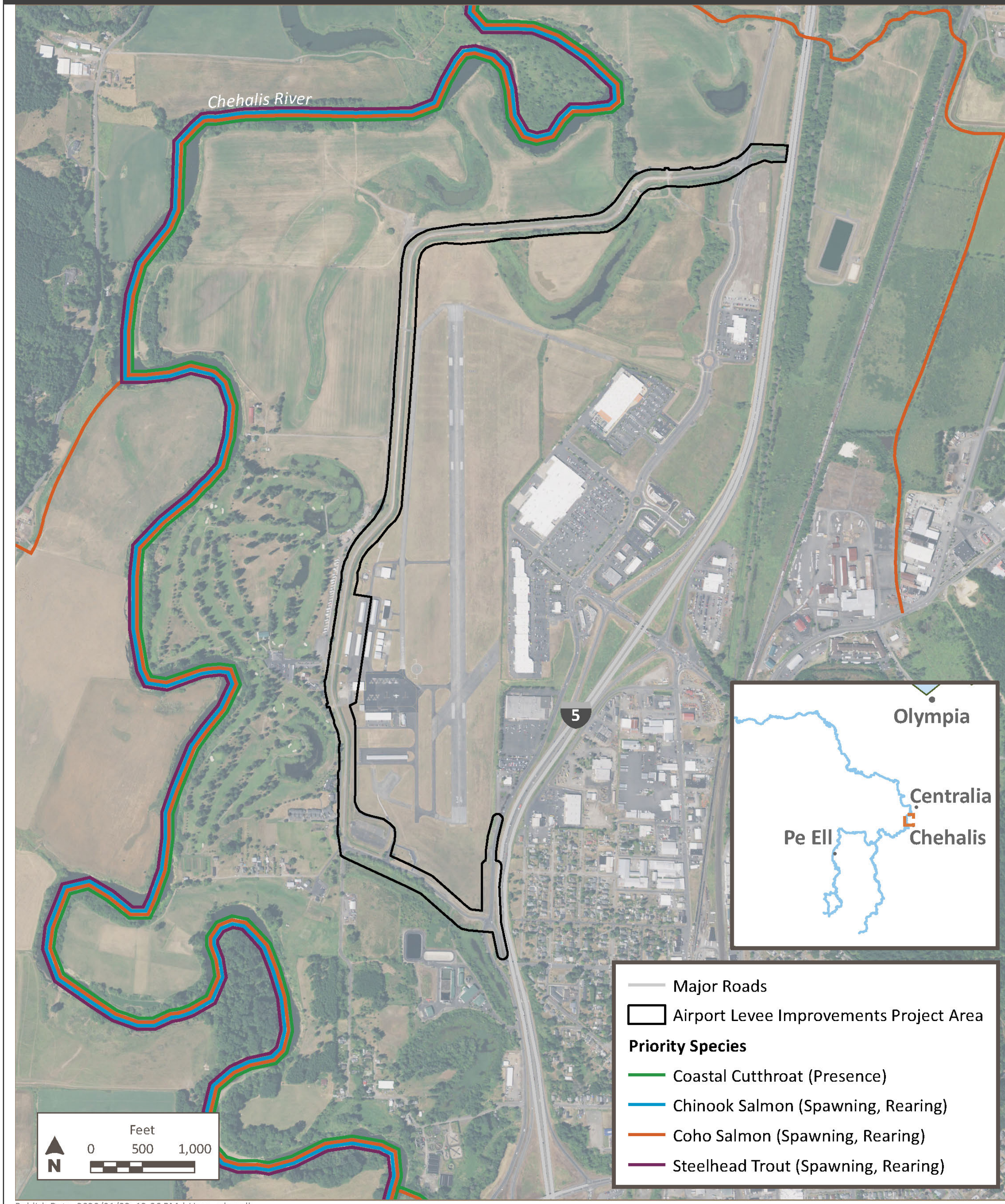
The Chehalis River 100-year floodplain study area includes the parts of the 100-year floodplain of the mainstem Chehalis River that would experience a reduction in flood elevation during major floods as a result of the proposed action (i.e., downstream of the facility). This part of the study area extends from the location of the proposed flood retention facility at RM 108 downstream to RM 33 near Porter (Figure 5.1-2). Porter is approximately 42 miles downstream from the city of Chehalis (RM 75). This area also includes the lower ends of twelve major tributaries whose confluences occur within the 100-year floodplain of the mainstem Chehalis River, including the South Fork Chehalis River, Newaukum River, Skookumchuck River, Black River, Stearns Creek, Dillenbaugh Creek, Salzer Creek, Lincoln Creek, Independence Creek, Garrard Creek, Cedar Creek, and Porter Creek. Beyond RM 33, the potential effects of the project on a major flood are diminished to the point of being negligible. This is because tributaries, tides, and a channel constriction in the floodplain at this location have more effect on hydrology than the potential project may have.

The Airport Levee Improvements project area is located entirely within this part of the study area. However, it is recognized as a separate project area, as described in Section 5.1.3.

5.1.3 Airport Levee Improvements Project Area

The Airport Levee Improvements project area includes the limits of the proposed improvements upland and east of the mainstem Chehalis River. This project area is between approximately RM 73.5 and RM 70 (Figure 5.1-3) and is at a minimum 700 feet distant of the mainstem Chehalis River. While it is within the Chehalis River 100-year floodplain, the Airport Levee Improvements project area is not connected to the floodplain. This is because of the presence of the existing airport levee and other flood control structures in the vicinity. No streams, rivers, or drainages were identified in the Airport Levee Improvements project area (Anchor QEA 2018b). Therefore, no aquatic habitats considered in this report have the potential to be directly affected by the Airport Levee Improvements. Semi-aquatic species and wetland habitats with the potential to be indirectly affected are addressed in other discipline reports. This includes the *NEPA Discipline Report for Wetlands and Other Waters* (Corps 2020a), the *NEPA Discipline Report for Terrestrial Species and Habitat* (Corps 2020b), and the *NEPA Discipline Report for Water Quantity and Quality* (Corps 2020c). For these reasons, the Airport Levee Improvements project area is not discussed further in this discipline report.

Figure 5.1-3
Airport Levee Improvements Project Area



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5.2 Study Area Background

The different habitat features present as the Chehalis River moves from the upper portions to the lower portions of the study area determine the distribution of species. The upper portions of the study area above the South Fork Chehalis River confluence at RM 88 are generally confined by steep valleys with bedrock outcrops and gravel and cobble substrates and fast flowing water (Corps 2020d; GHLE 2011). Salmonids and other fish species use the habitat in this area for spawning and rearing. A recent study conducted in this area found that upstream segments of the river dominated by salmonids were consistently cooler than those downstream segments dominated by native non-salmonids and non-native species. This transition of species dominance occurred around the town of Pe Ell (Winkowski et al. 2018a) with salmonids as the dominant species upstream of Pe Ell.

Major to large tributaries of the Chehalis River in this area have low to medium gradients with similar types of habitat to the mainstem Chehalis (Caldwell et al. 2004). Compared to the mainstem Chehalis River, smaller tributaries in the upper Chehalis River Basin have a higher proportion of large woody material (LWM), and of cascade, step-pool, and plane bed habitat (Winkowski et al. 2016). While some small tributaries have continuous flow, others experience low seasonal flows (Corps 2020c). Both low seasonal flows and fast water with several feet of elevation drop can limit fish access to habitat (Caldwell et al. 2004).

As the river progresses downstream, it becomes less confined with alternating stretches of confined bedrock and unconfined areas with more frequent floodplain connectivity and lower gradient. Substrate sizes also decrease as the river moves downstream until the confluence with the Skookumchuck River near RM 67. The Skookumchuck River introduces cobble and gravel to the mainstem. From about RM 62 downstream to the farthest downstream end of the study area near the city of Porter (RM 33), the mainstem Chehalis River is unconfined and slow-moving with a wide floodplain and dominant substrates of gravel and cobble. The unconfined areas with floodplain connections to adjacent wetlands provide additional habitat for aquatic species. Several native and non-native species were observed using flooded wetlands, including coho, Chinook, and chum salmon, and coastal cutthroat trout. The dominant species observed in the flooded wetland areas were coho salmon, Olympic mudminnow, and three-spine stickleback (Henning et al. 2006, 2007).

Aquatic habitat is constrained in the study area. Human-induced changes related to logging and other land uses have degraded habitat for aquatic species. For example, areas of erosion have been documented in the upper Chehalis River and some riparian areas are in poor condition because of past logging and agricultural practices (GHLE 2011). Sediment transport has increased because of high sediment loading from the tributaries (Winkowski et al. 2016). Fish passage barriers are also present from culvert and road crossings (GHLE 2011). There is a lack of LWM in the mainstem Chehalis River, particularly in the upper Chehalis River, where large wood load (volume) ranged from 0.9% to 5.6% of the 317 cubic meters per 100 meters recommended as a restoration target for unmanaged streams

(WGD and Anchor QEA 2017). Riparian cover is present but lacking in some areas. Water quality throughout the project area is variable (GHLE 2011).

Flows are also an important component of habitat for aquatic species. In the Chehalis River, precipitation impacts flows, which causes a large variation between flows in the winter and flows in the summer. Generally, flow in the Chehalis River is highest from November to March, which corresponds to the heaviest occurrence of precipitation, and lowest during the summer dry season from July to September (Corps 2020c). Dry summer conditions lead to increased water temperature that could limit habitat access for fish requiring cool water, such as spring-run Chinook salmon. In the last 47 years, there have been seven large floods, all of which occurred between November and February (Corps 2020c). Large floods, including major and catastrophic floods, that occur in the winter would scour and destroy eggs of fish that spawn in the winter (Sloat et al. 2018). These floods would also move LWM from upstream to downstream areas creating complex instream habitat. An analysis of historical aerial photography and flow records between 1955 and 2008 estimated that floods from past storms have moved between 2,300 and 3.3 million cubic yards of LWM into the Chehalis River system since 1955 (WGD and Anchor QEA 2017). The existing conditions in the flood retention facility project area and Chehalis River 100-year floodplain study area are described in greater detail below.

5.2.1 Flood Retention Facility Project Area

The dominant aquatic features of the flood retention facility project area include the Chehalis River and associated tributaries within the nine sub-basins upstream of the proposed flood retention facility (Figure 5.1-2). These waters include large river and stream systems, primary and secondary tributaries of these systems, and isolated channels that flow at some times during the year. The upper mainstem Chehalis River is formed by the confluence of the East and West Fork Chehalis River at RM 118.9. The East Fork Chehalis River is considered part of the mainstem (Caldwell et al. 2004). The Crim, Roger, Thrash, and Big tributary creeks are also important for fish production. Cinnabar and George creeks, tributaries to the East Fork Chehalis; Sage Creek, a tributary to the West Fork Chehalis River; and Lester Creek, a tributary to Crim Creek, also contribute to fish production in this area (Figure 5.1-3; Caldwell et al. 2004). From the headwaters to RM 108, the stream system is considered confined, with an average gradient of 1.1% in the mainstem, and limited potential for channel migration (Ecology 2017).

Within the footprint of the proposed temporary reservoir, there are approximately 118 streams, creeks and drainages. These waters were delineated in 2018 (Anchor QEA 2018b). Table 5.2-1 lists the total number of waters, including the total length (in feet) and approximate area (in acres) found in each drainage within the reservoir footprint. The drainages are tributary streams that drain into the Chehalis River within the proposed temporary reservoir footprint. The footprint includes approximately 114 acres of waters. The tributaries represent 18% of total delineated instream habitat area, and 38% of delineated instream habitat length (Table 5.2-1) within the footprint of the temporary reservoir. No ponds or lakes were identified in this area.

Table 5.2-1
Delineated Waters within the Temporary Reservoir Footprint

NAME	TOTAL NUMBER OF DELINEATED WATERS	TOTAL LENGTH (FEET)	TOTAL AREA (ACRES)
Upper Chehalis River (CR)	66	55,543	93.17
Crim Creek (CC)	30	18,083	12.94
Lester Creek (LC)	8	4,681	2.79
Hull Creek (HC)	5	3,631	0.69
Browns Creek (NC)	4	2,127	0.67
Big Creek (BC)	2	2,820	1.28
Rogers Creek (RC)	2	2,372	2.03
Smith Creek (SC)	1	144	0.02
Total	**118**	**89,401**	**113.59**

Note:
The temporary reservoir footprint is shown in Figure 5.1-1. Additional habitat for aquatic species within the flood retention facility project area occurs above the temporary reservoir footprint, including in Alder Creek, Thrash Creek, Mack Creek, and the East and West Fork Chehalis River, which were not delineated.

5.2.2 Chehalis River 100-Year Floodplain Study Area

The Chehalis River 100-year floodplain in the Chehalis River valley is mainly within WRIA 23 in Grays Harbor, Lewis, and Thurston counties. This portion of the study area consists of approximately 43,107 acres and includes about 75 miles of the 100-year floodplain and aquatic habitat along the mainstem Chehalis River between RM 108 and RM 33.

Based on the National Hydrography Dataset (NHD), there are a total of 1,739 mapped segments (about 263 miles) of rivers, streams, and drainages in this portion of the study area. These waters primarily include perennial and intermittent streams. Because NHD mapped streams are depicted as lines, it was not possible to accurately calculate the area of those features.

The Chehalis River 100-year floodplain study area also includes the downstream ends of the South Fork Chehalis River, Newaukum River, Skookumchuck River, Black River, Elk Creek, Stearns Creek, Dillenbaugh Creek, Salzer Creek, Lincoln Creek, Independence Creek, Garrard Creek, Cedar Creek, and Porter Creek (Figure 5.1-1).

The Chehalis River valley has a wide floodplain that, both historically and currently, contains numerous wetlands, natural and human-created ponds, and other off-channel aquatic habitats. Hydrologically, the Chehalis River 100-year floodplain extends across six watersheds of the upper Chehalis Basin (WRIA 23), including the Skookumchuck River (Hydraulic Unit Code [HUC] 1710010303), South Fork Chehalis River-Chehalis River (HUC 1710010301), Independence Creek-Chehalis River (HUC 1710010304), Black River-Chehalis River (HUC 1710010305], Newaukum River [HUC 1710010302], and Cloquallam Creek-Chehalis River [HUC 1710010404) (USGS 2019a). Hydrologic characteristics in the project area are influenced by regional groundwater, direct precipitation, surface water runoff, and overbank flows from the Chehalis River and its tributaries.

The land in this project area is used for a variety of purposes, including forestry; agriculture; recreation; commercial, industrial, and institutional development; and rural and urban residential uses. Infrastructure and development present include multiple paved and unpaved roads, bridges, culverts, railroad lines, buildings, and other structures. Utilities present include multiple power line crossings and belowground pipelines.

5.3 Aquatic Habitats and Species

The Chehalis River and its tributaries support a diverse mix of aquatic species. This includes fish (salmonids, lamprey, other native fish, and non-native fish), freshwater mussels, and aquatic plants. Marine mammals do not occur in the study area but are addressed in Section 5.3.6 to the extent they depend on fish prey (e.g., Chinook salmon) that may be affected by the proposed action.

This section describes special-status species and special-status aquatic habitat in the study area. It then describes the aquatic species and habitat in the study area that have the potential to be affected.

5.3.1 Special-Status Habitats

This section addresses habitat designations that receive special protections under state or federal law. This includes critical habitat designated under the ESA, essential fish habitat under the Magnuson-Stevens Act, and WDFW Priority Habitat.

5.3.1.1 Critical Habitat

There are no federal critical habitat designations in the flood retention facility project area. In the Chehalis River 100-year floodplain study area, the mainstem Chehalis River, from approximately RM 16.5 to about RM 45, is federally designated critical habitat for bull trout (Figure 5.1-1; USFWS 2019b). This designation includes about 12 river miles of the mainstem Chehalis River within the Chehalis River 100-year floodplain. Other areas adjacent to but not within the study area have also been designated as critical habitat for bull trout. This includes Grays Harbor, West Fork Satsop and Wynoochee rivers, and portions of the Wishkah and Humptulips rivers, which have been identified as potential foraging, migration, and overwintering habitat for bull trout (USFWS 2004, 2010).

5.3.1.2 Essential Fish Habitat

The upper and lower Chehalis River Basin has been designated essential fish habitat for Chinook salmon and coho salmon (NOAA 2019b). This designation encompasses the flood retention facility project area and Chehalis River 100-year floodplain study area. Habitat areas of particular concern include stream reaches where Chinook and coho salmon spawning and rearing are known to occur (NOAA 1999).

5.3.1.3 Washington Department of Fish and Wildlife Priority Habitat

The WDFW PHS list identifies two priority aquatic habitats that are known to be present in the study area: “fresh deepwater habitats” and “instream habitats” (WDFW 2008). These priority habitats may occur in the study area based on the habitat attributes as described further below.

5.3.1.3.1 Fresh Deepwater Habitats

Deepwater habitats are instream areas greater than 6 feet deep. Deepwater habitats include environments where surface water is permanent, so that water, rather than air, is the principal medium within which the dominant organisms live. The dominant plants are hydrophytes. However, the substrates are considered non-soil because the water is too deep to support emergent vegetation. These habitats include all underwater structures and features (e.g., LWM, rock piles, caverns). Fresh deepwater habitat only occurs in the Chehalis River 100-year floodplain study area.

5.3.1.3.2 Instream Habitats

Instream habitats are defined by WDFW 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.

Instream habitat occurs in both the flood retention facility project area and the Chehalis River 100-year floodplain study area. Impacts to deepwater and instream aquatic habitats may affect the reproduction, rearing, and distribution of salmonids and other aquatic species in the project area, as further discussed in Section 6.

5.3.2 Special-Status Species

This section describes special-status species with the potential to occur in the study area. Special-status species include federally listed threatened and endangered species, federal species of concern, state species of concern (endangered, threatened, sensitive, and candidate species, priority species), and WNHP species. Special-status species with the potential to be found in the flood retention facility project area or Chehalis River 100-year floodplain study area are presented in Appendix B and summarized below.

5.3.2.1 Federally Listed Species

5.3.2.1.1 Fish

Fish species likely to be found in the study area are presented in Appendix B, Table B-1 (salmonids) and Table B-2 (lamprey and other native fish) and are discussed in Section 5.3.3. Federally listed fish with the potential to be found in the study area are discussed in greater detail below.

Bull Trout

Bull trout (*Salvelinus confluentus*) are listed as federally threatened by USFWS and have the potential to be present throughout Grays Harbor, Lewis, and Thurston counties (USFWS 2019d). However, none have been confirmed in the Chehalis River 100-year floodplain study area during field investigations to date. Historically, bull trout have been caught by anglers in the lower Wynoochee River, and in the West Fork Satsop, Canyon, Wishkah, and Humptulips rivers, and have been detected in Grays Harbor during surveys from 1966 through 1981 and in 2001 to 2002 (USFWS 2004). Surveys conducted during the summer months from 2013 to 2016 detected two bull trout in the West Fork Humptulips River (Winkowski et al. 2018a). However, these areas are all outside the study area. Although bull trout have not been confirmed in the study area, they could be present in the Chehalis River 100-year floodplain study area.

Bull trout prefer to occupy cold side streams with cover, woody material, clean gravel and cobble substrate, pools, and undercut banks. Juveniles prefer lower velocity water compared to adults. Bull trout spawn in large gravel substrate from August through November and fry emerge from early April through May. Resident bull trout reside in small headwater streams. Migratory bull trout live in tributaries for several years before migrating downstream to a larger river or lake and may not return for several more years to spawn in tributaries (Troffe 1999; Rieman and McIntyre 1993).

Pacific Eulachon

Pacific eulachon (*Thaleichthys pacificus*) are listed as federally threatened by NMFS and have the potential to be present throughout Grays Harbor and Lewis counties. However, their presence in the study area has not been confirmed during field investigations to date. Environmental DNA monitoring and larvae density estimates conducted in the Chehalis Basin from 2015 to 2018 identified eulachon DNA in low densities in the lower Chehalis, Wishkah, and Wynoochee rivers. The mean egg/larvae densities were highest in February 2015 and March 2016 and 2018 (Langness et al. 2018). However, these areas are outside the study area. In general, eulachon spawning is limited to lower reaches of the river that are influenced by the tides and river systems fed by snow melt or glacial runoff (76 Fed. Reg. 65324, "Endangered and Threatened Species; Designation of Critical Habitat for the Southern Distinct Population Segment of Eulachon"). Tidal influence on the Chehalis River extends to RM 14 (WEST 2014), which is approximately 9 miles downstream of the study area. Therefore, eulachon are assumed to not be present within the study area.

Southern Distinct Population Segment Green Sturgeon

Southern Distinct Population Segment (DPS) green sturgeon (*Acipenser medirostris*) are listed as federally threatened by NMFS and have the potential to be present throughout Grays Harbor County. An acoustic tag study conducted from 2005 to 2006 indicated that green sturgeon frequently use Grays Harbor during summer and early autumn months (Lindley et al. 2011). WDFW determined that the Chehalis River is suitable green sturgeon spawning habitat. However, no evidence of spawning has been detected in the basin to date (NOAA 2005a) and spawning has only been confirmed in the Rogue River in Oregon and the Klamath and Sacramento rivers in California (74 Fed. Reg. 52300, "Endangered and Threatened Wildlife and Plants: Final Rulemaking to Designate Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon"). According to the critical habitat designation for Southern DPS green sturgeon, "the species occur throughout their natal river systems (i.e., the Sacramento River, lower Feather River, and lower Yuba River), but are believed to be restricted to the estuaries in non-natal river systems (i.e., north of and including the Eel River)" (74 Fed. Reg. 52300).Therefore, green sturgeon are assumed to not be present within the study area.

5.3.2.1.2 Freshwater Mussels

There are no special-status freshwater mussels in the flood retention facility project area or Chehalis River 100-year floodplain study area (NOAA 2019a, 2019e; USFWS 2019a, 2019b). Species likely to be found are presented in Table B-5 and described in Section 5.3.4.

5.3.2.1.3 Aquatic Plants

Water howellia (*Howellia aquatilis*) is listed as federally threatened by USFWS and has the potential to be present throughout Grays Harbor, Lewis, and Thurston counties. The plant was not identified in the temporary reservoir footprint during wetland and other waters delineation work in 2018 (Anchor QEA 2018b). Although its presence has not been confirmed during field investigations to date, there is a potential for it to occur within ponds and oxbow lakes in the Chehalis River 100-year floodplain study area. Therefore, water howellia is further discussed in Section 5.3.5.

5.3.2.1.4 Marine Mammals

There are no federally listed marine mammals in the flood retention facility project area or Chehalis River 100-year floodplain study area (NOAA 2019e; USFWS 2019a, 2019b). As noted previously, the federally listed Southern Resident killer whale (*Orcinus orca*) depends on fish that are found in the study area. Although marine mammals are not likely to be found within the study area, they are known to occur within Grays Harbor, and are therefore discussed in Section 5.3.6.

5.3.2.2 State Species of Concern

5.3.2.2.1 Fish

There is one state-sensitive and eight state species of concern fish species that may be present in the flood retention facility project area and Chehalis River 100-year floodplain study area. These species are indicated in Tables B-1 and B-2.

Four of these species, spring-run Chinook salmon, fall-run Chinook salmon, steelhead (*Oncorhynchus mykiss*), and Olympic mudminnow (*Novumbra hubbsi*), have been confirmed to be present in the study area during field investigations. The species that have not been confirmed could be present within the study area. Fish species are discussed in further detail in Section 5.3.3.

The WDFW PHS list identifies two more fish species that are either vulnerable or are of recreational, commercial, and/or tribal importance, that may be present in Grays Harbor, Lewis, or Thurston counties (Table 5.3-1). Both species, coho salmon (*Oncorhynchus kisutch*) and Pacific lamprey (*Lampetra tridentate*), have been confirmed to be present in the study area during field investigations and are discussed further in Section 5.3.3.

5.3.2.2.2 Freshwater Mussels

There are no special-status freshwater mussels in the flood retention facility project area or Chehalis River 100-year floodplain study area (WDFW 2019a, 2019b). Species likely to be found are presented in Table B-5 and described in Section 5.3.4.

5.3.2.2.3 Aquatic Plants

There are two state-listed plant species present in the study area. Water howellia is state threatened and is discussed in Section 5.3.2.1.3. State sensitive blunt-leaved pondweed (*Potamogeton obtusifolius*) has not been identified in existing studies, but suitable habitat exists in the mainstem Chehalis River (Anchor QEA 2018b; Hayes et al. 2019). Therefore, blunt-leaved pondweed is assumed to be present in the Chehalis River 100-year floodplain study area.

5.3.2.2.4 Marine Mammals

There are no state-listed marine mammals in the flood retention facility project area or Chehalis River 100-year floodplain study area (WDFW 2019a, 2019b). However, marine mammals include one state endangered species, the Southern Resident killer whale, which depends on fish that are found in the study area. Although marine mammals are not likely to be found within the study area, they are known to occur within Grays Harbor and are therefore discussed in Section 5.3.6.

5.3.2.3 Washington Natural Heritage Program Species

The WNHP catalogs animal and plant species known to exist in the state of Washington and develops a rank for each species to help guide conservation efforts. These rankings are described in Table 5.3-1.

Table 5.3-1
Washington Natural Heritage Program Rankings

RANK	DEFINITION
Global	Prefix that characterizes the relative rarity or endangerment of the element worldwide
State	Prefix that characterizes the relative rarity or endangerment within the state of Washington
1	Critically Imperiled: At very high risk of extinction or elimination due to very restricted range, very few populations or occurrences, very steep declines, very severe threats, or other factors
2	Imperiled: At high risk of extinction or elimination due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors
3	Vulnerable: At moderate risk of extinction or elimination due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors
4	Apparently Secure: At fairly low risk of extinction or elimination due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors
5	Secure: At very low risk or extinction or elimination due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats
NR	Unranked
NA	Not applicable

Note:
Sources: WDNR 2017, 2019

The WNHP List of Animal Species with Ranks includes 41 freshwater or anadromous fish species and two shellfish species that may be present in Grays Harbor, Lewis, or Thurston counties (Tables B-1, B-2, B-3, and B-4). Thirty-five of these species have been confirmed to be present in the study area during field investigations. Most of these species include non-listed (both federally and state) native and non-native fish, which have WNHP global and state rankings of low to secure. Seven species with confirmed presence in the study area have state program rankings of vulnerable or more at risk, including chum salmon (*Oncorhynchus keta*), Pacific lamprey, river lamprey (*Lampetra ayresii*), western brook lamprey (*Lampetra richardsoni*), Olympic mudminnow, western ridged mussels (*Gonidea angulate*), and western pearlshell (*Margaritifera falcata*). These species are discussed in further detail in Sections 5.3.3.1, 5.3.3.2, 5.3.3.3, and 5.3.4.

The WNHP Vascular Plant Species of Special Concern list includes two aquatic plant species (water howellia and blunt-leaved pondweed) that may be present in the study area. The presence of water howellia is discussed in Section 5.3.2.1.3. No surveys have been conducted in the study area to confirm presence of blunt-leaved pondweed. However, adequate habitat for this deep-water vascular plant exists in the Chehalis River 100-year floodplain study area, and it is assumed to be present. Adequate habitat does not exist in the flood retention facility project area, so this plant is assumed to not be present.

5.3.3 Fish

5.3.3.1 Salmonids

This section addresses the distribution, and status, and habitat requirements of salmonids known to occur within the study area. These species, including their special status, are listed in Table B-1 and discussed in greater detail below. Annual timing of salmonid species presence within the study area by life-stage is shown in Figure 5.3-1.

5.3.3.1.1 Habitat Requirements

Salmonids are present throughout the flood retention facility project area and Chehalis River 100-year floodplain study area at varying life stages. Optimal habitat varies with each life stage. Freshwater spawning sites require a certain instream flow, water quality conditions, and specific substrate size to support spawning, incubating eggs, and developing larvae. Rearing sites require different instream flows compared to spawning sites, as well as floodplain connectivity to form and maintain physical habitat conditions to support juvenile growth and mobility. These areas must include adequate forage, instream structures (e.g., LWM, boulders) and riparian vegetation to provide cover from predators, and areas of slower-moving water and deep cooler pools for refuge. Out-migrating smolts require freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions that provide places of lower flow to rest, coldwater inputs and deep pools, and natural cover (NOAA 2005b; 50 CFR 226). Returning adults also require certain water quantity and quality conditions, including adequate instream flows for upstream fish passage to spawning grounds, places to rest, and cool water (NOAA 2005b).

Degraded habitat conditions for salmonids currently exist in the flood retention facility project area. Degraded conditions in this area include a large amount of fine sediment that adversely impacts the survival of incubating eggs, high water temperatures that impact spawning and rearing conditions, and a lack of deep pools that are important for summer rearing (WGD and Anchor QEA 2017, Anchor QEA 2014, Anchor QEA 2018b, Corps 2020d). Areas with impaired water quality are described in greater detail in the *NEPA Discipline Report for Water Quantity and Quality* (Corps 2020c). Floodplain connectivity for rearing is also limited because of both natural channel confinement and human influences. In the project area at least 52 full or partial fish passage barriers have been identified (ASRPSC 2019). These barriers impede the upstream migration of adults to spawning grounds and out-migration of smolts to the estuary and impact transport of spawning gravel and LWM.

In the Chehalis River 100-year floodplain study area, high levels of fine sediment exist, notably from the South Fork Chehalis and Newaukum rivers. LWM in the mainstem Chehalis River is lacking and poor riparian conditions exist throughout the project area. Migration corridors to the estuary are unobstructed. However, transportation infrastructure has disconnected some floodplain habitat.

Floodplain connectivity is higher toward the downstream end of the project area. Water quality and quantity is a concern throughout the entire study area because it impacts all life stages of salmonids (ASRPSC 2019; Smith and Wenger 2001).

5.3.3.1.2 Modeled Salmonids

As discussed in greater detail in Section 6.2.1, fish modeling was completed to support the analysis of impacts on aquatic species. Modeling involved four species of salmonids. These species were chosen for the modeling because they spawn in the study area, are an important natural resource, and have a potential to be affected by the proposed project. For these reasons, these four species are discussed in greater detail below.

Spring-run Chinook Salmon

Chehalis spring-run Chinook salmon belong to the evolutionarily significant unit (ESU) of Washington Coast Chinook salmon. This population is categorized as having a very low risk of extinction. However, stock-specific goals are currently being re-examined (WDFW 2019c; WDNR 2017). State-wide, Chinook salmon are considered a candidate for state listing and priority species (WDFW 2019b). Overall, in the Chehalis Basin, spring-run Chinook salmon annual run size was estimated by WDFW to be 1,749 fish on average with a maximum of 3,495 based on data from 2009 to 2018 (Mike Scharpf, WDFW, spreadsheet dated August 8, 2019, as cited in Appendix A, Attachment A). This range may be an over-estimate of the spring-run Chinook salmon run size as described at the end of this section. Spring-run Chinook salmon have the most limited spawning area of salmonids in the study area. They spawn in both mainstem and tributary habitats from the middle Chehalis River to the upper basin, including in the Skookumchuck, Newaukum, and South Fork Chehalis rivers and tributaries (ASEPTC 2014; WDFW 2019c).

Spawner surveys conducted during the 2013-2014 to 2017-2018 seasons found that the estimated abundance of adult spring-run Chinook salmon in the flood retention facility project area was 23 adults based on a 5-year average (Ronne et al. 2020). However, the estimated abundance for the 2015-2016 to 2018-2019 seasons was only three to eight adults (based on observation of one to three redds), showing a trend of declining abundance in recent years (Ashcraft et al. 2017; Ronne et al. 2018, 2020). In the 2018-2019 season, the only redd in the flood retention facility project area occurred within the proposed temporary reservoir footprint.

Supplemental surveys conducted in 2017 and 2018 identified significantly more spring-run Chinook salmon redds in the Chehalis River 100-year floodplain study area upstream of the confluence with the Newaukum River (about RM 75.5) compared to the flood retention facility project area (Ronne et al. 2018, 2020). During these 1-week supplemental surveys, an average of 35 spring-run Chinook salmon redds were observed in the Chehalis River 100-year floodplain study area upstream of the confluence with the Newaukum River (Ronne et al. 2018, 2020). Approximately one-third of the redds in the supplemental survey areas occurred below Rainbow Falls Park at RM 98 to RM 78.5 just downstream of Adna, Washington. Because supplemental surveys were only conducted for 1 week during peak spawning, adult abundances were not estimated (Ronne et al. 2018, 2020). However, a summer survey between Rainbow Falls and the Newaukum confluence in 2018 observed 14 adult Chinook salmon (Winkowski et al. 2018a). These adults were assumed to be spring-run Chinook salmon because the timing of the survey (June through September) is consistent with spring-run Chinook salmon run timing (Figure 5.3-1). The distribution of spring-run Chinook salmon spawning grounds in each part of the study area is presented in Figure 5.3-2.

Spring-run Chinook salmon begin entering the lower Chehalis River in mid-February and hold in deep, cooler water pools for 3 to 7 months before migrating upstream through early October to spawn (Liedtke et al. 2016; Ronne et al. 2018). Spawning activities occur in the flood retention facility project area and upper reaches of the Chehalis River 100-year floodplain study area typically from early September to mid-October (ASEPTC 2014; Caldwell et al. 2004; Ronne et al. 2018; WDFW 2019c). After incubation, juveniles outmigrate to the ocean as fry from January to March, or rear in freshwater for weeks to months and outmigrate as subyearlings between the months of April and July (Liedtke et al. 2016; Winkowski and Zimmerman 2019). Anticipated migration periods and life stages of Chehalis spring-run Chinook salmon are presented in Figure 5.3-1.

Spring-run Chinook salmon tend to migrate earlier and spawn in upriver locations, while fall-run Chinook salmon typically arrive later and spawn in downriver locations. Although environmental conditions are often harsher (e.g., low flow, high temperature) during the summer and early fall, arriving earlier likely provides the advantage of habitat exclusivity (Thompson et al. 2019a, 2019b). Spring-run Chinook salmon are therefore disproportionally affected by human activities that restrict their exclusive access to the upper reaches of watersheds (Thompson et al. 2019a, 2019b). When spring-run Chinook salmon are blocked from preferred spawning grounds, there is more likely to be intermingled breeding between spring-run and fall-run types with a resulting loss of genetic diversity that may not be recoverable (Thompson et al. 2019c).

Recent analyses indicate that Chehalis Basin Chinook salmon run types have genetic differences, though in some areas the run types interbreed. This is a new finding because previous analyses had found that Chinook salmon run types did not have genetic differences in the Basin (Brown et al. 2017). The recent genetic analyses were based on a well-established run-type genetic marker. Results indicate that previously field identified “spring-run Chinook” in the lower basin were misidentified and were actually fall-run Chinook salmon. The results further indicate that previously field identified spring-run Chinook salmon in the upper Chehalis River Basin (i.e., in the Skookumchuck River and above) were much more likely to be spring-run type fish that are genetically distinct from the fall-run type (Thompson et al. 2019a). More specifically, the genetic research results indicate that, of the sampled fish field-identified as spring-run Chinook salmon (145 fish), 34% were found to be genetic fall-run Chinook salmon, and 18% were found to be a genetic mix between the two run types (Thompson et al 2019a). These results mean that available population estimates of spring-run Chinook salmon in the Chehalis Basin are likely an overestimate of the actual population and that the available population estimates of fall-run Chinook salmon are likely an underestimate of the actual population (Thompson et al. 2019a, 2019b).

The results of the recent analyses also found that spring-run Chinook salmon that spawn in the upper Chehalis River Basin show greater evidence of interbreeding with fall-run Chinook salmon than spring-run Chinook salmon from other areas of the Chehalis Basin. These results mean that upper Chehalis River Basin spring-run Chinook salmon may currently be at risk for loss of genetic diversity because of interbreeding (Thomson et al. 2019a, 2019b, 2019c). Additional research is needed to verify Chinook salmon species abundance and diversity throughout the Chehalis Basin.

Figure 5.3-1
Anticipated Migration Periods of Selected Fish Species and Life Stages in the Chehalis Basin

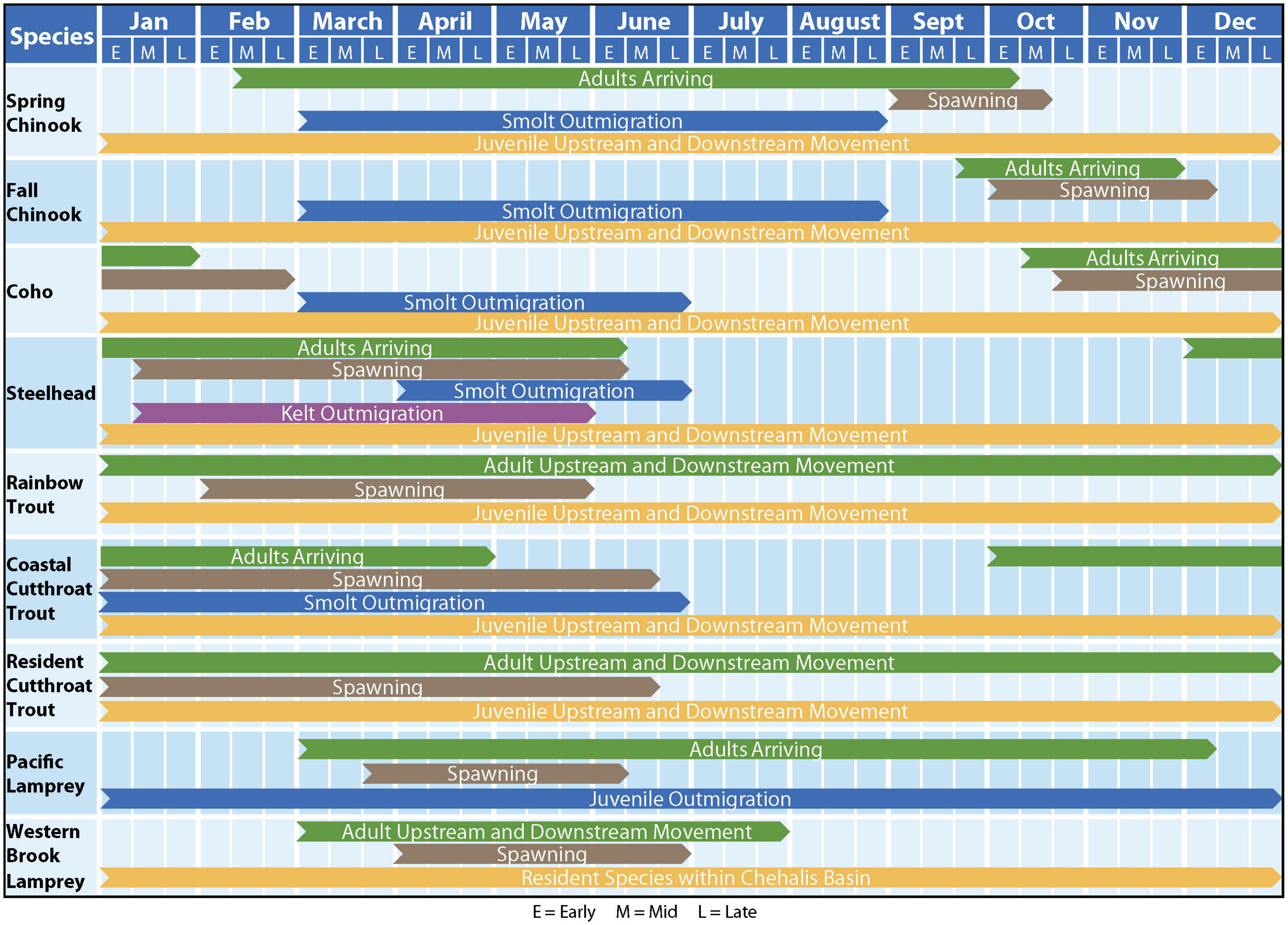
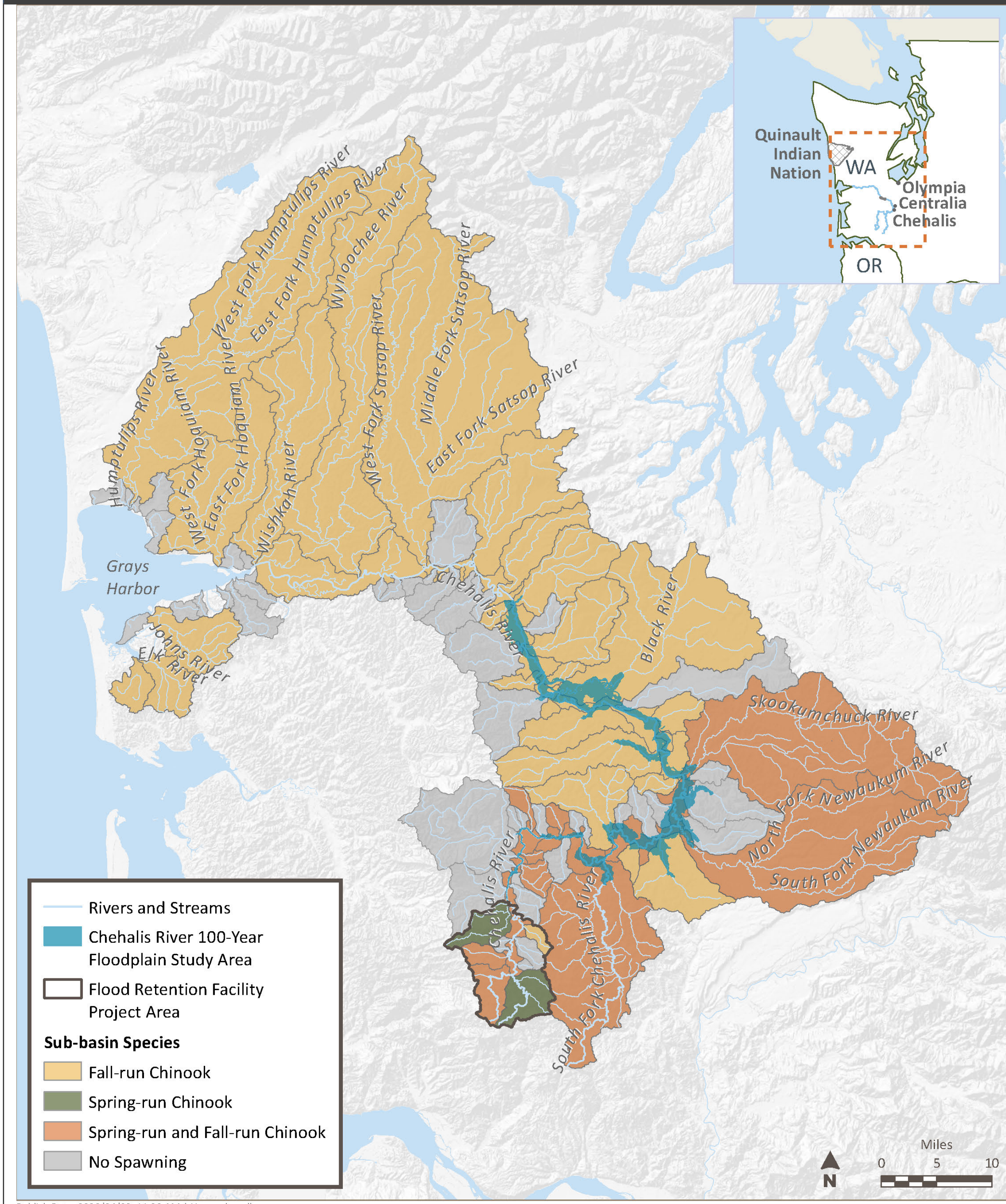


Figure 5.3-2
Distribution of Fall-Run and Spring-Run Chinook in the Chehalis Basin



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Filepath: \\orcas\gis\Jobs\WA_OFM_1023\NEPA\Maps\Discipline_Report\Aquatic_Species_and_Habitats\AQ_NEPA-EIS_ASH_G_EDT_SubBasins_Chinook_Fall_and_Spring.mxd

Fall-run Chinook Salmon

Chehalis fall-run Chinook salmon belong to the ESU of Washington Coast Chinook salmon. This population is also categorized as having a very low risk of extinction. However, stock-specific goals are currently being re-examined (WDFW 2019c; WDNR 2017). State-wide, Chinook salmon are considered a candidate and priority species (WDFW 2019b). Overall, in the Chehalis Basin, fall-run Chinook salmon run population size was estimated by WDFW to be 13,782 fish on average with a maximum of 21,474 fish based on data from 2009 to 2018 (Mike Scharpf, WDFW, spreadsheet dated August 8, 2019, as cited in Appendix A, Attachment A). Fall-run Chinook salmon spawn in several mainstem and tributary locations throughout the study area, as presented in Figure 5.3-2 (ASEPTC 2014; WDFW 2019c).

Spawner surveys conducted from the 2013-2014 to 2017-2018 seasons, found that the estimated abundance of adult fall-run Chinook salmon in the flood retention facility project area (including the nine sub-basins upstream of the proposed flood retention facility) was 320 adults based on a 5-year average. The estimate for the most recent season, 2018-19, was 578 adults based on 230 redds, representing an increase in abundance compared to the previous 5-year average (Ronne et al. 2020) Two-hundred twenty-one of the redds (96%) occurred on the mainstem Chehalis River and tributaries within the proposed temporary reservoir footprint, while nine occurred upstream of it. In the 2017-2018 and 2018-2019 seasons, surveys included a 1-week supplemental survey in the Chehalis River 100-year floodplain study area upstream of the confluence with the Newaukum River, during which an average of 339 fall-run Chinook salmon redds were found (Ronne et al. 2018, 2020). Approximately one-third of the redds in the supplemental survey areas occurred below Rainbow Falls Park at RM 98 to RM 76.2. Because supplemental surveys were only conducted for 1 week during peak spawning, adult abundances were not estimated for these redds (Ronne et al. 2018, 2020).

Fall-run Chinook salmon enter the lower Chehalis River in late September to late November (Ronne et al. 2018). Spawning activities occur in the flood retention facility project area and Chehalis River 100-year floodplain study area typically during the months of October through December (Ronne et al. 2018). Outmigration patterns observed in juveniles are the same as spring-run Chinook salmon (Liedtke et al. 2016; Winkowski and Zimmerman 2019). Anticipated migration periods and life stages of Chehalis fall-run Chinook salmon are presented in Figure 5.3-1.

Recent genetic research found that 100% of Chinook salmon field-surveyed in the lower Chehalis River Basin (downstream of Black River, between RM 45 and 50) were genetic fall-run Chinook salmon, though many were misidentified in the field as spring-run Chinook salmon (Thompson et al. 2019a, 2019b). The fall run-type represents most Chinook salmon individuals in the Chehalis Basin. Fall-run Chinook salmon were found to be genetically distinct from spring-run Chinook salmon, though there was evidence of intermating between the two run types (Thompson et al. 2019a, 2019b).

Coho Salmon

Chehalis coho salmon belong to the ESU of Southwest Washington coho salmon, which have a fairly low risk of extinction, but with possible concern as a result of local recent declines, threats, or other factors

(WDFW 2019c; WDNR 2017). Overall, in the Chehalis Basin, coho salmon run size was estimated by WDFW to be 71,787 fish on average with a maximum of 128,525 fish based on data from 2009 to 2018 (Mike Scharpf, WDFW, spreadsheet dated August 8, 2019, as cited in Appendix A, Attachment A). Coho salmon spawn in mainstem and tributary habitats throughout the entire study area, and often prefer spawning in the upper reaches of tributaries (ASEPTC 2014; WDFW 2019c). The distribution of coho salmon spawning grounds in each project area is presented in Figure 5.3-3.

Spawner surveys conducted from the 2013-2014 to 2017-2018 seasons, found that the estimated abundance of adult coho salmon in the flood retention facility project area was 858 adults based on a 5-year average. In 2018-2019, there were 2,128 estimated adults based on 961 redds (Ronne et al. 2020). Coho salmon have experienced the greatest population fluctuations, with estimated abundances of 174; 1,590; 1,010; 280; 1,236; and 2,128 over the last 6 years (Ashcraft et al. 2017; Ronne et al. 2018, 2020). These fluctuations are thought to be distinct 3-year brood cycle declines related to the 2007 flood (Ronne et al. 2020). In the 2018-2019 season, 25% of the redds observed were within the temporary reservoir inundation footprint, while 75% were upstream of the footprint (Ronne et al. 2020). In 2017-2018 and 2018-2019, these same surveys included 1-week peak spawning supplemental surveys in the Chehalis River 100-year floodplain study area from RM 108 to Adna, during which an average of five coho salmon redds were observed (Ronne et al. 2018, 2020). No redds were observed below Rainbow Falls Park at RM 98. No adult abundances were estimated, but in contrast, an average of 450 coho salmon redds were observed in the flood retention facility project area during the peak spawning week (Ronne et al. 2018, 2020).

Coho salmon experience an early and late run in the study area (Winkowski et al. 2018b; Seamons et al. 2019). Spawning activities occur in the flood retention facility project area and Chehalis River 100-year floodplain study area typically from late October to February (Ronne et al. 2018). Coho salmon fry emerge beginning in February, rear in freshwater for 1 to 2 years, using low gradient wetlands and side channels, and then outmigrate as subyearlings or yearlings as early as mid-February to as late as mid-June (Caldwell et al. 2004; Winkowski and Zimmerman 2019). Anticipated migration periods and life stages of Chehalis coho salmon are presented in Figure 5.3-1.

Temporal fluctuation in fish densities was noted in a summer riverscape study, particularly for juvenile coho salmon in the flood retention facility project area and Chehalis River 100-year floodplain study area upstream of Rainbow Falls (about RM 103; survey area). This study also found that, among the salmonids surveyed, juvenile coho salmon and juvenile steelhead were the two most abundant species in the survey area in all years of study (2013 to 2016; Winkowski et al. 2018a). Chehalis Basin coho salmon have a complex genetic structure, which varies by brood year, spawning tributary, and run timing, and is strongly influenced by hatchery production. Genetic structure in "upper Chehalis coho" has been documented as different from other "Chehalis coho;" however, sample locations were unknown or from locations downstream of the proposed flood retention facility. Additional genetic research is needed to distinguish between separate populations (Seamons et al. 2019).

Steelhead

Chehalis winter-run steelhead (referred to in the rest of the document as steelhead) belong to the distinct population segment (DPS) of Southwest Washington Steelhead. This population is also categorized as having a very low risk of extinction (WDFW 2019c; WDNR 2017). Overall, in the Chehalis Basin, steelhead run size was estimated by WDFW to be 8,657 fish on average with a maximum of 12,352 fish based on data from 2009 to 2018 (Mike Scharpf, WDFW, spreadsheet dated August 8, 2019, as cited in Appendix A, Attachment A). Steelhead spawn in mainstem and tributary habitats throughout the entire study area (ASEPTC 2014; WDFW 2019c). The distribution of steelhead spawning grounds in each project area is presented in Figure 5.3-3.

Spawner surveys conducted from the 2013-2014 to 2017-2018 seasons found that the estimated abundance of adult steelhead in the flood retention facility project area was 1,295 adults based on a 5-year average. In 2018-2019 there were an estimated 956 adults based on 589 redds (Ronne et al. 2020). Based on the 5-year average, steelhead are the most abundant spawners in the flood retention facility project area compared to Chinook and coho salmon. However, in the last 2 years, coho salmon have been more abundant (Ashcraft et al. 2017; Ronne et al. 2018, 2020). Spawner surveys in 2018-2019 found that steelhead use both the mainstem and tributaries to spawn in the flood retention facility project area. Steelhead preferred to spawn upstream of the footprint of the temporary reservoir, where 67% of the redds were observed. Nine percent of steelhead in the flood retention project area were considered to be of hatchery origin (Ronne et al. 2020). In 2017-2018 and 2018-2019, surveys included a 1-week peak spawning supplemental survey in the Chehalis River 100-year floodplain study area upstream of the confluence with the Newaukum River. During supplemental surveys, an average of thirty steelhead redds were observed, all but one occurring above Rainbow Falls Park at RM 98 (Ronne et al. 2018, 2020).

Steelhead enter the river anytime between December and June (Caldwell et al. 2004; Winkowski et al. 2018b). Spawning activities occur in the flood retention facility project area and Chehalis River 100-year floodplain study area typically during the months of mid-January to early June (Ronne et al. 2018). Steelhead fry emerge beginning in April. Juveniles rear in freshwater for 1 to 3 years and outmigrate to the ocean between April and June (Caldwell et al. 2004; Winkowski and Zimmerman 2019). Anticipated migration periods and life stages of Chehalis steelhead are presented in Figure 5.3-1.

Steelhead are unique of the modeled salmonids in displaying multiple reproduction (iteroparous) life histories. Kelts are adult spawners that migrate back to the ocean and return to spawn again in a subsequent year. There is limited research on kelts in the Chehalis Basin, but in other Pacific Northwest basins, the kelt life-history can make up 1.6% to 58% of total upstream runs (Hatch and Branstetter 2002; Hatch et al. 2013). Because of the physical demands of spawning, outmigrating kelts can experience poor body condition, including low weight and infections, and can experience high mortality at passage barriers (Hatch et al. 2013). Reconditioning occurs as post-spawning feeding recommences over 4 to 8 weeks after spawning ends (Hatch and Branstetter 2002).

Chehalis Basin steelhead show genetic structure by spawning tributaries with clear clustering among the Upper Chehalis (South Fork and upper Chehalis River), Middle Chehalis (Skookumchuck and Newaukum rivers), and Lower Chehalis (Humptulips, Wishkah, Wynoochee, and Satsop rivers) mainstem and tributary systems. These clusters also correlate with headwater geography (Willapa Hills, Cascade Range, and Olympic Range drainages, respectively). The upper Chehalis River populations have slightly lower diversity comparatively, possibly because of hatchery influences (Seamons et al. 2017).

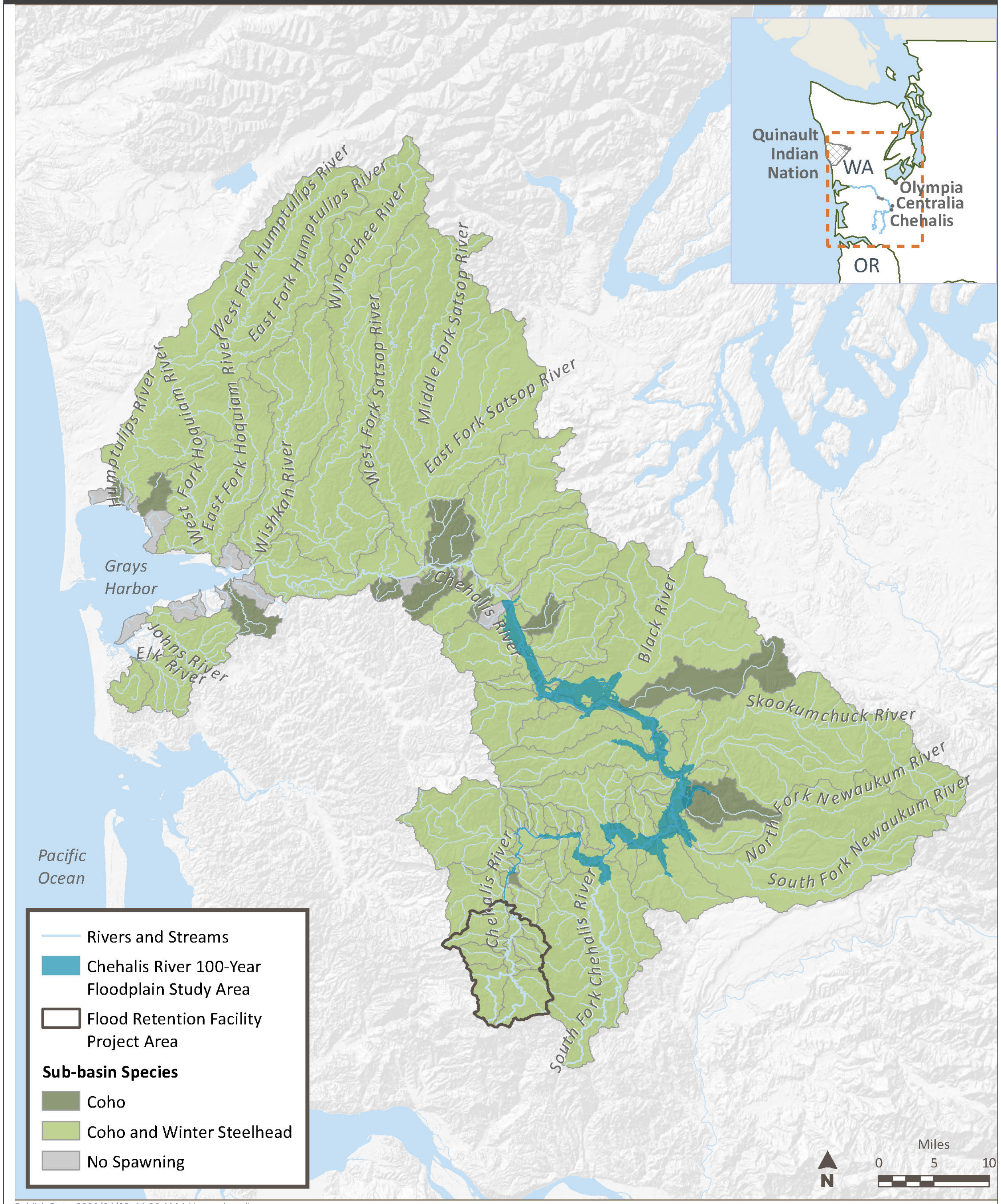
5.3.3.1.3 Other Salmonids

Other salmonids known to be present in the study area are presented in Table B-1. These include mountain whitefish (*Prosopium williamsoni*), rainbow trout (*Oncorhynchus mykiss*), resident cutthroat trout (*Oncorhynchus clarkia*), coastal cutthroat trout (*Oncorhynchus clarkii clarkii*), and chum salmon. Chum salmon spawn outside of the study area, but could be present in the lower portion of the Chehalis River 100-year floodplain study area. Bull trout have not been confirmed in the study area, but could be present in the Chehalis River 100-year floodplain study area. Additional discussion of bull trout is provided in Section 5.3.1.1.

Mountain whitefish and a mix of resident trout were encountered in the flood retention facility project area and Chehalis River 100-year floodplain study area during summer riverscape surveys conducted from 2013 to 2016 (Winkowski et al. 2018a). Rainbow trout were documented in both the flood retention facility project area and Chehalis River 100-year floodplain study area during genetic surveys conducted from 2015 to 2016 (Seamons et al. 2017). An instream study conducted in 2015 found that rainbow trout were one of the most widely distributed species in the reaches surveyed within the temporary reservoir inundation footprint, occupying 23 of the 25 reaches. Mountain whitefish and cutthroat trout were also identified during this survey, but to a lesser extent (Winkowski et al. 2016). Cutthroat trout encountered during studies in the flood retention facility project area may be resident, coastal, or a mix of both forms (Winkowski et al. 2016, 2018a). Cutthroat trout were also among the native fish species observed in a screw trap located on the mainstem Chehalis River at about RM 52 during a 2018 smolt production study (Winkowski and Zimmerman 2019). Radio-tagged mountain whitefish on the Newaukum and mainstem Chehalis are known to make large migratory movement likely associated with spawning in winter when water temperatures are below 6°C (Winkowski et al. 2019a).

Table B-6 provides information on rearing and spawning habitat for these species. The anticipated migration periods and life stages of rainbow trout and resident and coastal cutthroat trout are also presented in Figure 5.3-1.

Figure 5.3-3
Distribution of Coho Salmon and Steelhead in the Chehalis Basin



Publish Date: 2020/04/02, 11:29 AM | User: adowell
Filepath: \\orcas\gis\Jobs\WA_OFM_1023\NEPA\Maps\Discipline_Report\Aquatic_Species_and_Habitats\AQ_NEPA-EIS_ASH_F_EDT_SubBasins_Coho_Steelhead.mxd

5.3.3.2 Lamprey

This section addresses three species of lamprey that are known to occur or likely to occur within the study area. These species, including their special-status, are presented in Table B-2 and discussed in greater detail below. Annual timing of lamprey species presence within the study area by life-stage is shown in Figure 5.3-1.

5.3.3.2.1 Distribution and Population Status in Study Area

Pacific lamprey are known to be present in the study area. Pacific lamprey are anadromous and return to the Chehalis River from early March to mid-December to spawn from late March to early June (Wydoski and Whitney 2003). Lamprey larvae, known as ammocoetes, rear in freshwater habitats for 3 to 7 years before migrating to the ocean (Ostberg et al. 2018). The anticipated migration periods and life stages of Pacific lamprey are presented in Figure 5.3-1. Exact spawning grounds throughout the study area are unknown, but Pacific lamprey are known to spawn in Thrash Creek (Winkowski et al. 2016). However, an instream survey conducted in 2015 identified Pacific lamprey ammocoetes in the flood retention facility project area, throughout the mainstem portion of the inundation footprint and in 41% of the reaches surveyed (Winkowski et al. 2016). Another study, conducted in 2018, collected 542 Pacific lamprey ammocoetes in the flood retention facility project area and Chehalis River 100-year floodplain study area upstream of Rainbow Falls (Winkowski et al. 2019b). Adult Pacific lamprey have been encountered in the Chehalis River 100-year floodplain study area in the mainstem Chehalis River and in off-channel habitats at Chehalis River RMs 76.6, 44.3, and 36.5 (Hayes et al. 2019; Kendall and Zimmerman 2018; Winkowski et al. 2019a; Winkowski and Zimmerman 2019). Radio-tagged Pacific lamprey in the Newaukum and mainstem Chehalis River showed winter holding behavior within the tributary prior to spring spawning (Winkowski et al. 2019a).

River lamprey may be present in the study area. River lamprey are a native anadromous fish previously identified as potentially present in the upper Chehalis River Basin (Winkowski et al. 2016) and have also been identified as potentially present in Grays Harbor, Lewis, and Thurston counties. However, the presence of river lamprey in the study area has not been confirmed during field investigations to date.

Western brook lamprey are known to be present in the Chehalis River 100-year floodplain study area. Western brook lamprey are not anadromous and reside and spawn in freshwater habitats (Ostberg et al. 2018). Larvae burrow in stream margins to rear for 4 to 6 years (WDNR 2005). The anticipated migration periods and life stages of western brook lamprey are presented in Figure 5.3-1. An instream survey conducted in 2015 did not encounter western brook lamprey in the 25 streams surveyed in the flood retention facility project area within the temporary reservoir inundation footprint. However, western brook lamprey ammocoetes were encountered in supplemental reaches surveyed in the Chehalis River 100-year floodplain study area (Winkowski et al. 2016). Adult western brook lamprey were encountered in the Chehalis River 100-year floodplain study area during floodplain habitat surveys in 2016 and 2017, in three off-channel habitats (at RM 93.8, 44.3, and 36.5; Hayes et al. 2019).

5.3.3.2.2 Habitat Requirements

Pacific lamprey spawn in areas with shallow, fast-moving water with riffles and various gravel sizes. Ammocoetes rear in slower-moving freshwater areas with silt and sand (Kendall and Zimmerman 2018). A fish density study conducted in 2018 found Pacific lamprey ammocoetes in areas with a pool-riffle channel type with gravel, bedrock, and cobble substrates (Winkowski et al. 2019b). Adult Pacific lamprey have been encountered in both the mainstem Chehalis River and off-channel permanently and seasonally connected wetland habitats (Hayes et al. 2019; Kendall and Zimmerman 2018; Winkowski et al. 2019a; Winkowski and Zimmerman 2019).

River lamprey spawn at the upstream end of riffled streams with gravel. Ammocoetes rear in low velocity, side-channels with silt or sand. Macropthalmia (juvenile phase) reside in deep river channels in nearshore marine and estuarine habitats and return to freshwater tributaries as adults to spawn (USFWS 2019e; WDNR 2005).

Western brook lamprey spawn in freshwater in areas with course gravel at the head of small, riffled streams. Larvae use silty areas of stream margins for rearing (WDNR 2005). Western brook lamprey ammocoetes have been encountered in the mainstem Chehalis River (Winkowski et al. 2016). Adult western brook lamprey have been encountered in off-channel permanent and seasonal wetland habitats (Hayes et al. 2019).

Floodplain connectivity and instream structures are important habitat requirements for rearing ammocoetes. Unobstructed migratory corridors are important for out-migrating juveniles and anadromous adults.

5.3.3.3 Other Native Fish Species

Other native fish species, noting special-status species, are presented in Table B-2 and discussed in greater detail below.

5.3.3.3.1 Distribution and Population Status in Study Area

Other native fish species known to be present in the study area include largescale sucker (*Catostomus macrocheilus*), speckled dace (*Rhinichthys osculus*), longnose dace (*Rhinichthys cataractae*), redside shiner (*Richardsonius balteatus*), and reticulate sculpin (*Cottus perplexus*).

Torrent sculpins (*Cottus rhotheus*) are known to be present in the flood retention facility project area. Native freshwater fish previously identified as potentially present in the upper Chehalis River Basin, but not confirmed in the flood retention facility project area during field investigations to date, include peamouth chub (*Mylocheilus caurinus*), prickly sculpin (*Cottus asper*), riffle sculpin (*Cottus gulosus*), shorthead sculpin (*Cottus confuses*), and salish sucker (*Catostomus carli;* Winkowski et al. 2016). Although these species are not confirmed, they could be present in the flood retention facility project area and the Chehalis River 100-year floodplain study area.

Other native fish species known to be present in the Chehalis River 100-year floodplain study area include northern pikeminnow (*Ptychocheilus oregonensis*), Olympic mudminnow, peamouth chub, riffle sculpin, prickly sculpin, and threespine stickleback (*Gasterosteus aculeatus*). White sturgeon (*Acipenser transmontanus*) have historically been caught by anglers in the mainstem Chehalis River, mostly downstream from the confluence with the Black River (between RM 45 and 50; ASEPTC 2014). There is also a tribal white sturgeon fishery in the lower Chehalis River from below the confluence of the Wynoochee River to Grays Harbor. However, the presence of white sturgeon in the Chehalis River 100-year floodplain study area has not been confirmed during field investigations to date.

Table B-6 provides information on rearing and spawning habitat for these species.

5.3.3.3.2 Habitat Requirements

Studies indicate that river temperature plays a significant role in the distribution of native non-salmonid versus salmonid species in the study area. A summer riverscape survey conducted from 2013 to 2016 found that salmonids tended to occupy the colder temperature areas farther upstream and that non-salmonids were more present in the warmer, downstream areas (Winkowski et al. 2018a). Sculpin, speckled dace and longnose dace were found to be more tolerant of colder water habitats compared to other non-salmonid native fish species (Winkowski et al. 2016). Speckled dace spawning and rearing and largescale sucker rearing habitat have been documented just downstream of the proposed flood retention facility (Winkowski and Kendall 2018). This relationship between temperature and species distribution was also observed in the Newaukum River (Winkowski et al. 2018b). Other native species have been observed in several mainstem habitats in the Chehalis River 100-year floodplain study area but also often occupy off-channel permanent and seasonal wetland habitats with heavy instream vegetation (Hayes et al. 2019; Kendall and Zimmerman 2018; Kuehne and Olden 2016; Winkowski et al. 2016, 2018a).

Maintaining access to off-channel floodplain habitats is important for native fish species. Areas of riparian cover and instream structures provide protection from predation.

5.3.3.4 Non-Native Fish Species

Non-native fish species with the potential to be in the study area are presented in Table B-3 and discussed in greater detail below.

5.3.3.4.1 Distribution in Study Area

No non-native fish species have been confirmed to be present in the flood retention facility project area. However, 10 non-native fish species have been confirmed to be present in the Chehalis River 100-year floodplain study area, including a mix of catfish, herring, minnows, perch, and sunfish (Hayes et al. 2019; Winkowski and Zimmerman 2019). A summer riverscape survey conducted from 2013 to 2016 did not detect any non-native fish species upstream of Rainbow Falls (Winkowski et al. 2018a). The same survey also did not detect largemouth or smallmouth bass above the confluence with the South Fork Chehalis River.

5.3.3.4.2 Habitat Requirements

Most of the non-native fish species in the Chehalis River 100-year floodplain are present in off-channel permanently and seasonally connected wetland habitats and pose little to no adverse impacts on native aquatic species. However, largemouth bass (*Micropterus salmoides*) and smallmouth bass (*Micropterus dolomieu*) present the highest potential impacts to native fish species because they are known to prey on juvenile salmon species and other native fish. These fish have been observed in off-channel permanently and seasonally connected wetland habitats as well as mainstem habitats (Hayes et al. 2019; Winkowski and Zimmerman 2019). As such, these fish are the focus of this section. Largemouth bass typically occupy ponds, swamps, and side-channels of rivers and streams, using instream vegetation and other structures as cover from prey. Adults prefer areas with mud, sand, or gravel substrate for spawning. Smallmouth bass occupy cooler temperature rivers and streams in areas with gravel and rocky substrates (ASEPTC 2014; Pribyl et al. 2004; USFWS 2019f).

5.3.4 Freshwater Mussels

Freshwater mussels with the potential to be in the study area are presented in Table B-4 and discussed in greater detail below.

5.3.4.1 Distribution and Population Status in Study Area

Freshwater mussel species that may be present throughout the study area include western ridged mussels, western pearlshell, and *Anodonta* species, known as "floaters." A summer riverscape study conducted from 2013 to 2016 encountered freshwater mussels in the mainstem Chehalis River upstream of Rainbow Falls. However, it is unclear how far upstream these mussels were encountered, and the mussels were not identified to the species level. Most mussels were concentrated between Rainbow Falls and the confluence of the Newaukum River. In several of these segments, mussels were considered the dominant substrate (Winkowski et al. 2018a). Another study identified eight beds of western ridged mussels in the Chehalis Basin, co-occurring with western pearlshell and floaters. However, the exact location of the beds was not defined (Blevins 2018).

5.3.4.2 Habitat Requirements

As larvae, called glochidia, all freshwater mussels attach to the gills of host fish for a few days up to a few months before they release and settle into the sediment to begin their life separate from the host fish (Nedeau et al 2009). Host fish are generally cold-water native species, such as salmonids, that transport the larvae to suitable locations for growth. Habitat requirements for western ridged mussels, western pearlshells, and floater mussels that may be present throughout the study area are described below.

Generally, western ridged mussels are found in low- to mid-elevation watershed streams along banks with sediment habitats. Western ridged mussels are more tolerant of fine sediments compared to other freshwater mussels; however, they are not typically found in areas with very soft substrates. The life history of western ridged mussels is not clear. However, habitat preference suggests fish hosts may include fish that inhabit colder water such as trout and salmon. The presence of glochidia on a brown trout host has been found to negatively impact growth (Chowdhury et al. 2019). Western pearlshells can be found along the banks of small headwater streams, but more commonly inhabit the banks of larger rivers in areas with large boulders and sand, gravel, and cobble substrates. Freshwater mussel larvae, called glochidia, are released from adult mussels around July. Host fish that may be present in the Chehalis Basin include trout, salmonids, and speckled dace. After several weeks, juvenile mussels release from the host fish and burrow in the sediment, where they remain for 9 to 12 years until mature. Floaters can tolerate environments low in oxygen and grow faster in nutrient-rich waters such as lakes, ponds, marshes, sandbars, and other sedimentary habitats. Glochidia are released around spring and summer and several fish species can serve as a host. Juvenile mussels remain in the sediment for 4 to 5 years until mature (Nedeau et al 2009). One study indicated that populations of western ridged mussels, western pearlshell, and floaters were localized in areas with bank edges and fine sediment, gravel, clay, and boulder substrates (Blevins 2018).

Maintaining habitat that supports salmonid and trout life stages is important for freshwater mussels because these fish species play an important role in the reproduction of freshwater mussels in the study area.

5.3.5 Aquatic Plants

Native and non-native aquatic species with the potential to be in the study area, noting any special-status species, are presented in Table B-5. These species are discussed in greater detail below.

5.3.5.1 Distribution and Population Status in Study Area

Eight native aquatic plant species confirmed to be present in the study area include common duckweed (*Lemna minor*), two common mosses (*Racomitrium* spp. and *Scleropodium* spp.), two common liverworts (*Pellia* spp. and *Marchantia* spp.), Canadian waterweed (or American waterweed; *Elodea canadensis*), common pondweed (*Potamogeton natans*), and yellow pond lily (also called yellow waterlily or spatterdock; *Nuphar lutea or Nuphar polysepala*). Common duckweed, the two common mosses, and the two common liverworts were encountered in the flood retention facility project area during field investigations for the *Wetland, Water, and OHWM Delineation Report*. Common duckweed was found in eddies below the ordinary high-water mark (OHWM) and liverworts and mosses were common in the Crim, Lester, Chehalis, and Roger creek drainages (Anchor QEA 2018b).

Common duckweed, Canadian waterweed, common pondweed, and yellow pond lily were encountered in the Chehalis River 100-year floodplain study area during floodplain habitat surveys conducted from 2016 to 2017. These species were found in off-channel wetland habitats and permanent and ephemeral ponds with seasonally varying water depths. Habitats were located from RM 36.5 upstream to RM 107.6 (Hayes et al. 2019).

Water howellia (a federally listed threatened species) has not been confirmed in this section of the Chehalis River, but the species could be present. Water howellia grows in freshwater ponds surrounded by riparian shrubs and trees (USFWS 2019b). Pond size and depth and distance to a river are variable. Germination occurs in the fall when the pond dries, and seeds are exposed to an aerobic environment. Plant growth resumes in the spring when the ponds fill and the plant is exposed to an anaerobic environment. Plants mature and produce seeds in the mid-summer (Weichmann 2018).

Brazilian elodea (*Egeria densa*) and parrotfeather (*Myriophyllum aquaticum*) are non-native aquatic plant species confirmed to be present in the study area. Brazilian elodea was first documented in the Chehalis River during a survey of Lewis County in 2003, and established populations have been identified in the river between Centralia and Oakville. Parrotfeather was identified in the Chehalis River in 1994 (Simon and Peoples 2006). A reach of the mainstem Chehalis River downstream of Centralia has been listed with water quality category 4C Invasive Exotic Species for the presence of these two species (Ecology 2019b).

Other studies documented instream vegetation in the mainstem Chehalis River and tributary habitats throughout the flood retention facility project area. However, these studies only documented the presence of instream vegetation. Information to the species level was not collected.

5.3.5.2 Habitat Requirements

In general, nonvascular species such as common mosses and common liverworts can be found in the splash zone at the edge of streams or within the open channel. Most mosses tend to root and attach to rocks below the OHWM while the liverworts prefer rooting or attaching to mineral soil or saturated organics such as logs and branches in shaded and sheltered areas (Anchor QEA 2018b). Typically, rooted vascular plants do not establish below the OHWM in high energy river/stream systems. The seasonal scour and bedload of rock and sand eliminates most vascular plants. However, in some years with low rainfall, weedy annuals may root on gravel or sandbars. This condition was found to be limited in the flood retention facility project area. Submerged aquatic vegetation may also establish in low energy systems (slack water), such as those found in the Chehalis River 100-year floodplain study area (Anchor QEA 2018b).

Canadian waterweed is a submersed plant often found in freshwater rivers and ponds. Canadian waterweed can also tolerate slightly brackish water. Common pondweed is a floating leaved rooted aquatic plant species often found in shallow freshwater ponds or slow-moving water. Common pondweed can also tolerate brackish water. Yellow pond lily is a floating leaved rooted plant found in shallow ponds and slow-moving streams (Ecology 2019a). Common duckweed is a vascular plant that prefers still and slow-moving waters in many freshwater habitats and is often found along the shoreline after water levels have dropped (Ecology 2019a).

Brazilian elodea is a submersed plant found in slow-moving freshwater. Parrotfeather easily adapts to habitats high in nutrients and can also be found in smaller freshwater ponds and streams (Simon and Peoples 2006).

Adequate water quantity and quality are important for native plant species to thrive.

5.3.6 Marine Mammals

Marine mammals are not expected to be in the study area. However, killer whales and sea lions are known to eat salmonids while they are in Grays Harbor and other marine areas. Salmonids are in the study area and could be impacted by the proposed action. Therefore, these marine mammal species are discussed in this report with respect to their reliance on salmonids.

Southern Resident killer whales, California sea lions (*Zalophus californianus*), and Steller sea lions (*Eumetopias jubatus*) are known to be present within the vicinity of Grays Harbor. The Southern Resident DPS of killer whale is listed as federally endangered. Southern Resident DPS pods travel from central southeast Alaska to central California and spend most of the year off the coasts of Washington and Southern Vancouver Island, British Columbia, and in the Salish Sea near the San Juan Islands (NOAA 2010). The Southern Resident killer whale diet is composed primarily of Chinook salmon, but also includes steelhead, coho, and chum salmon (Cascadia 2018). California and Steller sea lions are also present off the coasts of Washington. California sea lions are opportunistic feeders whose diet includes a variety of fish, including salmonids. The diet of Steller sea lions also includes salmonids (NOAA 2010).

5.4 Climate Variability

This section provides a discussion of the historical and current climate of the study area, including an analysis of how it could potentially change under future climate variability scenarios. The analysis focused on the potential climate variability of the Chehalis Basin as a result of modeled climate variability in the 21st century (2000 to 2099) relative to historical conditions. This information is summarized in this discipline report because of how climate variability may affect the potential for impacts on aquatic species and habitat, as discussed in Section 6.

5.4.1 Temperature and Temperature Extremes

The Chehalis Basin is typically characterized as having relatively cool winters and moderately warm summers. Historically, seasonal variation in average temperatures has ranged from approximately 41°F in January and 75°F in August (USGS 2019b). Over the last century (1901 to 2000), both annual average maximum (i.e., daytime high) and the annual average minimum (i.e., nighttime low) temperatures in the Pacific Northwest have increased by approximately 1.5°F (Vose et al. 2017). Temperature extremes (e.g., cold snaps, heat waves) occur in the Chehalis Basin, with cold extremes typically occurring less frequently than warm extremes (Vose et al. 2017; Peterson et al. 2013; Bumbaco 2013). Over the last century (1901 to 2000) the occurrence of cold extremes has decreased over time while warm extremes, especially nighttime heat waves, have increased in frequency.

Future climate variability is expected to result in an increase in air temperature across the United States with warming expected to be slightly greater in summer months and amplified in the northern parts of the United States (Vose et al. 2017). In the Pacific Northwest, potential increases in annual average air temperatures are projected to be between 3.7°F and 4.7°F by mid-century (2036 to 2065) and 5.0°F and 8.5°F by late-century (2071 to 2100; Vose et al. 2017). In the counties that contain the Chehalis Basin, projected average increases in the annual mean minimum (winter) air temperatures is expected to be 2.2°F to 2.8°F by 2040 and 4.1°F to 6.8°F by 2080 (USGS 2019b). The average potential increase in the annual mean maximum (summer) air temperature in the Chehalis Basin area is expected to be 2.2°F to 2.9°F by 2040 and 4.2°F to 7.0°F by 2080 (USGS 2019b). Overall, climate variability is expected to result in greater temperature extremes.

Climate variability is also projected to result in more extreme heat events in the summer and fewer extreme cold events in the winter. Historically rare extreme high temperatures are projected to become more common, with the Chehalis Basin potentially experiencing up to 10 additional days of temperatures above 90°F in the summer (Vose et al. 2017).

Projected increases in both minimum and maximum temperatures and extreme heat events in the Chehalis Basin would increase evapotranspiration during the spring and summer. Such conditions would reduce soil moisture and increase the likelihood of droughts and wildfires. Hotter summer conditions would also lead to higher water temperatures in rivers and streams. Warmer temperatures during the winter would cause wintertime precipitation to shift from snow to rain in the higher elevation portions of the basin. This shift could increase winter streamflow and contribute to higher downstream flows and increased flooding potential.

5.4.2 Precipitation and Precipitation Extremes

In the Chehalis Basin, precipitation varies considerably between seasons as evidenced by the occurrence of very wet winters and dry summers. In Lewis County, monthly average precipitation ranges from approximately 1.1 inches in July to 10.9 inches in January (USGS 2019b). Although annual precipitation has not changed significantly over the last century, the amount of precipitation that falls in the winter and summer has slightly declined while spring precipitation amounts have slightly increased (Easterling et al. 2017). Atmospheric river events have historically caused abnormally high (extreme) rainfall in the Chehalis Basin, but the frequency and intensity of such events has not changed much over the last century.

As a result of future climate variability, annual precipitation amounts in the Pacific Northwest are projected to increase by 5% to 8% by the latter part of the 21st century relative to the 1979 to 1990 baseline (May et al. 2018). The largest precipitation increases in the Chehalis Basin are projected to occur during the winter months with potential increases of up to 10% above baseline amounts by the latter half of the century (2070 to 2099; Easterling et al. 2017). During this same period, summer precipitation is projected to decrease by 10% to 20% (Easterling et al. 2017). Climate models have less confidence in predicting changes in precipitation than changes in temperature, especially with the confounding influence of such events as El Niño and La Niña, which strongly influence precipitation over seasonal and interannual time periods in the region.

The frequency of extreme precipitation events is also projected to increase in the future. This is because of both projected increases in atmospheric water vapor and convective energy resulting from higher temperatures, and projected increases in the frequency and intensity of atmospheric river events along the west coast. Such events are also expected to become more intense.

The projected increases in winter precipitation and the frequency and intensity of atmospheric river events would both contribute to an increased risk of winter and spring flooding in the Chehalis Basin. Decreased summer precipitation coupled with higher summer temperatures would reduce flow in rivers and streams and likely increase instream water temperatures.

5.4.3 Snowfall

The Chehalis Basin is rain-dominated (i.e., rain produces more runoff than snow), in part because most of the basin is low lying and maintains relatively warm temperatures because of the moderating influence of the Pacific Ocean. However, the Chehalis Basin does have a few areas that accumulate snowpack during the fall, winter, and early spring. Those areas occur at higher elevations in headwater streams of the southern Olympic Mountains, Cascade foothills, and a very small portion of the Willapa Hills (Perry et al. 2016). Historically, snowfall in those portions of the Chehalis Basin typically begins in November, with peak snowfall amounts occurring between February and late March (USGS 2019b). Snowfall then tapers off until June.

Projected changes in snowfall because of climate variability include decreases in annual snowpack, future snow water equivalent, number of extreme snowfall events, and number of snowfall days (Georgakakos et al. 2014; Easterling et al. 2017). In the counties that contain the Chehalis Basin, projected decreases in snowfall range from an average of 1.9 to 2.4 inches by mid-century (2025 to 2049) to 2.8 to 3.3 inches by late-century (2050 to 2074; USGS 2019b). It is expected that there will be a shift from snow to rainfall in the Chehalis Basin over time, reducing the amount of water retained in snow from fall and winter storms.

As a result of these projected changes in snowfall, winter flows in headwater streams in portions of the Chehalis Basin that currently support snowpack accumulation would be expected to increase as precipitation contributes directly to runoff instead of being retained as snowpack. When coupled with increased winter precipitation through the rest of the basin, this could in turn lead to an increased potential for winter flooding and landslides in downstream portions of the Chehalis Basin. In addition, the reduction in snowpack may also lead to increased drought risk because of less water availability from snow melt in the spring and summer.

6 ENVIRONMENTAL CONSEQUENCES

6.1 Assumptions

The following assumptions, applicable to both aquatic species and habitat, were used in the analysis of impacts:

- The EIS analysis period extends from 2025 to 2080. The construction phase will occur over a 5-year period between 2025 and 2030 and the operation period will extend for 50 years between 2030 and 2080.
- In-water work would occur July through September. Construction below OHWM in the dry river channel created by diverting the river around the work area would occur year-round.
- Direct impacts during construction would occur within the footprint of the flood retention facility and associated structures, including staging areas, bypass tunnel, temporary trap-and-transport facility, and permanent collection, handling, transport, and release (CHTR) facility.
- All blasting activities would occur in the dry. Blasting for the flood retention facility foundation excavation is the activity that would occur nearest the water. This activity would occur in the dry with the river diverted to the diversion tunnel. Additionally, a minimum 25-foot-wide buffer would be maintained between the blast site and the cofferdam to isolate the in-water work area from the active river flow. Additional noise and vibration attenuation best practices would also be used to reduce the potential for impacts to fish (CRBFCDZ 2019). The timing of blasting for each activity is assumed as follows:
  - Two times per day for up to 9 months for blasting during diversion tunnel construction
  - Four times per week for up to 3 years for blasting at the quarries
  - Four times per week for 12 months for blasting during construction of the FRE facility foundation excavation
- The estimated temporary reservoir inundation zones identified in the August 31, 2016 *Proposed Flood Retention Facility Pre-construction Vegetation Management Plan* (Anchor QEA 2016) were used to define the areas proposed for tree removal.
  - Prior to construction, the Applicant would remove all trees from the inundation zone that have a 5% chance of being flooded in a year (20-year flood). That zone occurs between elevations of 424 and 584 feet NAVD88 and is estimated to be approximately 485 acres in area.
  - Tree removal would occur during the construction phase of the project.
- Following initial tree removal, replanting of flood-tolerant native shrubs and trees would be performed in areas susceptible to increased risk of landslides and erosion.
- For the project duration, all trees greater than 6 inches diameter at breast height located below the 20-year flood elevation, including those that may have been replanted, would be periodically (approximately every 7 to 10 years) removed.

- Tree removal from riparian areas would result in substantial removal of shade-providing vegetation from along the Chehalis River mainstem and all tributaries within the portion of the temporary reservoir footprint below 584 feet NAVD88. Trees and shrubs that remain would not provide an equivalent level of shading.
- Although shrubs and small trees would remain in the cleared portions of the temporary reservoir footprint following initial tree removal, they would be subject to occasional flooding during retention events and may not survive during prolonged inundation.
- For the operation of the flood retention facility, the following scenarios were evaluated to assess impacts on aquatic species and habitat:
  - 2-year flood
  - 10-year flood
  - 100-year flood
  - A back-to-back flood in which a 10-year flood occurs in one year and a 100-year flood occurs in the next year
- Potential impacts affected by variability in climatic conditions (e.g., changes in flows or temperature) different from the current condition were addressed qualitatively where relevant.

6.1.1 Aquatic Habitats

The following assumptions should be used for the analysis of impacts on aquatic habitats:

- All aquatic habitats occupying the footprint of the proposed flood retention facility and its associated structures would be permanently impacted by project construction.
- Aquatic habitat existing in the proposed temporary reservoir footprint would be either temporarily or permanently impacted during operation of the flood retention facility. This includes changes to the hydrologic regime, inundation frequency, and sedimentation rates. This may include changing some terrestrial habitats to aquatic or changing from one type of aquatic habitat to another. For the 7-year and 100-year flood scenarios, aquatic habitat present in the inundation area would be adversely affected once every 7 years and once every 100 years, respectively. For the back to back scenario, aquatic habitat present within the 7-year inundation footprint would be impacted in one year and habitat present within the 100-year inundation footprint would be impacted in the second year.
- Permanent and temporary impacts on habitats within the project footprint may indirectly impact adjoining or nearby aquatic habitats.

6.1.2 Aquatic Species

The following assumptions were used in the analysis of impacts on aquatic species:

- All aquatic species occupying the footprint of the proposed flood retention facility and its associated structures would be permanently displaced by project construction.
- Fish passage assumptions during construction include the following (see Appendix A, Section 3.3.2 for additional rationale for the fish passage rates):

- Outmigrating juvenile salmonids that travel through the diversion tunnel and through the picket weir structure would have a survival rate of 85% for spring-run Chinook, fall-run Chinook, and coho species. The survival rate for juvenile steelhead would be 95%. The outlet of the diversion tunnel occurs upstream of the temporary trap-and-transport facility. Therefore, it is assumed that the juvenile salmonids traveling downstream would be able to pass through the picket weir structure to reach downstream habitats. This would result in the previously described salmonid passage survival rates. The diversion tunnel length is longer than the length of the flood retention facility conduit tunnels and the tunnels/culverts considered in fish passage design criteria (NMFS 2011; WDFW 2013). However, the additional length is not expected to decrease survival (see the NOAA meeting notes included in Appendix A, Attachment C). Therefore, the assumed fish passage values are consistent with those derived by the Chehalis Basin Strategy Science and Technical Review Team Fish Passage Subgroup for travel through the flood retention facility conduits, as described in the *FRO-FRFA Final Conceptual Combined Dam Fish Passage Design Report* (HDR 2017). The Chehalis Basin Strategy Fish Passage Subgroup consisted of experts from NOAA, WDFW, Ecology, and the Quinault Indian Nation, as well as from consultants Anchor QEA and HDR
- Downstream migrating steelhead and coastal cutthroat kelts are assumed to have 0% total survival during construction because they would be in poor physical condition after spawning and would be too large to pass the picket weir in the downstream direction.
- Only the four modeled salmonid species plus coastal cutthroat are identified by the Applicant for upstream trap and transport during construction. All other species, including Pacific lamprey, would only be moved incidentally and are assumed to remain below the construction area.
- During construction, adult salmonids migrating upstream would be trapped using a picket weir and transported above the construction area. The passage survival would be 63% for spring-run Chinook, 66% for fall-run Chinook, 41% for coho, and 45% for steelhead. These survival rates considered capture efficiencies and survival for navigating through the picket weir and being transported upstream and delayed mortality after being trapped and transported. The picket weir structure is more likely to fail in winter from weather and flow related events that allow fish to pass over, under, or around the structure. Therefore, passage efficiencies for species that migrate in the winter (i.e., coho and steelhead) are lower than for species that migrate when flows are low (i.e., spring and fall-run Chinook). Adults of all species may avoid the ladder entrance and/or jump or attempt to jump the weir, but documented mortality at the weir is assumed to be low (Engle et al. 2010; Wilson et al. 2018). It is assumed that NMFS (2011) passage guidelines for temporary trap, holding, and transport would be followed, including picket barrier and fish ladder design guidelines and monitoring.
- Upstream migrating coastal cutthroat are assumed to have similar passage survival to other winter migrating salmonids (coho salmon and steelhead).

- Mean weekly pre-spawn survival probabilities were used to estimate delayed mortality. Pre-spawn survival probabilities for spring-run Chinook salmon after trap-and-transport release ranged from 80 to 100% (Keefer et al. 2010). It is assumed that the mid-range weekly pre-spawn survival value of 0.9 is appropriate because not all pre-spawn mortality would be attributable to trap and transport. It is also assumed that pre-spawn survival is higher during cooler temperatures, so winter migrating species (coho, steelhead) would likely have better pre-spawn survival (i.e., 99% for coho and steelhead versus 81% for spring-run Chinook salmon and 90% for fall-run Chinook salmon).
- The Applicant is not proposing to design the diversion tunnel to meet NMFS requirements for upstream passage of juvenile salmonids. Therefore, it is assumed that no upstream movement of juvenile salmonids through the diversion tunnel would occur during construction. Although juvenile salmonids are not a target life history stage for the temporary trap-and-transport facility, any that are incidentally captured and collected at the facility would be transported upstream of the construction area and released back to the Chehalis River. Juvenile salmonids that are not incidentally captured would remain below the construction area.

- Fish passage assumptions during operation include the following:
  - Downstream juvenile salmonids moving through the facility conduits when open would have a survival rate of 85% (spring-run Chinook, fall-run Chinook, and coho) and 95% (steelhead). Adult salmonids moving upstream through the facility conduits when open would have survival rates of 94% (spring-run Chinook, fall-run Chinook, and coho) and 96% (coho). The derivation of these upstream and downstream fish passage survival rates is described in the *FRO-FRFA Final Conceptual Combined Dam Fish Passage Design Report* (HDR 2017) and was reviewed with a Fish Passage Subgroup member (see the meeting notes with John Ferguson included in Appendix A, Attachment C).
  - Upstream fish passage survival rates for adult passage through the CHTR facility would be 90% for spring-run Chinook salmon, fall-run Chinook salmon, coho salmon, and steelhead. Upstream passage values would be 54% for coastal cutthroat trout and lamprey. These values were based on the values described in the *FRO-FRFA Final Conceptual Combined Dam Fish Passage Design Report* (HDR 2017). A modifier was added to the salmonid fish passage value to account for delayed mortality. The delayed mortality modifier was developed based on studies conducted by Ronne et al. (2018) and Keefer et al. (2010). Based on these studies, it is expected that Chinook salmon would have low delayed mortality because most fish would pass through the flood retention facility conduits (Ronne et al. 2018) during their migration upstream. Coho salmon and steelhead would also have low delayed mortality because river temperature would be cool and less stressful for winter migrating species (Keefer et al. 2010; Ronne et al. 2018).
- Operation of the proposed project has the potential to disturb, injure, or kill aquatic species present within the footprint of the proposed flood retention facility temporary reservoir and adjoining areas affected by operations (e.g., inundated shorelines). For the 7-year and 100-year

flood scenarios, species present in the inundation area would be adversely affected once every 7 years and once every 100 years, respectively. For the back-to-back scenario, species present within the 7-year inundation footprint would be impacted in one year and species present within the 100-year inundation footprint would be impacted in the second year.

6.2 Methods

This section describes the methods used to asses direct and indirect impacts associated with the project alternatives. Impacts were also evaluated for whether they would be permanent or temporary.

Direct impacts are those that would occur as the result of and at the same time and place as the activities authorized by the Department of the Army permit (40 CFR 1508.8). Permitted activities include those involving the direct placement or removal of fill from wetlands or waters of the United States. Examples include installing the diversion channel and isolating in-work areas. Indirect impacts are those that would occur later in time or farther in distance but that are attributable to the authorization of a proposed project by the Department of the Army permit (40 CFR 1508.8). Indirect impacts would include the secondary effects from construction (e.g., certain water quality impacts) and effects that would occur as the result of operating the proposed project over time (e.g., changes in flooding).

Permanent impacts are those that would injure or kill aquatic species, permanently remove aquatic or riparian vegetation, or remove or alter habitat types to such a degree that they would not return to their preconstruction state during the EIS analysis period (2025 to 2080). Temporary impacts are those that would result in short-term disturbance of aquatic wildlife, plants, or habitats but would not prevent the re-establishment of pre-project conditions.

Impacts to aquatic species and habitat were evaluated quantitatively and qualitatively. The quantitative analysis was completed using fish models. The qualitative analysis was done using available information about species presence, habitat use, and status within the study area. The quantitative and qualitative methods used to evaluate impacts are described in Sections 6.2.1 and 6.2.2.

6.2.1 Fish Habitat Modeling

Analytical modeling was done to evaluate construction and operation impacts to fish from habitat changes that could be caused by the proposed flood retention facility construction and operations. Analytical modeling was also done to evaluate the No Action Alternative condition through the same time period. This allowed for a relative comparison of the proposed flood retention facility construction and operations to the No Action Alternative. This modeling was completed for four salmonids and other native fish species.

Salmonid modeling included the use of the Ecosystem Diagnostic and Treatment (EDT) model to produce outputs related to habitat potential, which is discussed further below. These results were then integrated with Life Cycle Models (LCMs). The integration process means the key results or outputs from EDT were used as inputs into the LCMs. Both modeling efforts evaluated salmonid population responses to changes in habitat. Four salmonids were modeled: spring-run Chinook salmon, fall-run Chinook salmon, coho salmon, and steelhead. Because EDT is a habitat model and the integrated EDT-LCMs are using EDT outputs as inputs, the modeling results should not be interpreted as exact predictions of salmonid abundance, productivity, or diversity that would be realized. Instead, the results should be used to characterize the potential of the habitat (Appendix A, Attachment A). In addition, the modeling was done to compare the proposed flood retention facility construction and operations to the No Action Alternative condition. As such, the relative comparison (i.e., decrease or increase in modeled salmonid population responses to changes in habitat) is the focus of the interpretation of the results.

The results of the EDT model represent snapshots in time (e.g., construction, operation at mid-century [2040], operation at late-century [2080]). The integrated EDT-LCMs results represent a continuous time series from construction through the long-term operation of the flood retention facility. Results from both models were used to evaluate salmonid population responses to changes in habitat at the study area scale and the Chehalis Basin scale.

A limited physical habitat simulation (PHABSIM) model was used to evaluate impacts of temperature increases associated with the operation of the proposed project during 2-year flow conditions. The limitations of this model are described in more detail in Section 6.2.1.2. The limited model evaluated impacts on the spawning and rearing habitat of a subset of other native fish, including Pacific lamprey, speckled dace, largescale sucker, and mountain whitefish. Habitat for the key non-native predators largemouth bass and smallmouth bass was also modeled. The results of this modeling were used to evaluate changes in spawning and rearing habitat of these six species that would result from temperature increases during operation of the flood retention facility, as described in more detail in Section 6.2.1.2. These temperature increases are estimated to occur within the temporary reservoir footprint and downstream of the proposed flood retention facility to the Elk Creek confluence near RM 100 between the months of May and October.

The methods for these fish models are described in more detail in the following subsections.

6.2.1.1 EDT and Integrated EDT-LCMs

EDT and integrated EDT-LCMs were used to analyze construction and operation impacts and benefits to salmonid species for Alternatives 1 and 2 and under the No Action Alternative. The overall Chehalis EDT model encompasses the entire Chehalis Basin, including the mainstem river tributaries (Appendix A, Attachment A). This basin-scale model includes the Chehalis River and tributaries above and below the proposed flood retention facility site to Grays Harbor. It also includes tributaries that flow directly into Grays Harbor but does not include Grays Harbor (Appendix A, Attachment A). Basin-scale Chehalis EDT modeling results are used to provide larger-scale context for interpreting project impacts on modeled salmonids. The modeling reports are presented in Appendix A, Attachments A and B.

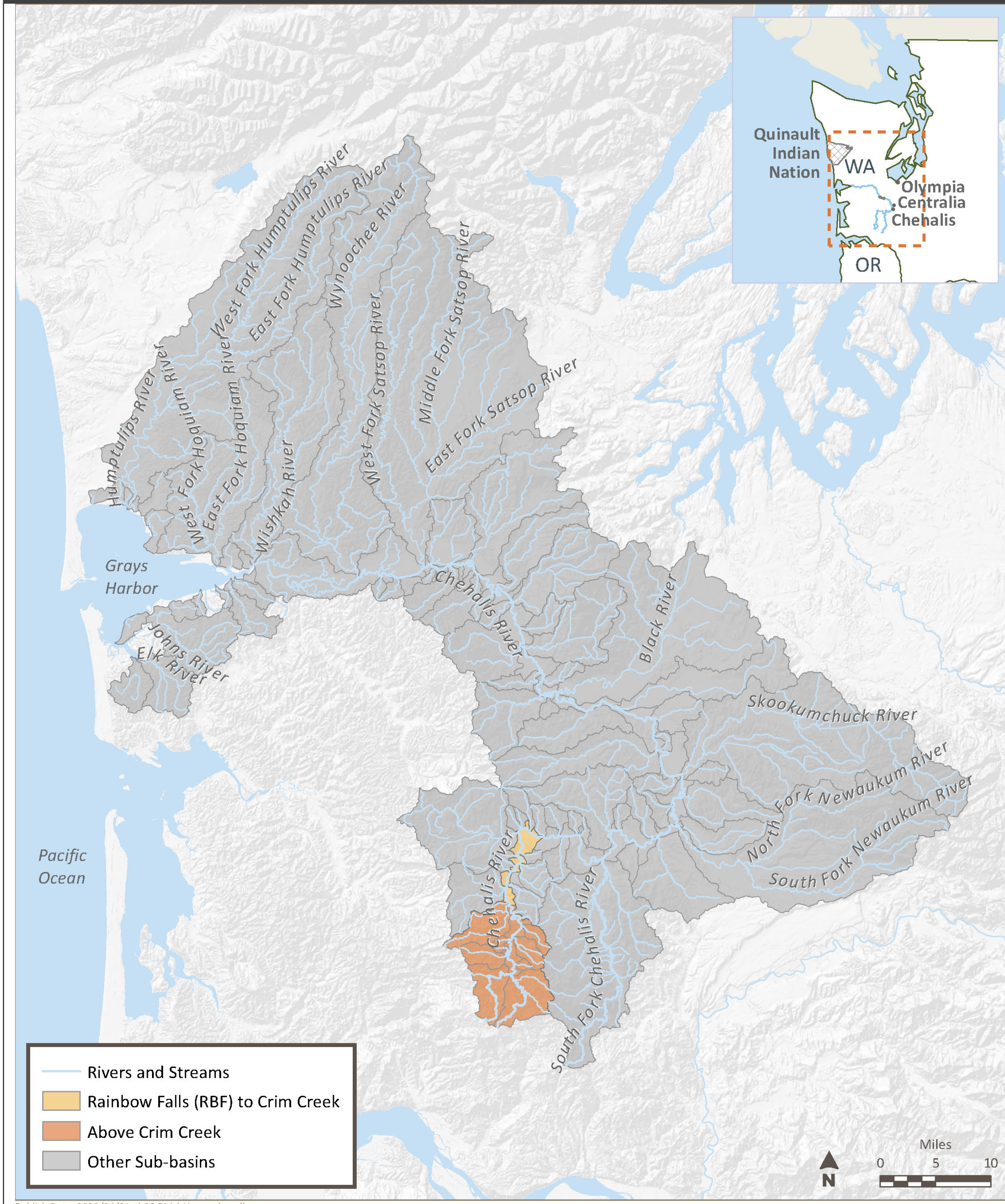
The construction and operation impacts of the flood retention facility on salmonids were modeled for the flood retention facility project area from the location of the proposed flood retention facility at RM 108 to RM 114 at the end of the proposed temporary reservoir ("Above Crim Creek" in modeling Appendix A, Attachments A and B), and in the 100-year Chehalis floodplain study area, from RM 98 at Rainbow Falls to RM 108 ("RBF to Crim Creek" in modeling Appendix A, Attachments A and B). The modeled areas are shown in Figure 6.2-1. This endpoint was selected because below Rainbow Falls, the modeled salmonids spawn primarily in tributaries where the effects of the proposed action would be negligible (Mike Scharpf, WDFW, spreadsheet dated August 8, 2019, as cited in Appendix A, Attachment A; Lestelle et al. 2019). Additionally, while some geomorphology impacts of the flood retention facility extended to RM 75 (Corps 2020d), these impacts were small in magnitude below approximately RM 98 and showed no change in the qualitative geomorphology ratings in EDT between Alternatives 1 and 2 and the No Action Alternative (Appendix A, Attachment E; Lestelle 2005). RM 114 was selected as the uppermost extent of the model domain because it is the upstream limit of the temporary reservoir.

6.2.1.1.1 EDT Modeling

The EDT model is habitat based and evaluates habitat potential. Habitat potential refers to how changes in the amount and quality of habitat directly affect salmonid population metrics. The population metrics that were modeled include abundance, productivity, and diversity. Changes in these metrics occurred when there were changes in habitat quantity and/or quality. The EDT model estimated changes for specific time periods based on model inputs for how habitat and fish passage conditions were predicted to change. Modeled aquatic habitat includes the physical and biological features needed for modeled species to spawn, rear, forage, and migrate, as described in Appendix A, Attachments E, F, and G. Modeled fish passage includes the conditions that are described in Appendix A, Attachment H. The specific timeframes and scenarios modeled are summarized below.

The 19 scenarios shown in Table 6.2-1 were modeled for Alternative 1 and the No Action conditions. Alternative 2 was assumed to be similar to Alternative 1 and any notable differences were addressed qualitatively.

Figure 6.2-1
Fish Habitat Modeling Areas



Publish Date: 2020/04/01, 4:23 PM | User: adowell
Filepath: \\orcas\gis\Jobs\WA_OFM_1023\NEPA\Maps\Discipline_Report\Aquatic_Species_and_Habitats\AQ_NEPA-EIS_ASH_E_EDT_SubBasins_Overview.mxd

Table 6.2-1

Scenarios Modeled in EDT to Characterize the FRE Facility

		NO ACTION ALTERNATIVE			FRE FACILITY			
FLOOD RECURRENCE	MODELED FLOW YEAR	CURRENT	MID-CENTURY	LATE-CENTURY	CONSTRUCTION	POST-CONSTRUCTION	MID-CENTURY	LATE-CENTURY
2-year	2011	2019	2040	2080	2025	2030	2040	2080
10-year	2009	2019	2040	2080		2030	2040	2080
100-year	1996	2019	2040	2080		2030	2040	2080

As discussed further in Appendix A, Attachment A, habitat and fish passage assumptions were made for the No Action Alternative and Alternative 1. Assumptions were also made for specific periods in time and for specific flood conditions (2-year, 10-year, and 100-year flood flows).

As noted above, the EDT modeling results provide an assessment of habitat potential in terms of abundance, productivity, and diversity. Abundance is the number of adults that return to spawn. In EDT, abundance is estimated based on habitat quantity (capacity) and quality (productivity). Capacity in EDT describes how large a population can grow given the quality of habitat (Appendix A, Attachment A). Productivity describes the number of juveniles that survive and return as adults to spawn per original adult spawner. A productivity of 1 means that each adult spawner replaces itself. If productivity is less than 1, the population abundance will decrease. If productivity is greater than 1, the population abundance will increase. Diversity in EDT is the proportion of life history options that contribute to abundance. Life history options are defined as combinations of life histories and spawning areas. As habitat is degraded, the proportion of life history options that increase abundance (i.e., productivity is greater than 1) is reduced. This means that the population relies on an increasingly narrow range of suitable habitat and life history options to sustain it (Appendix A, Attachment A).

6.2.1.1.2 Integrated EDT-LCMs

The integrated EDT-LCMs are described in more detail in Appendix A, Attachment B. These models are age-structured population models that estimate salmon and steelhead species population abundance over a continuous time period. This is different from the EDT results, which provide estimates for specific snapshots in time. To isolate the impacts of the proposed flood retention facility for each of the floods compared to the No Action Alternative, the EDT-LCMs did not include other key variables (e.g., marine survival) that could influence salmonid abundance.

The productivity (returning adults produced by one spawner) and capacity (habitat quantity) results from EDT were inputs to the LCMs. The EDT results for each species and life stage were used to evaluate changes with the integrated EDT-LCMs for Alternative 1 and 2 and No Action Alternative conditions over the project evaluation period. The integrated EDT-LCMs also modeled a back-to-back flood scenario in which a 10-year flood occurred in one year and a 100-year flood occurred in the next year, resulting in four modeled scenarios. The integrated EDT-LCMs model ran each of the four scenarios 100 times, and the median (middle value of all runs) was used as the estimate of habitat potential with a range of results for each of the 100 years.

For each of the 100 runs, the integrated EDT-LCMs randomly selected the flood (i.e., 2-year, 10-year, or 100-year flood) that would occur each year of the 100-year run. At each simulation step, 2-year, 10-year, or 100-year flood conditions were applied according to their probabilities of recurrence. In every year of the model, one of the three floods always occurred.

6.2.1.1.3 Model Uncertainties and Considerations

Uncertainties are inevitable in any ecological modeling effort. Uncertainties and considerations associated with the EDT and integrated EDT-LCMs are discussed in Appendix A, Attachments A and B. Model results may overpredict or underpredict the response of salmonid populations depending on the uncertainty or consideration. Therefore, the modeled results are not used as exact predictions of salmonid populations, but rather are used as a relative comparison between the No Action Alternative and Alternative 1 to determine potential impacts of the proposed action on modeled salmonid species. Analyzing the relative changes between the alternatives is the most appropriate way to use the results given the uncertainties and considerations. Uncertainties and considerations that were factored in when interpreting the model results are summarized as follows:

- There is uncertainty in the EDT estimates of abundance for each of the modeled species. The EDT model is calibrated to each species-watershed combination by adjusting marine survival rates to those that produce predicted equilibrium abundance sizes under current conditions similar to those observed by WDFW. However, previous WDFW observed abundance values for the modeled species were used for this calibration. This is because the most recent WDFW abundance estimates were not provided to the modelers in time to incorporate into these model runs. The impact of uncertainties related to fish abundance is that the exact abundance numbers estimated by EDT as a result of the proposed action or the No Action Alternative could be higher or lower than actual abundance numbers. Because the same uncertainties apply to both the proposed action and the No Action Alternative, modeled results are best evaluated relative to modeled results of the No Action Alternative.
- There is uncertainty in the parameters used to define the changing No Action Alternative baseline over time. For example, maturation of riparian areas in managed forests was included in the model as well as land use degradation and early action restoration projects in five sub-basins. There is inherent uncertainty in the details of how land use degradation and riparian maturation in managed forests may affect Chehalis Basin habitat because management regimes and land use practices and laws may change in the future. As such, future conditions assumed in the EDT model could turn out to be different. Climate variability modeling was also not included.
- For the EDT model, a HEC-RAS model was used to estimate the flow and channel width in the mainstem Chehalis River from the FRE facility location downstream to approximately RM 22 in 3 water years selected from the hydrologic record with and without the FRE facility (Hill 2019). The flow associated with the 3 selected water years is shown in Figure 3-4 in Attachment A to Appendix A. The 2-year, 10-year and 100-year floods were brief episodic events within their respective water years and were chosen to represent specific floods that would highlight operation of the FRE facility. The 3 flood-flow years do not represent a progression of increasing average flows. Each flow year has a unique pattern of flow and channel width that affects model estimates of different life stages of salmon. For example, it can be seen in Figure 3-4 in Attachment A to Appendix A that the 100-year flood in 1996 occurred in mid-February, the

10-year flood in 2009 occurred in early January, and the 2-year flood in 2011 occurred in mid-December. Additionally, EDT models flow and the resulting channel width as a monthly average and is not responsive to brief, episodic events such as a flood lasting a few days except as it affects the monthly average flow and channel width.

- The FRE facility would operate when a 7-year flood is predicted to occur at the Grand Mound gage. However, the modeling uses a 10-year flood to evaluate impacts. As such, the FRE facility would operate slightly more often than what is modeled. It is uncertain whether the slight increase in operation would significantly change the estimated response of modeled species over a long period of time.
- The model assumed that bed scour would increase in the 10-year and 100-year floods relative to the 2-year flood. There are no quantitative data available to determine what the bed scour would be under the different flood scenarios. Therefore, the values were based on qualitative information. Bed scour was not assumed to increase in the higher flood years below Elk Creek (RM 98) because of the very low gradient of the mainstem river below this point.
- The integrated EDT-LCMs were constructed based solely on the parameters provided by the EDT outputs. As such, uncertainties specific to the EDT inputs transfer to the EDT-LCMs.
- Integrating EDT and LCM models required several simplifying assumptions to ensure their compatibility, particularly for steelhead. The EDT outputs included emigration of smolts to the ocean that were age 2 and age 3 outmigrants, which was consistent with previous reports from scales of fish captured in the fisheries. However, recent observations of smolt trapping in the Chehalis Basin suggest that steelhead emigrants consisted of mostly age 1 and age 2 smolts, with a very small proportion of age 3 outmigrants. Efforts to reconcile smolt ages determined from juvenile trapping and from scales of adult returns are ongoing, but were not available for use in the EDT model used for this analysis. Therefore, for the integrated EDT-LCM, all model runs used the ages determined from adult scales. The effect of updating the age structure using the smolt trap data is unknown.
- For each scenario, EDT outputs included parameters for 2-year, 10-year, and 100-year flood conditions. At each integrated EDT-LCM time step, the 2-year, 10-year, or 100-year flood condition was chosen based on its probability of recurrence. In every year of the integrated EDT-LCM model (100 years total), one of the three floods always occurred. In other words, it was assumed that the chance any one of the three floods occurring during a 1-year period would be 100%. The chance that a less than 2-year flood occurs is not modeled, so the total number of chances each year is 61 (50+10+1 = 61). Therefore, the integrated EDT-LCM modeling overestimates the likelihood of occurrence of each flood as follows:
  - 2-year flood – In the model this flood has an 82.0% chance (50/61) of occurring in each year of a 100-year run. Generally, in the Chehalis Basin flows of this size would only have an approximately 50% chance of occurring in each year.

  - 10-year flood – In the model this flood has a 16.4% chance (10/61) of occurring in each year of a 100-year run. Generally, in the Chehalis Basin flows of this size would only have an approximately 10% chance of occurring in each year.
  - 100-year flood – In the model this flood has a 1.6% chance (1/61) of occurring in each year of a 100-year run. Generally, in the Chehalis Basin flows of this size would only have an approximately 1% chance of occurring in each year.

  This means that the modeling overpredicts the impacts from high-flow events over time relative to existing conditions.

- The proportions of steelhead smolt ages varied by subpopulation in the EDT outputs. However, proportions of smolts at age were held to a fixed proportion (at the median of the subpopulations' proportions) so that there would be a common ocean maturation rate for all subpopulations. This simplification would mute differences in modeled abundance among subpopulations for a given habitat condition but would have little effect on differences among scenarios for each subpopulation.
- A biological aspect of Chehalis Basin steelhead not characterized in the EDT model was the contribution of respawning adults, or kelts. They tend to be older, larger, and more fecund than first-time spawners. Inclusion of kelts would tend to increase spawner abundances slightly in all scenarios, but the effect on the differences among the modeled scenarios is unknown.
- A biological aspect of Chehalis Basin salmonid behavior not captured by the EDT model is possible downstream movements by predominantly upstream moving adults and daily or seasonal upstream movements by rearing juveniles. In the model adults are assumed to only move upstream and juveniles are assumed to only move downstream.
- The salmonid models only include a 2-year flood condition during construction and do not include a flood scenario. Therefore, impacts during construction could be greater if a 10-year or 100-year flood occurs.
- One general limitation of the integrated approach of the EDT-LCMs is related to when a new modeling year began. This limitation only applies to steelhead and coho salmon because they spend more than a year in the river before migrating out to the ocean. A new year in the steelhead EDT modeling began on approximately April 1 and ran until April of the following year. However, the new water year begins in October and runs through September. This distinction of when the modeling years began is a limitation because of habitat carryover effects from the previous winter that are applied in EDT until April 1. Therefore, in the integrated EDT-LCM, a single flow condition was chosen for each year, which meant that the same flow conditions prevailed from April to April when in reality a water year would run from October to September. Because of the annual break set in April, the same flow condition prevailed for spring to fall and the following winter, with no opportunity to change flow conditions in the fall. This means that flood conditions in one year impacted incubating eggs and the rearing or outmigration life stages in the second year when in reality the outmigration life stages in the second year would experience a different water year. This may have similarly impacted coho salmon EDT-LCMs

results because, like steelhead, coho salmon spend multiple years in freshwater. However, because of the relatively small differences in the EDT outputs for the 2-year, 10-year, and 100-year flood conditions, the carryover effects were likely very small and only applied to a portion (i.e., 6 months) of the second-year life stage. Spring- or fall-run Chinook salmon would not be affected by this limitation because these species only spend less than 1 year in freshwater such that flood conditions primarily affect incubating eggs but not the rearing or outmigration stages.

6.2.1.2 Physical Habitat Simulation Model (PHABSIM)

PHABSIM was used to evaluate the spawning and rearing habitat of six additional fish species. These include Pacific lamprey, speckled dace, largescale sucker, mountain whitefish, largemouth bass (a key non-native predator), and smallmouth bass, as described in more detail in Appendix A. The model was used to evaluate how spawning and rearing habitat would change because of temperature increases predicted to occur during operation with 2-year flow conditions. The PHABSIM model extends from the upper Chehalis River Basin near the proposed flood retention facility site downstream to Porter (RM 33) (Normandeau 2012; Caldwell et al. 2004). The change in usable spawning and rearing habitat was calculated for one site upstream of the proposed flood retention facility (at RM 110.9; originally surveyed by Caldwell et al. 2004) and various sites downstream of the flood retention facility from Pe Ell to Porter (surveyed by Normandeau 2012).

The change in usable spawning and rearing habitat that would occur with the flood retention facility was evaluated for each PHABSIM modeled fish species using the metric Weighted Usable Area. The model was developed to estimate relationships between flow and temperature and the usable habitat. The PHABSIM model was used to examine the change in the average amount of habitat available as average temperatures vary throughout the year with 2-year flow conditions under the No Action Alternative and Alternative 1.

The model could only be used to evaluate 2-year flow conditions and was not used to examine the changes associated with major flood conditions or greater because the data do not exist to do so. This is because for the original PHABSIM modeling effort, flow and habitat variables were measured in the field within the ranges that were safe to measure (Normandeau 2012; Caldwell et al. 2004; Beecher 2015). The model was expanded to include higher flows based on these measurements, but only for flows with water elevations that remained within the banks of the river. Under the No Action Alternative, the 10-year and 100-year floods would result in flows with water levels above the banks of the river. Therefore, temperature was the only element that changed in the model as a result of the proposed action. The average monthly flows did not change.

6.2.2 Qualitative Evaluation

Qualitative evaluation was used to determine potential impacts to non-modeled aquatic species and habitat. Non-modeled aquatic species include other salmonids, native fish species, and non-native fish species not modeled by EDT, EDT-LCMs, or PHABSIM, freshwater mussels, and aquatic plants. Non-modeled aquatic habitat includes the physical and biological features needed for aquatic species not included in Section 6.2.1 to spawn, rear, forage, and migrate.

6.2.2.1 Construction Impacts

Direct impacts on non-modeled aquatic species from construction were determined based on potential presence of species within the flood retention facility construction site. In the flood retention facility project area, this included the footprint of the proposed facilities, the diversion tunnel, staging and spoil areas, and access roads. This qualitative impact assessment was informed by literature review of existing species data, and by project-specific species studies.

Direct impacts on habitat were determined by estimating the area of aquatic habitat that would be converted to other uses (e.g., flood retention facility structure, spoils, staging areas). The impacts were qualitatively assessed and informed by literature review of existing habitat data, and by project-specific habitat delineations. The analysis also looked at how the project alternatives would indirectly affect aquatic species by altering the types and functions of available habitats (e.g., increase in turbidity or temperature). Removal, alteration, or fragmentation of existing habitats or habitat characteristics may alter the quality of habitat for existing aquatic species, especially fish species, and affect their ability to occupy, spawn in, migrate through, or otherwise use the modified habitat.

6.2.2.2 Operation Impacts

Indirect impacts on non-modeled aquatic species from operations were determined by assessing the potential for loss or degradation of habitat suitable for aquatic species. The analysis of operational impacts considered how operation of the flood retention facility would change habitat and affect aquatic species in the shorter-term, when the temporary reservoir is impounding water. The analysis also considered the impacts over time, as the result of longer-term changes occurring in the study area. This assessment was informed by literature review of existing habitat and species data and by project-specific habitat studies.

The indirect impact analysis also assessed the potential impacts on marine mammals from declines in prey species, specifically anadromous salmonids. This assessment was informed through literature review of existing habitat and species data, and by project-specific species studies, including the fish modeling described in Section 6.2.1.

6.3 No Action Alternative

The potential impacts of the No Action Alternative on aquatic species and habitat are described in the following sections. The No Action Alternative represents the conditions anticipated without the proposed project over the course of the analysis period from 2019 through 2080.

6.3.1 Flood Retention Facility Project Area

Under the No Action Alternative, aquatic habitat condition and function would remain stable or slightly improve compared to existing conditions. This is because of the assumed improvements from reductions in water temperature and bed scour associated with riparian tree growth during the analysis period. This means that aquatic species would be expected to benefit, and the populations of most species found in this area would remain stable or slightly increase. Non-native species are not currently found in the flood retention facility project area and would not be expected to spread, assuming current best practices are maintained.

Improved habitat conditions are expected because timber harvest would continue in accordance with the WDNR Forest Practices Habitat Conservation Plan in the managed forestland. As part of timber harvest management, riparian trees are protected from harvest. As such, growth of riparian trees is assumed to continue throughout the project time period (2025 through 2080). Growth of riparian trees would benefit aquatic habitat by providing shade for cool water, a supply of LWM for aquatic habitat, habitat for terrestrial insects that can be prey of aquatic species, and filtered rainwater into the adjacent river and streams (Anderson et al. 2007). When LWM deposits in streams, it forms pools of deeper water. Pools help to neutralize the effect of bed scour during high flows (Brooker 1985).

The current levels of LWM in the Chehalis River are low (ASRPSC 2019; Smith and Wenger 2001). Sources of wood are episodic, providing wood during large storm/flow events and little wood input during non-storm/peak flow times (Corps 2020d). Under the No Action Alternative, the amount of LWM in the flood retention facility project area would be expected to increase because of riparian tree growth in managed forests.

As noted in Section 6.2.1, fish modeling was completed to provide further information about potential impacts on the four modeled salmonids and to inform the analysis of the potential for impacts on other fish. This included EDT and integrated EDT/LCM modeling of the No Action Alternative. EDT modeling assumed riparian tree growth would continue. Therefore, assumptions about decreases in water temperature, increases in LWM supply, and decreases in bed scour because of riparian tree growth were incorporated into the modeling. In addition, EDT assumed that culverts would be removed as part of the No Action Alternative condition. Detailed assumptions are described in Appendix A, Attachment A. Under these conditions, all modeled salmonids (spring-run Chinook salmon, fall-run Chinook salmon, coho salmon, and steelhead) would experience stable or slightly improving habitat potential based on estimates of abundance, productivity, and diversity above the proposed flood retention facility through mid-century and late-century, compared to current conditions (Appendix A, Attachment A).

Results of the integrated EDT-LCMs also showed little variation in habitat potential over time and that the modeled populations were resilient to back-to-back floods. Figures and tables illustrating the EDT and integrated EDT-LCMs results for the four modeled salmonids under the No Action Alternative compared to the other alternatives are provided in Section 6.4.4.1.1 (Figures 6.4-1 through 6.4-4).

The habitat potential for other fish species is expected to be similar to modeled salmonids and to remain stable or slightly increase through time. These conditions are because of improved habitat functions similarly caused by increased riparian tree growth and removal of culverts assumed under the No Action Alternative.

Non-native fish such as largemouth bass, smallmouth bass, and bluegill are currently excluded from the proposed flood retention project area. This is likely because of a habitat temperature preference for warmer water (Winkowski et al. 2018a). If non-native fish were able to expand into the flood retention project area, they could indirectly impact native species. For example, non-native species may prey on native species or compete with them for habitat and food. However, variability in possible future environmental conditions makes it difficult to predict if this would occur in the project evaluation period. Based on No Action Alternative conditions compared to current conditions, impacts to non-native species are not anticipated.

6.3.2 Chehalis River 100-year Floodplain Study Area

Under the No Action Alternative, aquatic habitat condition and function in the Chehalis River 100-year floodplain is expected to decrease compared to existing conditions. The overall impact is anticipated to be a medium degradation of aquatic habitat and a low to medium impact on aquatic species, as discussed below.

Under the No Action Alternative, the negative and beneficial impacts from major or greater floods on aquatic species and habitat would be expected to continue to affect the Chehalis River 100-year floodplain. There would also be impacts related to continued growth and development of urban areas and continued agricultural uses. There would be some beneficial impacts from habitat restoration activities and local flood control projects. However, it is still expected that potential impacts related to the ongoing risks of major to catastrophic floods would remain.

Under the No Action Alternative, human population growth and continued development within the Chehalis River 100-year floodplain could impact aquatic species and habitat. In addition to direct habitat conversion, urbanization is associated with decreased habitat connectivity (including floodplain connections), increased runoff into streams and rivers carrying pollutants from impervious surfaces, altered nutrient cycles, and local increases in air and water temperature (Grimm et al. 2008). Impacts related to agriculture include altered hydrologic regimes from irrigation, changes in vegetation from grazing, and increased runoff of fertilizers and pesticides from crop and pasture lands into streams and rivers (EPA 2019). Taken together, these effects would likely have a negative impact on aquatic species and habitat under the future No Action Alternative conditions compared to current conditions.

During major flooding, the river would be free-flowing and the river channel would continue to experience bed scour in the higher-gradient portions of the river. Bed scour causes disruption to the substrate and to benthic invertebrates, which are prey resources for fishes. During these events, any fish nests or eggs placed prior to the flood would be harmed. Also, during flooding, straying of salmonids could occur, causing a portion of annual runs to be unable to reach historical spawning grounds. When floodwaters recede, some adult and juvenile fish are likely to be stranded. Depending on how many fish are stranded, there could be a broader impact on these populations. However, major or greater floods also drive important large-scale ecosystem processes such as soil formation and groundwater recharge (Talbot et al 2018). Species such as salmon have evolved with floods and have life histories that are adapted to floods as a natural part of the ecosystem. Though major floods can impact salmon populations, they can also benefit salmon. Floods can result in gravel recruitment, redistribution of silt and the removal of fine sediment from the spawning gravels, and displacement of predators (Ferguson 2020). During smaller floods, flows across the floodplain connect nearby wetlands, ponds, oxbows, and other off-channel habitats that are important for fish rearing or that support species that rely on periodic flooding. Smaller floods can also provide benefits such as increases in aquatic food supply, nutrients, primary production, and groundwater recharge (Talbot et al. 2018). These variable conditions are expected to continue to late-century.

Some of the No Action Alternative projects and programs would provide local relief from flooding (e.g., elevating structures). However, none of these projects or programs are expected to significantly affect regional flood levels. This is because the scale of each project is small relative to the overall river floodplain. Therefore, the analysis of potential impacts on aquatic species and habitat under the No Action Alternative is based on HEC-RAS (1D and 2D) modeling and remote sensing (LiDAR) data inputs to EDT (WSE 2019a, 2019b) that depict existing topography and significant infrastructure.

Under the No Action Alternative, there would also be a potential benefit to aquatic habitats, and indirectly to aquatic species, from restoration actions and ongoing local programs and activities intended to reduce flood-related damage. Some of these activities aim at restoring riparian and off-channel habitat, reducing bank erosion, and creating, restoring, and enhancing wetlands. Direct benefits to migratory fish species would result from the Washington State Department of Transportation (WSDOT) state-wide culvert replacement fish passage restoration program. Under this program, WSDOT replaces culverts that do not allow fish to move upstream and downstream with culverts or bridges that allows fish to move upstream and downstream.

Direct benefits to aquatic habitats and species are expected to result from currently approved early-action Aquatic Species Restoration Plan (ASRP) projects. The entire ASRP is a long-term, basin-wide process focused on restoring and maintaining riparian forest areas, reconnecting floodplain and other off-channel habitat, restoring supply of LWM, and targeting removal of fish passage barriers. The expected benefits of ASRP include increasing the amount and quality of aquatic habitats in the Chehalis Basin, maintaining cooler water temperatures that are preferred by native salmonids, and allowing migrating fish to move upstream and downstream.

As noted in Section 6.2.1, fish modeling was completed to provide further information about potential impacts on four salmonid species. This included modeling the No Action Alternative. The adverse effects of human population growth and development in the Chehalis River 100-year floodplain are reflected in the EDT and integrated EDT-LCMs. Model assumptions include decreases in supply of LWM and riparian function, increases in water temperature and pollution, and changes to flow. These assumptions were applied to the area within this section of river where land use is a mixture of small urban, agriculture and managed forest as discussed further in Appendix A, Attachment A. The beneficial effects associated with ASRP restoration and flood control actions were reflected in the modeling by increasing riparian function supply of LWM, and habitat connectivity. Improved access to culverts addressed by the WSDOT culvert replacement program was also accounted for. Additional details are discussed in Appendix A, Attachment A.

Under the No Action Alternative, habitat potential in the Chehalis River 100-year floodplain downstream of the flood retention facility to Rainbow Falls (near RM 98) for all modeled salmonid populations was predicted to decrease through late-century as shown in figures included in Section 6.4.4.1.2 (Figures 6.4-7 through 6.4-10). This decrease in habitat potential is primarily because of the assumption that increased growth and development into the future (Appendix A).

Integrated EDT-LCMs results of the No Action Alternative in the Chehalis River 100-year floodplain study area also indicated a stable to slightly decreasing trend in habitat potential for spring-run and fall-run Chinook salmon. The results indicated more substantial declines in abundance for coho salmon and steelhead. All four modeled species showed little variation in response to different levels of flooding and were able to recover from to back-to-back floods that occurred in mid-century (Section 6.4.4.1.2).

Habitat quantity and quality for other aquatic species, such as bull trout and chum salmon, lamprey, other native fish species, freshwater mussels, and plants are expected to follow a similar trend. This means that over the course of the 61-year analysis period, habitat quality and quantity is expected to remain stable or decrease. Non-native fish, such as largemouth bass, smallmouth bass, and bluegill, are currently present in the Chehalis River 100-year floodplain study area (Winkowski et al. 2018a). Negative impacts are associated with non-native fish species because they may prey on native fish species or compete with them for habitat and food. The non-native plant species Brazilian elodea and parrotfeather form dense mats that shade out native plants and give a competitive advantage to non-native fish species, such as largemouth bass that have a greater affinity for plants than do native salmonids (Dibble 2009). However, variability in possible future environmental conditions, ongoing noxious weed management, and planned restoration actions make it difficult to predict how these interactions would occur during the project evaluation period. The trend toward decreasing habitat quantity and quality over time means there is a potential that invasive species could increase.

6.3.3 Chehalis Basin

The results from modeling the four salmonids are presented in this section at the scale of the Chehalis Basin for the No Action Alternative. This is done to provide additional context for comparing results with the alternatives and to assist in addressing the potential for impacts on marine mammals outside the study area.

At this scale, under the No Action Alternative, there would be a decline in modeled spring-run Chinook salmon, fall-run Chinook salmon, and coho salmon abundance attributed to changes in habitat over the course of the 61-year analysis period (Table 6.3-1; Figures 6.4-11 through 6.4-12). During this period, the model predicts that steelhead would experience an increase in abundance. Killer whales and sea lions living in Grays Harbor that eat salmonids as part of their diets may experience slight impacts from the slight decreases in abundance of salmonids, particularly Chinook salmon, by late-century. However, as discussed in Section 6.4.2.3, a recent memorandum reported that total Chinook salmon spawners above the proposed flood retention facility contribute less than 5% to the Chehalis Basin and Grays Harbor escapement (number of fish that go out to the ocean and return to spawn) (Table 6.4-6; Ronne 2019). Therefore, it is likely that these marine mammal populations would experience a low impact by this small loss of part of their food source.

Table 6.3-1
Modeled Habitat Potential in the Chehalis Basin under the No Action Alternative

SPECIES	2019 TO 2080 ABUNDANCE (NO. OF FISH)	GREATEST CHANGE IN ABUNDANCE	GREATEST CHANGE IN PRODUCTIVITY	GREATEST CHANGE IN DIVERSITY
Spring-run Chinook salmon	1,157-1,176 to 1,155-1,180	-2.0%	+20.2%	-12.0%
Fall-run Chinook salmon	39,239-32,415 to 36,618-36,783	-7.1%	-2.5%	-3.2%
Coho salmon	73,858-74,200 to 71,625-71,957	-3.5%	-1.4%	+4.7%
Steelhead	14,521-14,527 to 16,094-16,099	+10.8	+14.9%	+17.2%

6.3.4 Climate Variability

As discussed in Section 5.4, temperature and precipitation patterns could change in the future, for example, as a result of climate variability. There could be hotter summer air conditions and decreased summer precipitation. If this happens, there could be reduced flow in rivers and streams and higher instream water temperatures. Increased instream water temperatures would negatively affect salmonids and other native fish species, plants, and freshwater mussels. The increase in water temperature could also favor non-native species that would outcompete native species. These adverse impacts of increased water temperature are described in more detail in Section 6.4.2.2.2.

If warmer temperatures occurred in the winter, wintertime precipitation may shift from snow to rain in the higher elevation portions of the Chehalis Basin. This shift would increase winter streamflow and contribute to higher downstream flows and increased flooding potential. Additionally, winter precipitation and the frequency and intensity of atmospheric river events have also been predicted to increase. This would contribute to an increased risk of winter and spring flooding in the Chehalis Basin.

Increased instream flow during the winter and spring could lead to more frequent occurrence of major and catastrophic floods that would cause both short-term negative and longer-term beneficial impacts.

6.4 Alternative 1 (Proposed Project): Flood Retention Expandable (FRE) Facility and Airport Levee Improvements

This section describes the potential for impacts to occur under Alternative 1 relative to the No Action Alternative. Construction and operations would result in low to high impacts on aquatic species and habitat. These impacts are described in Sections 6.4.1 through 6.4.4.

As discussed in the discipline report for water quantity and quality (Corps 2020c), there would be minimal potential for indirect water quality impacts from construction in the Airport Levee Improvements project area. Additionally, there is less potential for impacts on aquatic species or habitat because none are present in this project area and there is no connection to aquatic habitats except during floods. Therefore, this discussion focuses on the flood retention facility project area and the area downstream of the proposed flood retention structure down to RM 33.

6.4.1 Aquatic Habitat – Construction Impacts

Potential impacts on aquatic habitat would include a high permanent and low temporary loss of aquatic habitat from FRE facility construction. Construction would also result in low to high impacts on habitat function. These impacts are related to high permanent and temporary habitat loss, high temperature increases, and dissolved oxygen decreases between RM 114 and RM 100, low impacts from increased turbidity and risks of spills, and low to medium decreases in the supply of LWM.

6.4.1.1 Habitat Loss and Impairment

Permanent impacts on aquatic habitat by construction activity because of fill within the flood retention facility project area are shown in Tables 6.4-1 and 6.4-2 (Corps 2020a). These activities are expected to permanently fill 2.65 acres and temporarily impact 2.77 acres of aquatic habitat, mainly from the Chehalis River, but also from unnamed intermittent streams, as detailed in Tables 6.4-4 and 6.4-5. Of the 2.65 acres, only 2.05 acres are expected to be accessible to fish species.

Table 6.4-1
Permanent and Temporary Direct Impacts on Aquatic Habitat within the Temporary Reservoir and for Off-site Haul and Access Roads in the Flood Retention Facility Project Area (Area)

CONSTRUCTION ACTIVITY	WATER NAME	WATER TYPE	IMPACT TYPE	IMPACT AREA (ACRES)
Cofferdams/Staging	Chehalis River	Perennial Stream	Temporary	0.61
Diversion Tunnel Inlet/Outlet	Chehalis River	Perennial Stream	Permanent	0.36
Dewatered channel above downstream cofferdam	Chehalis River	Perennial Stream	Temporary	1.5
Dewatered channel below upstream cofferdam	Chehalis River	Perennial Stream	Temporary	0.66
FRE Facility – flood retention structure	Chehalis River	Perennial Stream	Permanent	1.12
FRE Facility	Chehalis River	Perennial Stream	Permanent	0.43
Spoil Placement	Unnamed Stream	Intermittent Stream[1]	Permanent	0.01
Spoil Placement	Unnamed Stream	Intermittent Stream[1]	Permanent	0.01
Spoil Placement	Unnamed Stream	Intermittent Stream[1]	Permanent	0.01
Haul Road	Unnamed Stream	Intermittent Stream[1]	Permanent	0.08
Haul Road	Unnamed Stream	Intermittent Stream[1]	Permanent	0.01
Haul Road	Unnamed Stream	Intermittent Stream[1]	Permanent	0.01
Haul Road	Unnamed Stream	Intermittent Stream[1]	Permanent	0.01
Culverts on Haul and Access Roads[2]	Unnamed Streams	Intermittent Streams	Permanent	0.60
			Total	**5.42**

Notes:
1. Intermittent streams are assumed to be accessible to salmonids when they are flowing and are considered as EFH in this report.
2. Based on a review of the delineation mapping for project area roads and the NHD for roads, approximately 262 crossings may be required. Assuming an average road width of 24 feet and an average stream width of 4 feet, an additional 0.6 acre of other waters could be affected by the construction or improvement of culverted road crossings for access roads. Because it is unlikely that all of the streams mapped by the NHD would be jurisdictional under federal, state, and local regulations, this impact estimate is likely higher than what would occur if the project were constructed. It should also be noted that road crossing installation and improvement would not completely remove those resources because flow would still be conveyed through the culvert, and that these very small streams are likely not accessible by fish and are not considered EFH or WDFW Priority Habitat.

An area of 4.82 acres of permanent and temporary fill (all impact areas except estimated culverts on haul and access roads) is considered EFH for Chinook salmon and/or coho salmon and WDFW priority instream habitat (coho salmon, Chinook salmon, steelhead, coastal cutthroat trout). Because the permanent lost habitat is special-status habitat, this loss is considered a high impact. Temporary loss of habitat could occur as a result of dewatering the work area and placement of cofferdams and staging areas for construction of the FRE facility. The dry work area needed for construction would be created by pumping water out of the area between two coffer dams and/or berms. Aquatic species would not be able to access this area while it is dewatered. The temporary losses would be low because the areas would be accessible after construction. There is additional potential for temporary loss of aquatic habitat that is not accounted for in the above tables. This includes the need to divert Mahaffey Creek from flowing into the dewatered work area during FRE facility construction. Currently, there is a waterfall at the confluence of Mahaffey Creek and the Chehalis River that is estimated to be approximately 6 to 8 feet above the OHWM of the Chehalis River. This prevents fish passage from the Chehalis River into Mahaffey Creek unless flows are higher than the OHWM.

High permanent impairment of habitat function would also result from pre-construction vegetation management activities within the temporary reservoir of the flood retention facility project area. These activities would impair habitat function by increasing temperature of the river, increasing the supply of fine sediment (TSS/turbidity), and reducing the supply of LWM.

Removal of trees would affect approximately 94 acres of aquatic habitat (Table 6.4-2). Most of the aquatic habitat impacted by tree removal (84%) is within the Chehalis River. All 94 acres of aquatic habitat affected by riparian tree removal is WDFW priority aquatic habitat used by Washington state candidate species (spring-run and fall-run Chinook salmon) and priority species (coho salmon, steelhead, and Pacific lamprey).

Table 6.4-2
Summary of Estimated Impacts on Aquatic Habitat from Tree Removal for Construction of the FRE Facility (Area)

WATER NAME	IMPACT AREA (ACRES)
Chehalis River	79.54
Crim Creek	9.83
Roger Creek	0.13
Unnamed Streams and Drainages – Upper Chehalis River Basin	1.20
Unnamed Streams and Drainages – Big Creek Basin	0.45
Unnamed Streams and Drainages – Browns Creek Basin	0.38
Unnamed Streams and Drainages – Crim Creek Basin	0.33
Unnamed Streams and Drainages – Hull Creek Basin	0.49
Unnamed Streams and Drainages – Lester Creek Basin	1.74
Total	**94.09**

6.4.1.2 Increased Water Temperatures

An increase in temperature in the river is expected to occur after vegetation removal. This increase would impair habitat function in the temporary reservoir footprint and downstream from RM 114 to RM 100 (Corps 2020c). As discussed in greater detail in the *Discipline Report for Water Quantity and Quality*, the removal of riparian vegetation from pre-construction vegetation management is predicted to result in a high increase in temperature in the temporary reservoir footprint and downstream to RM 100. During construction, water temperatures within the temporary reservoir footprint are expected to increase by up to 1 to 2°C in the spring and summer (May to October). This increase would raise water temperatures up to 26°C and extend warm temperatures further into the fall (Corps 2020c). As shown in Figure 5.3-1, salmonids and native species are expected to be in the river using the habitat for rearing and spawning. Temperature is important because it is one of the features of aquatic habitat that controls biological diversity and growth (Cramer 2012; USGS 2019a). Local aquatic organisms are adapted to live within habitat of a certain temperature range. As temperatures exceed this range the number of species and individuals adapted to that temperature range that the habitat can support declines (USGS 2019a). Increases in temperature also reduce the amount of oxygen the water can hold and increases the rate of chemical reactions, both of which can reduce the quality of aquatic habitat (USGS 2019a). As described in the *Discipline Report for Water Quantity and Quality* (Corps 2020c), there are three temperature criteria (i.e., temperatures that should not be exceeded) within the study area assigned for the protection of Core Summer Salmonid Habitat (CSSH), Salmonid Spawning, Rearing, and Migration (SRM), and Supplemental Spawning and Incubation Criterion (SSIC). During the summer months, only two of these criteria apply:

- CSSH: The temperature criterion is 16°C for the Chehalis River upstream of the Ceres Hill Road Bridge (near the confluence with the South Fork Chehalis River).
- SRM: The temperature criterion is 17.5°C downstream of the Ceres Hill Road Bridge.

Based on data collected by Ecology (Ecology 2001, 2019b) and other state-funded studies (e.g., Anchor QEA 2012, 2014), summertime Chehalis River temperatures already frequently exceed existing water quality criteria of 16 to 17.5°C related to SSRM habitat. Based on long-term stream temperature monitoring at Dryad, Chehalis River temperatures also frequently exceed spring-fall temperature criteria of 13°C (SSIC), especially in September and June (Ecology 2019b). Therefore, any increases would further degrade this condition.

6.4.1.3 Decreased Dissolved Oxygen

A medium long-term reduction in dissolved oxygen that exceeds the state water quality criterion associated with temperature increases during 2-year flows is predicted in the temporary reservoir and downstream of the flood retention facility to RM 100 between May and October. Because the background dissolved oxygen concentrations are frequently lower than the applicable criterion (CSSH) of 9.5 milligrams per liter (mg/L) for CSSH in the summer, any decrease in dissolved oxygen more than 0.2 mg/L (WAC 173-201A-200) would trigger an exceedance of the water quality criterion. This water quality criterion was developed to be protective of CSSH. The decrease in dissolved oxygen caused by the project is likely to be less than 0.2 mg/L, but because of the uncertainty and limitations of the models, it could be equal to, or greater than, the allowed decrease (Corps 2020c). As such, exceedances of the criterion could impact salmonid habitat.

6.4.1.4 Increase in Total Suspended Solids and Turbidity

Removal of vegetation from the temporary reservoir would also increase the likelihood of soil material being disturbed in the temporary reservoir footprint. Additionally, in-water work and the storage of soils near the river could result in an increase of soil material in the water (Corps 2020d). More soil disturbance could increase the amount of fine sediment in the rivers and streams flowing through the temporary reservoir footprint and immediately downstream within the Chehalis River 100-year floodplain study area. It has not been predicted how far downstream this impact would occur, but it would be expected to decrease as the river moves downstream from the construction area.

The fine sediment causes an increase in total suspended solids (TSS) and turbidity in the water column. Turbidity is a measure of water clarity that is often related to TSS. The suspended sediment could deposit over the top of spawning gravels, reducing the quality of spawning habitat. The deposition of fine sediment could also smother deposited eggs and animals living on the bottom of the river. However, it was assumed that minimization measures and best management practices (BMPs) would be implemented during construction to prevent the migration of soils into the river and streams.

The increased turbidity would be a low impact for flows less than or equal to a 3-year flood. If flows are greater than that level, increased turbidity could be a medium impact on habitat function. This is because there would be greater risk that additional fine sediment from the spoil piles would end up in the water. However, the Applicant would require the contractor to prepare a plan for minimizing impacts when a flood greater than a 3-year flood is predicted to occur.

6.4.1.5 Increased Risk of Spills and Leaks

Construction activities in staging and work areas would have the potential to result in low to high increases in the risk of accidental spills or leaks. Pollutants from construction equipment could enter surface waters through wind, stormwater runoff, or high flows (Corps 2020c). Use of construction equipment and storage of construction materials in the floodplain would also create an increased potential for contaminants (e.g., fuel, vehicle fluids) to be carried into the Chehalis River by stormwater runoff or high flows.

Impacts to aquatic habitat could also occur if there is an accidental spill of uncured concrete into the water. The pH of fresh water is normally between 6.5 and 8.5, but concrete spills can cause very alkaline water with a pH of up to 13 (WDFW 2009). The FRE facility would be built using concrete. Uncured and new concrete could raise the pH of water that comes into contact with it up to a pH of 12 or 13, which is highly alkaline (WDFW 2009). Because fish generally have a narrow range of pH preference, any water contaminated with concrete stormwater runoff would temporarily be unable to function as aquatic habitat (WDFW 2009).

Increased risk of spills and leaks during flow conditions up to a 3-year flood could be reduced by implementing standard BMPs for construction equipment use, material storage, and use of uncured concrete around rivers and streams. As such, this impact is expected to be low. If flow conditions are greater than a 3-year flood, these impacts could be medium depending on the size of the storm. This is because there would be greater risk that flows would reach work and storage areas and pollutants could enter the water. However, the Applicant would require the contractor to prepare a plan to address this condition during construction and how impacts would be minimized.

6.4.1.6 Increase in Fine Sediment

An increase in fine sediment could occur during construction from the increased risk of erosion and sedimentation from disturbing soils during construction or from disturbance to soils from large-scale tree removal in the temporary reservoir footprint. This increase in fine sediment could bury existing gravel and cobble substrate and aquatic plants or mussel species that are unable to move to avoid the fine sediment. It could also make habitat within the temporary reservoir footprint less suitable for fish spawning and rearing or shellfish settling, because it would be less able to provide the critical habitat elements described in Sections 5.3.3 and 5.3.4.

6.4.1.7 Decreased Supply and Transport of Large Woody Material

Removal of trees also reduces the supply of LWM coming into the temporary reservoir footprint. Field surveys show the mainstem Chehalis River has low wood load inputs under current conditions, as discussed in Section 5.2, and the proposed FRE facility would further reduce the supply that is available to move downstream (WGD and Anchor QEA 2017). The transport of LWM downstream of the construction area would be hindered by the diversion tunnel. LWM is important to the formation of pools and spawning and rearing habitat. LWM also provides shade, creates resting areas for migrating species, and adds habitat complexity that increases the overall biological diversity an area can support (NOAA 2005b; Kovalenko et al. 2012). A further reduction of LWM supply in the mainstem Chehalis River is expected to reduce the ability of instream habitats to provide critical habitat elements, as described in Section 5.3.3. The decrease in transport of LWM from the diversion tunnel is expected to be a low habitat impairment. The longer term impact of reduced supply of LWM from tree removal is discussed in Section 6.4.3.5.

6.4.2 Aquatic Species – Construction Impacts

Construction impacts on aquatic species would also range from low to high. High impacts on aquatic species would occur mainly as the result of indirect impacts caused by the loss or impairment of habitat. These indirect impacts are described in Sections 6.4.2.1 through 6.4.2.3. There would also be a potential for low impacts to occur during construction as the result of increased risk of mortality or injury during the construction period. These direct impacts are described in Section 6.4.2.4.

6.4.2.1 Modeled Salmonids

Construction would result in a high impact on modeled salmonids in the flood retention facility project area and Chehalis River 100-year floodplain study area. This would mainly occur as the result of high indirect impacts from habitat loss and impairment (from RM 98 to RM 114) and low direct impacts during construction at the FRE facility construction site. Direct construction impacts are described in Section 6.4.2.4.

The indirect impacts on salmonids from habitat changes were modeled using EDT.[1] The EDT modeling was completed to evaluate how habitat changes could impact salmonid habitat potential measured as changes in abundance, productivity, and diversity (see Section 6.2.1 for definitions of these terms). Results are provided for RM 108 to RM 114 of the flood retention facility project area, RM 98 to RM 108 of the Chehalis River 100-year floodplain study area, and for the Chehalis Basin overall.

[1] As noted in Section 6.2, EDT covers the entire Chehalis Basin and modeled the effects of the proposed action from RM 98 to RM 114.

There would be additional impacts to the modeled salmonids that are not captured in the EDT model. If a flood larger than a 2-year flood occurs during construction, additional impacts to the modeled salmonids would occur as described in Sections 6.4.2.4.4 and 6.4.2.4.5. Another impact on the modeled salmonids that is not captured in the EDT model is reduced passage of juvenile fish from below the FRE facility to above it. Because no upstream passage accommodations would be made for juvenile salmonids, these species are not expected to be captured and transported above the construction area. However, if the juveniles are incidentally captured at the temporary trap-and-transport facility, they would be collected and moved upstream above the construction area.

6.4.2.1.1 Flood Retention Facility Project Area

The flood retention facility project area is an important spawning area for spring-run and fall-run Chinook salmon, including the mainstem, upper reaches, and tributaries. Disturbance to aquatic habitat, particularly along the Chehalis River mainstem from RM 108 to RM 114, would have the potential to cause high impacts to this project area overall. This is because of the permanent and temporary loss and degradation of habitat resulting from construction but also because of disruption of fish passage above the FRE facility during the construction period. As shown in Table 6.4-3, construction would result in a reduction in abundance of 40% to 78%, a decrease in productivity of 21% to 38%, and a decrease in diversity of 38% to 77%.

Table 6.4-3
Changes in Habitat Potential for Modeled Salmonids in the Flood Retention Facility Project Area (RM 108 to RM 114) During Construction

SPECIES	2019 ABUNDANCE (NO. OF FISH)	CHANGE IN ABUNDANCE DURING CONSTRUCTION	CHANGE IN PRODUCTIVITY DURING CONSTRUCTION	CHANGE IN DIVERSITY DURING CONSTRUCTION
Spring-run Chinook salmon	60 to 70	-78%	-38%	-77%
Fall-run Chinook salmon	185 to 200	-40%	-21%	-54%
Coho salmon	790 to 820	-72%	-34%	-83%
Steelhead	805 to 820	-53%	-25%	-38%

The spring-run Chinook salmon abundance was estimated to decrease by 78%. This means that the habitat potential dropped from between 60 and 70 fish to around 15 fish because of construction. This low of an estimate indicates that the population in this portion of the river could be at risk of not being viable. A viable population is one which has little to no risk of extinction over the next 100 years as a result of genetic change, demographic randomness, or normal levels of environmental variability (McElhany et al. 2000). In addition, a viable population should also be able to withstand catastrophic events and long-term demographic and evolutionary changes (McElhany et al. 2000). It is unclear if such a small population of Chinook salmon above the FRE facility would be viable during construction.

Spring-run Chinook salmon productivity was also estimated to decrease by 38% and diversity by 77% during construction. This means that the number of juveniles that survive to return to spawn produced by each spawner decreased by 38%. It also means that the number of suitable habitat and life history options available to contribute to a growing population decreased by 77%.

Some of the estimated decrease in abundance, productivity, and diversity is attributed to the assumed adult fish passage total survival rate (63%) through the temporary trap-and-transport facility. However, most of the modeled decreases in spring-run Chinook salmon population metrics above the construction site were because of the degradation of habitat conditions within the reservoir footprint from vegetation removal. Vegetation removal covered most of the modeled spawning areas for spring-run Chinook salmon above the proposed flood retention facility (Appendix A, Attachment A). The expected increase in summer water temperature within the temporary reservoir would also lead to decreased survival of spring-run Chinook salmon during the adult holding period (ICF 2019; Appendix A, Attachment A). Ideal summer holding temperatures for spring-run Chinook salmon are between 14 and 20°C (Bergendorf 2002) and summer temperatures are expected to reach 26°C with the proposed project (Corps 2020c).

Fall-run Chinook salmon abundance was estimated to decrease by 40%, which was the smallest change of the modeled salmon species. Similar to spring-run Chinook salmon, survival through the temporary trap-and-transport facility was assumed to be 66%. Unlike spring-run Chinook salmon, some fall-run Chinook salmon spawning was assumed to occur upstream of the temporary reservoir footprint. Additionally, these species are not holding in the river during the summer months like spring-run Chinook salmon (ICF 2019; Appendix A, Attachment A) and therefore are not as impacted by the higher summer temperature. Therefore, estimated abundance of fall-run Chinook salmon was less impacted by the habitat degradation associated with construction than spring-run Chinook salmon. Productivity and diversity also decreased for fall-run Chinook salmon by 21% and 54%, respectively.

Coho salmon abundance was estimated to decrease by 72%, productivity by 34%, and diversity by 83% during construction. These decreases were driven by the low passage survival rate of 41% assumed for adult passage through the temporary trap-and-transport facility (ICF 2019; Appendix A, Attachment A). Steelhead abundance was also estimated to decrease during construction by about 53%. Productivity and diversity were estimated to decrease by 26% and 38%, respectively. These decreases were also driven by an assumed low adult passage survival rate of 45%. The fish passage survival rates for coho salmon and steelhead were assumed to be low because these species migrate during the winter months when picket weirs are more likely to fail from weather and flow events. When the weirs fail, fish pass over, under, or around the structure (Schroeder 1996; Wilson et al. 2018).

6.4.2.1.2 Chehalis River 100-year Floodplain

EDT was also used to model habitat potential during construction from RM 98 to RM 108. This area is downstream of the flood retention facility and would be fully accessible to the modeled salmonid species throughout the construction phase. Because no construction activities would occur within this area, the main impacts affecting modeled salmonids would be from increases in temperature because of vegetation removal in the temporary reservoir footprint (ICF 2019; Appendix A, Attachment A). There would also be the potential for low indirect impacts related to changes in water quality and changes in habitat-forming process, as described in Sections 6.4.2.2.3 through 6.4.2.2.6.

EDT results show a decrease in abundance of 2% to 27% and a 7% increase in productivity up to a 14% decrease (Table 6.4-4). Fall-run Chinook salmon show an 11% increase in diversity, but all other species show a decrease in diversity of 43% to 78% (Table 6.4-4). The decreases are not as severe as in the flood retention facility project area (RM 108 to RM 114) but they are still considered high, particularly for spring-run Chinook salmon and steelhead, which have low current abundance (fewer than 50 fish of each species).

Table 6.4-4
Changes in Habitat Potential for Modeled Salmonids in the Chehalis River 100-Year Floodplain Study Area (RM 98 to RM 108) During Construction

SPECIES	2019 ABUNDANCE (NO. OF FISH)	CHANGE IN ABUNDANCE DURING CONSTRUCTION	CHANGE IN PRODUCTIVITY DURING CONSTRUCTION	CHANGE IN DIVERSITY DURING CONSTRUCTION
Spring-run Chinook salmon	30 to 40	-7%	+7%	-50%
Fall-run Chinook salmon	180 to 230	-13%	-14%	+11%
Coho salmon	70 to 90	-2%	+1%	-43%
Steelhead	15 to 20	-27%	-9%	-78%

6.4.2.1.3 Chehalis Basin Scale

At the Chehalis Basin scale, there was a small modeled increase in abundance for spring-run Chinook salmon and no change to slight decreases for fall-run Chinook salmon, coho salmon, and steelhead. Modeled productivity values only changed slightly for spring-run Chinook salmon and steelhead and were unchanged for coho salmon and steelhead. Modeled diversity changes were high for spring-run Chinook salmon and were low for fall-run Chinook salmon, coho salmon, and steelhead. These results are summarized in Table 6.4-5.

Table 6.4-5
Changes in Habitat Potential for Modeled Salmonids at the Chehalis Basin Scale During Construction

SPECIES	2019 ABUNDANCE (NO. OF FISH)	CHANGE IN ABUNDANCE DURING CONSTRUCTION	CHANGE IN PRODUCTIVITY DURING CONSTRUCTION	CHANGE IN DIVERSITY DURING CONSTRUCTION
Spring-run Chinook salmon	1,157 to 1,175	+1.3%	+1.8%	-12.0%
Fall-run Chinook salmon	39,239 to 39,415	0%	0%	-0.29%
Coho salmon	73,858 to 74,200	-0.1%	+0.1%	-0.51%
Steelhead	14,521 to 14,527	-0.1%	+1.0%	-1.30%

At the Chehalis Basin scale, spring-run Chinook salmon abundance is expected to increase by approximately 1.3% during construction, but estimated diversity is expected to be reduced by 12%. As shown in Figure 5.3-2, spring-run Chinook salmon spawn within the basin in the Skookumchuck, Newaukum, and South Fork Chehalis rivers, and the uppermost portion of the mainstem Chehalis River. This spawning distribution is the most limited of the modeled salmonid species, which means that impacts to any of these spawning areas individually could have a substantial impact on the species at the Chehalis Basin level. In a study conducted by Thompson et al. (2019a), field identifications of Chinook salmon as spring-run were associated with high rates of error (mis-identifying genetic fall-run Chinook salmon as spring-run), indicating that the total basin-wide population is likely smaller than estimated. However, because EDT reflects relative changes in habitat potential at each snapshot in time, it is still appropriate to make relative evaluations of the species at the Chehalis Basin level as well as the sub-basin level.

The life history advantage for spring-run Chinook salmon compared to the fall-run life-history is likely related to exclusive access to habitat, as discussed in Section 5.3.3.1.2. The construction of the flood retention facility would reduce diversity by restricting access to the upper most portion of the spring-run Chinook salmon spawning habitat. A temporary trap-and-transport facility would be constructed to move adults around the construction area to spawning areas above the construction zone, but fish passage survival would be reduced compared to No Action Alternative conditions. The spawning habitat within the temporary reservoir footprint would also be degraded from the removal of vegetation. This restriction could also lead to increased intermingled spawning of the spring-run Chinook salmon and fall-run Chinook salmon in the Chehalis Basin. A genetic study found that while spring-run Chinook salmon in upper Chehalis sub-basins above the proposed flood retention facility were not distinct from other spring-run Chinook salmon in the Chehalis Basin, they showed the most evidence of intermingling with fall-run Chinook (Thompson et al. 2019a, 2019b). This is important for determining impacts because recent studies have suggested that the genetic variation that controls run timing may be unrecoverable once lost (Thompson et al. 2019c). Because these modifications would last 5 years and limit access to spawning areas, construction impacts for spring-run Chinook salmon are expected to be high at the Chehalis Basin scale.

As shown in Figure 5.3-2, spawning areas for fall-run Chinook salmon are more expansive than for spring-run Chinook salmon. Also, as shown in Figure 5.3-3, spawning areas for coho salmon and steelhead occur in almost all available areas of the basin, including above the proposed flood retention facility site. However, fall-run Chinook salmon, coho salmon, and steelhead are expected to experience low impacts related to reduction in diversity because of restricted access to spawning habitat above the flood retention facility during construction. Because of the relatively high existing habitat potential, the expansive spawning areas throughout the Chehalis Basin, and the estimated no substantial change in abundance, productivity, and diversity (around 1% or less), construction impacts to fall-run Chinook salmon, coho salmon, and steelhead are expected to be low at the Chehalis Basin scale.

6.4.2.2 Other Fish, Freshwater Mussels, and Plant Species

The habitat changes resulting from Alternative 1 that are described in Section 6.4.1 would also have impacts on species other than the modeled salmonids. Lamprey, other native species, non-native species, freshwater mussels, plants, and special-status species could also be impacted during construction as discussed further below.

6.4.2.2.1 Habitat Loss and Impairment

The permanent loss of 2.05 acres of aquatic habitat because of fill and loss of trees within the Chehalis River riparian zone within the temporary reservoir footprint would impact aquatic species. This area is an important spawning area for salmonids and rearing area for lamprey. The filled habitat would no longer be accessible to aquatic species, which would reduce the amount of available habitat for aquatic species to spawn and rear. An additional 2.77 acres would be temporarily impacted during construction. This area would also not be accessible to aquatic species during construction but would be returned to existing conditions after construction. The permanent loss of trees within the riparian zone because of vegetation management activities within the temporary reservoir would also impact the ability of aquatic species to spawn and rear, particularly non-modeled salmonids, lamprey, and other native fish species. Overall, habitat loss and impairment are expected to impact the potential of the habitat to successfully produce native fish species. Therefore, this is expected to have a high impact on non-modeled salmonids, lamprey, and other native fish species within the temporary reservoir footprint. This is also expected to have a medium impact on freshwater mussels and plants.

6.4.2.2.2 Increased Water Temperatures

Pre-construction vegetation removal in the footprint of the temporary reservoir would result in removal of riparian vegetation. This is predicted to result in high increases in water temperature and associated decreases in dissolved oxygen in the mainstem Chehalis River between RM 100 and 114 from May and October in 2-year flow conditions. Similar to the modeled salmonids, this is expected to have the greatest impact on other salmonids and native species that require colder water for spawning and rearing.

Increased temperature would mainly affect species that use the reservoir area between May and October, which is all the salmonids, lamprey, and native species included in the life history timing figure (Figure 5.3-1). Under Alternative 1, removal of trees within the temporary reservoir during construction would reduce shade and increase water temperature between May and October because of solar heating. Juvenile salmonids could also be present during construction in these areas. Optimal temperatures for rearing are typically between 7°C and 14°C, with mortality exceeding 50% at temperatures over 17°C (Bergendorf 2002).

Salmon fry can become acclimated to warmer temperatures and growth rates may increase up to 17°C, however the increased growth rate may result in increased rates of descaling, disease, and mortality (Bergendorf 2002). Higher water temperatures have also been associated with early juvenile outmigration. Pacific lamprey embryo hatching is documented to occur at 15°C and significant death or deformation of eggs and ammocoetes occurs at 22°C (USFWS 2008). Optimal temperatures for western brook lamprey embryo and larval development fall between 10°C and 18°C (Santos et al. 2014). Less information is available about river lamprey, but ammocoetes are known to require high water quality and temperatures less than 25°C (Santos et al. 2014).

Based on data collected by Ecology (Ecology 2001, 2019b) and other state-funded studies (e.g., Anchor QEA 2012, 2014), summertime Chehalis River temperatures frequently exceed water quality criteria of 17.5°C and are often above or near 20°C in summer. Because the water temperature is currently above the upper range for optimal spawning and rearing, this impact is considered high for salmonids, lamprey, and other native fish species.

Mussels and plants may also be impacted by increases in temperature. The timing of glochidia (larvae) release and the amount of time larvae spend attached to host fish is strongly influenced by temperature for western pearlshells (Nedeau et al. 2009). In some systems, the release of larvae occurred between 10 and 15°C in late spring and early summer. This is cooler than existing conditions in the upper Chehalis River Basin, so it is difficult to determine how increased temperatures in the reservoir footprint would affect this species. Bryophytes (mosses and liverworts) are sensitive to both light and temperature and may experience photooxidation and a reduction in photosynthesis (Stream Bryophyte Group 1999). Because bryophytes can profoundly influence both the abundance and community structure of stream invertebrates (Stream Bryophyte Group 1999), this impact is considered medium.

The increase in water temperature could also change patterns of species distribution within the river. Elevated water temperature could expand the range of warm water predators into the temporary reservoir footprint and immediately downstream of the proposed FRE facility. Currently, largemouth or smallmouth bass have not been detected above the confluence with the South Fork Chehalis River, nor have any non-native fish species been detected upstream of Rainbow Falls (Winkowski et al. 2018a).

Because mussels have a lifecycle that depends on fish species, mussel distributions could also be altered as fish movements change. Increases in temperature could allow non-native plant species such as parrotfeather and Brazilian elodea to move further upstream. In the area downstream of the FRE facility to RM 100, there is greater likelihood that these two plant species could expand their range.

6.4.2.2.3 Decreased Dissolved Oxygen

Decreases in dissolved oxygen could impact aquatic species. Dissolved oxygen concentrations are expected to decrease by up to 0.2 mg/L because of the increases in temperature in the temporary reservoir footprint and downstream of the facility down to RM 100 from the proposed project compared to the No Action Alternative. Under current conditions, dissolved oxygen concentrations frequently do not meet the state water quality criterion of greater than or equal to 9.5 mg/L for CSSH between May and October within the temporary reservoir footprint and immediately downstream of the facility. To meet the state water quality standards (WAC 173-201A-200), the dissolved oxygen concentration associated with the proposed project cannot reduce the current dissolved oxygen concentration by more than 0.2 mg/L (Corps 2020c). The decrease in dissolved oxygen caused by the project is likely to be less than 0.2 mg/L, but because of the uncertainty and limitations of the models, it could be equal to, or greater than, the allowed decrease (Corps 2020c). Because the criterion is not met under the No Action Alternative and the expected decrease in dissolved oxygen with the proposed project is small, this impact is expected to be low for salmonids, lamprey, other non-native fish species, freshwater mussels, and plants.

6.4.2.2.4 Increase in Total Suspended Solids and Turbidity

Impacts caused by an increase in TSS and turbidity are expected to be limited to the flood retention facility project area and immediately downstream of the flood retention facility in the Chehalis River 100-year floodplain study area during construction, as described in more detail in Section 6.4.2.4.4.

6.4.2.2.5 Increased Risk of Spills and Leaks

Impacts caused by increased risk of spills and leaks are expected to be limited to the flood retention facility project area and immediately downstream of the flood retention facility in the Chehalis River 100-year floodplain study area, as described in more detail in Section 6.4.2.4.5.

Fish species could also be affected by changes in habitat-forming processes, including increases in fine sediment and decreased supply of LWM.

6.4.2.2.6 Increase in Fine Sediment

Fine sediment input is an important factor for determining habitat usability and quality (Nedeau et al 2009; Winkowski and Kendall 2018; Dolloff and Warren 2003). An increase in fine sediment could occur from the increased erosion and sedimentation from disturbing soils during construction or from disturbance to soils from large-scale tree removal in the temporary reservoir footprint. This increase in fine sediment could bury existing gravel and cobble substrate and aquatic plants or mussel species that are unable to move to avoid the fine sediment. It could also make habitat within the temporary reservoir footprint less suitable for fish spawning and rearing or shellfish settling. For salmonids, fine sediment loads can reduce inter-gravel water flow which reduces dissolved oxygen and limits embryo survival (Bergendorf 2002). Additional impacts from increases in fine sedimentation, such as giving advantage to fish, mussel, and plant species that prefer mud and sand substrate over gravel and cobble substrate over time, are described in Section 6.4.4.2.4.

Although there is a potential for these changes to habitat function to impact fish, freshwater mussels, and aquatic plants, minimization measures and BMPs would be in place during construction to minimize the input of fine sediment to the river and tributary streams from construction activities. Therefore, the changes in sediment input are expected to have low impacts on fish, freshwater mussels, and aquatic plants in the flood retention facility project area. These impacts would be less intense further downstream from the flood retention facility area. Increases in fine sediment would be limited to the area immediately downstream of the diversion tunnel outlet. Under normal flow conditions, these impacts would be low. However, under flows higher than designed for during construction (i.e., greater than a 3-year flood), impacts caused by increases in sediment load could be medium in both the flood retention facility project area and 100-year floodplain study area. This is because there would be a greater risk that additional fine sediment from the spoil piles would enter the water. However, the Applicant would require the contractor to prepare a plan for minimizing impacts when a greater-than-3-year flood is predicted to occur.

6.4.2.2.7 Decreased Supply and Transport of Large Woody Material

A decrease in LWM in the temporary reservoir footprint and downstream could impact fish species in the flood retention facility area and in the Chehalis River 100-year floodplain study area. LWM is important to habitat function because it creates pools that have cooler water and traps spawning size gravel upstream of wood creating spawning habitat (Davidson and Eaton 2015). Fish abundance has been shown to increase with more pools and salmonids are more abundant with pool-riffle sequences (Davidson and Eaton 2015). LWM also provides places for fish to rest and escape from predators. Because the Chehalis River is currently lacking in the supply of LWM because of past land use practices, this additional decrease in supply could have a medium impact on fish spawning and rearing habitat.

6.4.2.2.8 Reduced Supply of Prey Resources and Decrease in Overhanging Vegetation

Removal of trees in the temporary reservoir footprint could impact aquatic species by reducing overhanging vegetation cover and the availability of terrestrial prey sources. Both changes could impact juvenile and adult salmonids and other native species that use the habitat within the temporary reservoir for rearing and foraging. Riparian vegetation provides a way for terrestrial insect species to enter the water and for semi-aquatic insect species (e.g., mayflies, stoneflies, dragonflies) to complete their lifecycles. In aquatic food webs, insects serve as food items for many vertebrate and invertebrate predators, including salmonids and other fish (Hershey et al. 2010). Overhanging vegetation provides cover for fish and cooler areas to rest and hide from predators. Shade from overhanging vegetation also limits instream light levels which may control the distribution of aquatic vegetation. As described above, bryophytes (mosses and liverworts) are sensitive to light and may experience photooxidation without shade (Stream Bryophyte Group 1999). Reduced shading is expected to primarily affect mussels through increases in temperatures, as described above. Adult lamprey are primarily parasitic, while ammocoetes filter feed. Therefore, lamprey are expected to experience less negative effects from lack of prey input compared to salmonids and other jawed native fish. This impact would be medium on salmonids and other native fish species such as shiner, dace, and sculpins that eat insects because there are other sources of food and cover upstream and downstream of the temporary reservoir footprint. Streamside mosses that are overexposed to light would likely experience local high impacts.

6.4.2.2.9 Reduced Fish Passage

Because the temporary trap-and-transport facility would be designed consistent with NMFS and WDFW fish passage guidelines geared towards salmonids, other salmonids (mountain whitefish, coastal cutthroat, and rainbow trout) are expected to have fish passage survival rates similar to target salmonids. The target species for the temporary trap-and-transport facility design include the modeled salmonids and coastal cutthroat trout. Estimated fish passage survival values for these species are included in Table 6.4-6. Pacific lamprey is also included in Table 6.4-6 because of its cultural and historical importance. Because no upstream passage accommodations would be made for Pacific lamprey, other native fish, and juvenile salmonids during construction, these species are not expected to be captured and transported. However, if they are incidentally captured at the temporary trap-and-transport facility, they would be moved upstream above the construction area.

Mountain whitefish, coastal cutthroat trout, and rainbow trout are all documented above and below the trap-and-transport facility and are known to make migratory movements in the upper Chehalis River Basin. Based on field surveys in and above the temporary reservoir footprint, it is likely that Pacific lamprey spawn in areas above the proposed flood retention facility construction site (described in Section 5.3.3.2). Documented holding behaviors mean that Pacific lamprey would be unlikely to use spawning grounds on another tributary and would likely experience a high impact from not being able to move upstream of the trap-and-transport facility. Based on field surveys, suitable spawning habitat for mountain whitefish, coastal cutthroat, rainbow trout, speckled dace and largescale sucker also exists above the proposed flood retention facility construction site. However, there is a lack of research on the importance of these spawning areas. It is unclear how not allowing these species to move upstream of the trap-and-transport facility would impact their survival.

Adult steelhead and coastal cutthroat are expected to be able to use the diversion tunnel for downstream fish passage, but are expected to experience a medium impact related to the reduction in total survival by 22% to 26% compared to existing conditions (Table 6.4-6). However, the Applicant has not provided information on how adult kelts would bypass the picket weir once exiting the diversion tunnel. Kelts are expected to have poor physical condition and experience high mortality in response to downstream passage barriers. No passage or survival data were available to evaluate impacts of downstream passage through the diversion tunnel for other adult non-target salmonids or native fish. Fish passage and survival rates for modeled adult salmonids through the downstream diversion tunnel are further described in Section 3.3.2.1.1 of Appendix A.

Juvenile fish of many species including salmonids and lamprey are expected to be able to use the downstream diversion tunnel with relative ease. Juveniles of these species are expected to experience a low decrease in total survival by 5% to 15% from using the diversion tunnel compared to existing conditions (Table 6.4-6). Fish passage and survival rates for target juvenile salmonids through the downstream diversion tunnel are further described in Section 3.3.2.1.1 of Appendix A. The Applicant is not proposing to design the diversion tunnel to meet NMFS requirements for upstream passage of juvenile salmonids. Upstream passage through the diversion tunnel is not being considered because substantial design changes to the diversion tunnel would be required to approximate the natural channel in this section of river (HDR 2018; CRBFCZD 2019). Therefore, it is assumed that no upstream movement of juvenile salmonids, lamprey, or other native fish through the diversion tunnel would occur during construction. Although juvenile salmonids, lamprey, and other native fish are not a target life history stage for the temporary trap-and-transport facility, any that are incidentally captured and collected at the facility would be transported upstream of the construction area and released back to the Chehalis River. Juvenile salmonids, lamprey, and other native fish that are not incidentally captured would remain below the construction area. These upstream fish passage conditions would have additional negative effects on these species, and particularly on juvenile salmonids and Pacific lamprey that are known to make upstream migratory seasonal movements (Winkowski et al. 2016, 2019a).

Disruption of fish movement would also occur in road stream crossings that need to be upgraded as part of construction of the access and haul roads associated with quarry development. This disruption to fish passage is expected to be low and short-term.

Table 6.4-6

Fish Passage Performance and Survival Values during Construction

TARGET SPECIES	PERFORMANCE	SURVIVAL	TOTAL SURVIVAL[1,2]
UPSTREAM VIA TEMPORARY TRAP AND TRANSPORT			
Adult Spring-run Chinook Salmon	79%	98%	63%
Adult Fall-run Chinook Salmon	74%	98%	66%
Adult Coho Salmon	42%	98%	41%
Adult Steelhead	47%	98%	45%
Adult Coastal Cutthroat	Similar to coho salmon and steelhead[3]	Similar to other salmonids[3]	Similar to coho salmon and steelhead[3]
Adult Pacific Lamprey	N/A[2]	N/A[2]	N/A[2]
Juvenile Salmonids and Other Native Fishes	N/A[4]	N/A[4]	N/A[4]
ADULT DOWNSTREAM VIA DIVERSION TUNNEL			
Spring-run Chinook Salmon	--	--	--
Fall-run Chinook Salmon	--	--	--

TARGET SPECIES	PERFORMANCE	SURVIVAL	TOTAL SURVIVAL[1,2]
Coho Salmon	--	--	--
Steelhead (kelts)[2]	98%	75%	0%
Coastal Cutthroat (kelts)[2]	98%	80%	0%
Pacific Lamprey	--	--	--
JUVENILE DOWNSTREAM VIA DIVERSION TUNNEL			
Spring-run Chinook Salmon	100%	85%	85%
Fall-run Chinook Salmon	100%	85%	85%
Coho Salmon	100%	85%	85%
Steelhead	100%	95%	95%
Coastal Cutthroat	100%	85%	85%
Pacific Lamprey	100%	95%	95%

Notes:

Performance, Survival, and Total Survival values for all downstream adults and for downstream juvenile coastal cutthroat and Pacific lamprey were based on the *Chehalis Basin Strategy: Conceptual Combined Dam and Fish Passage Design Report*, Appendix G (HDR 2017).

1. Performance and Total Survival values for upstream adult passage of EDT modeled species (spring-run Chinook salmon, fall-run Chinook salmon, coho salmon, and steelhead) via temporary trap and transport were adjusted for picket weir capture efficiency and delayed mortality as described in Section 3.3.2.1.2 of Appendix A. Detailed calculations are provided in Attachment H of the same document.
2. Delayed survival for downstream moving kelts is 0% because of the picket weir barrier, resulting in 0% Total Survival.
3. Because the temporary trap-and-transport facility would be designed based on NMFS and WDFW fish passage guidelines geared toward salmonids, coastal cutthroat are expected to have similar survival rates to other winter migrating species.
4. Species with performance, survival, and total survival listed as "N/A" are not targeted for upstream passage, but would be moved upstream if they are collected. Therefore, these species would not be expected to pass through the temporary trap-and-transport facility.

--: No data are available or the species/life stage would not use passage in the given direction.

6.4.2.3 Marine Mammals

Based on the modeled basin-wide estimate of no substantial changes in abundance for all modeled salmonid species, there is expected to be a low impact on downstream marine mammal predators that rely on salmonids, at the end of construction (2030).

6.4.2.4 In-Water or Near-Water Work Impacts

In-water or near-water construction activities could temporarily impact aquatic species through direct disturbance, injury, or killing of aquatic species, increased underwater noise, entrainment or stranding of fish, increased turbidity, and increased risk of construction spills and leaks. Although these impacts are possible, minimization measures and BMPs would likely be implemented during construction to minimize the potential for construction activities to impact aquatic species. As such, these impacts are expected to be low for fish, freshwater mussels, and plants.

6.4.2.4.1 Direct Disturbance, Injury, or Killing of Aquatic Species

The placement of permanent and temporary fill in aquatic habitat could disturb, injure, or kill fish, shellfish, or plants that are in the vicinity of the construction work. Placement of the FRE facility, diversion tunnel inlet/outlet, spoil placement, haul roads, and temporary trap-and-transport facility would permanently impact aquatic habitat. Placement of the cofferdams, berms and staging areas would temporarily impact habitat. The placement of these structures would impact fish, freshwater mussels or plants located where the structures would be placed. However, BMPs and minimization measures would be implemented to minimize the potential for species to be present during the work and for the work to harm these aquatic species. For example, the in-water construction activities would occur during the in-water work window proposed by the Applicant (July 1 to September 30), when a low number of sensitive salmonids and other fish species are expected to be present. Additionally, work areas would be isolated from the rest of the river prior to the start of fill placement and fish would be removed from the isolated areas prior to construction.

Unlike fish, freshwater mussels and plants are not able to move to avoid placement of fill, so any present within the areas to be filled would be injured or killed during construction. Based on habitat settling preferences and field surveys, the western pearlshell mussel (a WNHP species) could be present in these construction areas. Water howellia, a federally listed plant species, could also be present, although the species has not been identified in field surveys to date. Freshwater mussels and plants would not be able to move to avoid injury. This impact is expected to be low because of the minimization measures and BMPs that would be implemented during the construction activities that could include moving freshwater mussel species to a safe location prior to construction if they are identified in the area.

6.4.2.4.2 Underwater Noise

Blasting noise levels are expected to be approximately 94 decibels (dB) at 50 feet in the air (Corps 2020e). Because noise levels increase by 6 dB at the air-water interface, the potential noise level in-water without accounting for any attenuation factors would be 100 dB (Navy 2011) at 50 feet. The Applicant has proposed blasting to occur at a minimum of 25 feet from the water's edge, but has also committed to implementing BMPs to reduce sound levels to below levels that have been shown to disrupt behavior in salmonids (i.e., 80 dB; Anchor QEA 2018a) and other fish species. Fish such as dace that have gas bladders connected to the ear structure may be more sensitive than salmonids, but there is limited research in this area (BOEM 2012). Freshwater mussels and aquatic plants are not expected to be affected by noise or vibration from blasting activities. Other construction equipment, such as rock drills, concrete batchers, and generators, could create ongoing noise and vibration, but blasting is expected to be the loudest noise- and vibration-generating activity.

Therefore, underwater noise and vibration from blasting associated with construction of the diversion tunnel and FRE facility and at the quarries to obtain rock for aggregate production is expected to have a temporary low impact on fish.

6.4.2.4.3 Entrainment and Stranding of Fish

Dewatering would occur during work area isolation for construction of the diversion tunnel portals, FRE facility, and any culvert upgrades needed on access and haul roads. During dewatering, there is a chance that fish could be entrained in a pump if one is used for dewatering or that fish could be stranded if water is removed too quickly. However, it is expected that prior to dewatering, fish removal would occur to relocate as many fish as possible. It is also expected that low dewatering rates would be used to allow for safe removal of fish from construction areas. If pumps are used to remove the water from the work areas, it is assumed that regulatory requirements would include fish screens to protect fish species such as salmonids. Additionally, during construction, water would be withdrawn from the river for 10 to 20 months to use for dust control, truck washing, and concrete production. The water withdrawal activities could strand fish if water is removed too quickly or entrain fish if pumps are used. However, the minimization measures described above would likely be implemented during these activities to reduce the potential for fish stranding or entrainment. Because of the minimization measures that are expected to be required, stranding or entrainment is expected to have a low impact on fish species present in the construction areas. Freshwater mussels and plants living in the portion of the channel that would be dewatered could also be stranded during the removal of water. Because the channel is a small proportion of the Chehalis River and freshwater mussels and plants could be relocated, this impact is expected to be low.

6.4.2.4.4 Increase in Total Suspended Solids and Turbidity

Impacts caused by turbidity are expected to be limited to the flood retention facility project area and immediately downstream of the flood retention facility in the Chehalis River 100-year floodplain study area. The impacts would be expected to decline with distance from the construction site. These impacts are considered low because minimization measures and BMPs would be required to limit erosion. Impacts to aquatic species caused by turbidity could be medium if a flow event greater than a 3-year flood occurred that would overcome the cofferdams and diversion tunnel set up to isolate the construction work areas (Corps 2020c). This is because there would be greater risk that additional fine sediment from the spoil piles would end up in the water. TSS could increase from movement of excavation or fill material from upland piles into the water. In the short term, high suspended solids in the water could block or damage fish and shellfish gills and smother plants, shellfish, fish eggs and larvae, and benthic macroinvertebrates (WDFW 2009).

Temporary low impacts to fish, freshwater mussels, and plant species could occur within the flood retention facility project area because of increases in turbidity, especially turbidity caused by suspended solids. However, the Applicant would require the contractor to prepare a plan for minimizing impacts when a flood greater than a 3-year flood is predicted to occur.

6.4.2.4.5 Increased Risk of Spills and Leaks

Impacts caused by potential spills and leaks are expected to be limited to the flood retention facility project area and immediately downstream of the flood retention facility in the 100-year floodplain study area. The impacts would be expected to decline with distance from the construction site. These impacts are considered low because minimization measures and BMPs would be required to minimize the potential for spills and equipment leaks to occur. Potential temporary low impacts to aquatic species could also occur in the flood retention facility project area if there is an accidental spill, including a spill of uncured concrete into the water. The pH of fresh water is normally between 6.5 and 8.5, but concrete spills can cause very alkaline water with a pH up to 13 (WDFW 2009). This can result in the direct killing of fish that often have a narrow range of pH tolerance (WDFW 2009). In rainbow trout, severe physiological effects occurred at a pH above 8.4 and mortality occurred at a pH of 9.3 (WDFW 2009). Other impacts from contaminant spills include physical damage, changes in behavior, and dispersal through the food web causing long term exposure through bioaccumulation (Wenger et al. 2017).

Impacts to aquatic species caused by an increased risk of spills and leaks could be medium if a flow event greater than a 3-year flood occurred that would overcome the cofferdams and diversion tunnel set up to isolate the construction work areas (Corps 2020c). This is because there would be greater risk that flows would reach work and storage areas and pollutants could end up in the water. However, the Applicant would require the contractor to prepare a plan for minimizing impacts when a flood greater than a 3-year flood is predicted to occur.

6.4.3 Aquatic Habitat – Operational Impacts

Potential operational impacts on aquatic habitat would occur as the result of high levels of change to habitat functions over time, mainly in the proposed footprint of the temporary reservoir, and the area immediately below the proposed FRE facility. Impacts to habitat during operation would result from high losses of habitat, high increases in the temperature of the river, decreases in dissolved oxygen, increased turbidity, and changes to habitat-forming processes. Changes in habitat-forming processes include changes in sediment amount, decreases in substrate size, decreases in the supply and transport of LWM, and reduced peak flows.

6.4.3.1 Habitat Loss and Impairment

Changes to aquatic habitat and habitat function because of the operation of the flood retention facility would happen over time. Two-year flow conditions would not trigger operation of the temporary reservoir. Two-year flow conditions are expected to occur most of the time with no loss of aquatic habitat because of inundation of the temporary reservoir footprint.

Major flood or greater conditions would occur on average once every 7 years and would trigger the impoundment of water behind the flood retention facility. During this type of event, the temporary reservoir would fill and empty within 32 days. When this happens, there would be a high impact on aquatic habitat in the flood retention facility project area from RM 108 up to RM 114. This impact would be caused by the formation of the temporary reservoir. Habitat within the temporary reservoir would change from fluvial to lacustrine for up to approximately 32 days in the lower elevations of the reservoir and for fewer days at the upper elevations. Fast-moving water would be contained and held back, creating a slow-moving reservoir condition. This change would eliminate existing spawning habitat for salmonids and native species in the temporary reservoir footprint. This habitat is considered EFH (spring and fall run Chinook salmon) and WDFW priority habitat (coho salmon, steelhead, and Pacific lamprey).

The effects of longer-term changes to habitat that would affect aquatic species over time are addressed in Section 6.4.4.

6.4.3.2 Increased Water Temperature

As noted in Section 6.4.1.2, vegetation clearing in the footprint of the reservoir would result in the permanent removal of riparian vegetation. This would result in increased temperature of the river under 2-year flows. With 2-year flows, increased temperature would occur between May and October (Corps 2020c) each year in the temporary reservoir footprint and in the Chehalis River 100-year floodplain study area downstream of the proposed FRE facility to the Elk Creek confluence near RM 100. Increased temperature would have high impacts on spawning habitat in the fall.

In years when there was an impoundment event and the temporary reservoir was operating, temperature-related impacts could be reduced compared to the No Action Alternative. These impacts are expected to be low if flood inundation occurs in the spring with a potential for medium impacts if flood inundation occurs in the fall. Impacts to habitat function from increased water temperatures are described in Section 6.4.1.2.

In addition, PHABSIM modeling was conducted to evaluate the impacts of temperature increases during operation on the habitat of a subset of native species during 2-year flow conditions. The native species used in the modeling included largescale sucker, mountain whitefish, Pacific lamprey, and speckled dace. Major or greater flood flows were not modeled because data do not exist to support this effort as described in Normandeau (2012). As such, differences in usable habitat were only driven by temperature changes caused by project operations. PHABSIM results for the temporary reservoir area estimate between a 5% and 15% loss of habitat for most species, life stages, and months (Table 6.4-7) because of the proposed project. However, there were some months in which much higher losses in habitat were estimated for various species. In the months of May and June, largescale sucker spawning habitat was estimated to decrease by approximately 30%, and in June speckled dace spawning habitat was estimated to decrease by 90%. In July, Pacific lamprey spawning habitat was estimated to decrease by 39% and speckled dace adult and juvenile rearing habitat was estimated to decrease by 33%. Potential mountain whitefish spawning habitat above the proposed FRE facility is estimated to be 100% lost.

Table 6.4-7
Physical Habitat Simulation Modeling Results for Native Fish Species Upstream of the FRE Facility

REACH	SPECIES	LIFE STAGE	PERCENT CHANGE IN USABLE HABITAT					
			MAY	JUN	JUL	AUG	SEP	OCT
Upper Chehalis (Upstream of the FRE/FRO Facility)	Largescale Sucker	Juvenile Rearing	-4%	-4%	-14%	-6%	-2%	-4%
		Spawning	-28%	-33%				
	Mountain Whitefish	Adult Rearing	-7%	-8%	-13%	-6%	-3%	-7%
		Juvenile Rearing	-7%	-8%	-13%	-6%	-3%	-7%
		Spawning					-100%	0%
	Pacific Lamprey	Juvenile Rearing	-4%	-7%	-18%	-7%	-6%	-4%
		Spawning	0%	-7%	-39%			
	Speckled Dace	Adult Rearing	-4%	-4%	-33%	-11%	-2%	-1%
		Juvenile Rearing	-4%	-4%	-33%	-11%	-2%	-1%
		Spawning	0%	-90%				

Month not relevant to life history | No change in habitat | Increasing loss in habitat

Note:
Mainstem water temperature data are from the PSU CE-QUAL-W2 model inputs to EDT.

In the Chehalis River 100-year floodplain study area, modeling results estimated no changes in spawning or rearing habitat in May and October for any species. However, estimates of available habitat decreased by over 15% for some species and life stages between June and September. In June, estimates of spawning habitat decreased by 17% for largescale sucker and 67% for speckled dace. In July, Pacific lamprey estimated spawning habitat decreased by 17%, speckled dace adult and juvenile rearing habitat estimates decreased by 14%, and mountain whitefish rearing habitat estimates decreased by 16%. Speckled dace usable spawning habitat estimates decreased by 90% in June (Table 6.4-8).

PHABSIM modeling for non-native predators (largemouth and smallmouth bass) was also completed for Pe Ell to Elk Creek. Results showed a 6% loss in usable habitat in August (Table 6.4-9). It is unclear whether or how this would change the distribution of these species relative to native fishes because bass were only modeled in one reach. There is potential that, as temperatures warm, largemouth and smallmouth bass would extend their range further upstream (Winkowski et al. 2016).

PHABSIM modeling for habitat for salmonid species was also performed in the flood retention facility project area and Chehalis River 100-year floodplain study area. The results were used as inputs to the EDT model, which is discussed in Section 6.4.4.1. As such, PHABSIM results for salmonid species are not reported in this section.

Table 6.4-8
Physical Habitat Simulation Modeling Results for Native Fish Species from Pe Ell to Elk Creek

REACH	SPECIES	LIFE STAGE	PERCENT CHANGE IN USABLE HABITAT					
			MAY	JUN	JUL	AUG	SEP	OCT
Pe Ell to Elk Creek (Downstream of the FRE/FRO Facility)	Largescale Sucker	Juvenile Rearing	0%	-2%	-7%	-18%	-4%	0%
		Spawning	0%	-17%				
	Mountain Whitefish	Adult Rearing	0%	-5%	-6%	-16%	-8%	0%
		Juvenile Rearing	0%	-5%	-6%	-16%	-8%	0%
		Spawning						0%
	Pacific Lamprey	Juvenile Rearing	0%	-4%	-9%	-23%	-7%	0%
		Spawning	0%	-4%	-17%			
	Speckled Dace	Adult Rearing	0%	-2%	-6%	-14%	-4%	0%
		Juvenile Rearing	0%	-2%	-6%	-14%	-4%	0%
		Spawning	0%	-67%				

Month not relevant to life history | No change in habitat | Increasing loss in habitat

Table 6.4-9
Physical Habitat Simulation Modeling Results for Non-Native Fish Species from Pe Ell to Elk Creek

REACH	SPECIES	LIFE STAGE	PERCENT CHANGE IN USABLE HABITAT					
			MAY	JUN	JUL	AUG	SEP	OCT
Pe Ell to Elk Creek	Largemouth Bass	Juvenile Rearing	0%	0%	-2%	-6%	-1%	0%
	Largemouth Bass	Spawning	0%	0%				
	Smallmouth Bass	Juvenile Rearing	0%	0%	-2%	-6%	-1%	0%
	Smallmouth Bass	Spawning	0%	0%				

Month not relevant to life history — Increasing loss in habitat

6.4.3.3 *Decreased Dissolved Oxygen*

Similar to construction, a medium long-term reduction in dissolved oxygen not meeting the state water quality criterion is predicted in the temporary reservoir and downstream of the FRE facility to RM 100 between May and October. This long-term reduction in dissolved oxygen associated with temperature increases during 2-year flows. Because the background dissolved oxygen concentrations are frequently lower than the applicable criterion (CSSH) of 9.5 mg/L for CSSH in the summer, any decrease in dissolved oxygen more than 0.2 mg/L (WAC 173-201A-200) would not meet the water quality criterion. This water quality criterion was developed to be protective of CSSH. The decrease in dissolved oxygen caused by the project is likely to be less than 0.2 mg/L, but because of the uncertainty and limitations of the models, it could be equal to, or greater than, the allowed decrease (Corps 2020c). As such, salmonid habitat could be impacted.

6.4.3.4 *Increase in Total Suspended Solids and Turbidity*

A low increase in turbidity above state water quality criteria is predicted to occur from re-suspension of fine sediment (silt and clay-sized particles) within the temporary reservoir during the first non-impounding storm following an impoundment (Corps 2020c). Additionally, during drawdown of the reservoir, turbidity water quality criteria are expected to be exceeded for 28 days, with the highest turbidity occurring during the final stages of reservoir drawdown (Anchor QEA 2019b; Corps 2020c). These turbidity impacts would occur within the temporary reservoir footprint and continue immediately downstream in the Chehalis River 100-year floodplain study area. The intensity of the impact would decrease further downstream. In addition, there would be a low increase in the potential for water quality degradation in tributaries adjacent to access roads from sediments and contaminants washed into them by stormwater runoff from the road surface. Habitat function impacts because of increased TSS and turbidity are described in Section 6.4.1.4.

6.4.3.5 Changes to Habitat-Forming Processes

Changes in habitat-forming processes could occur during operation. Over the life of the proposed project, there would be changes in sediment amount, a decrease in substrate size, a decrease in the supply and transport of LWM, and reduced peak flows. Taken together, all these impacts to habitat-forming processes could be high on spawning and rearing habitat for salmonids, non-salmonid native species, freshwater mussels, and plants within the temporary reservoir and downstream to RM 98. Impacts between RM 98 and 75 are considered low to salmonid habitat because most of the salmonid spawning habitat is located above RM 98 (Ronne et al. 2018). Impacts to habitat for non-salmonid native species, freshwater mussels, and plants are considered medium.

Geomorphology field studies have found that supply of LWM in the upper Chehalis River Basin is low for an unmanaged stream of its size under existing conditions, as described in Section 5.2. Most LWM input from the mainstem Chehalis River and transport downstream is currently from landslides during large floods, which would no longer occur under Alternative 1. The removal of trees and continued maintenance of tree removal in the temporary reservoir footprint would decrease the overall supply of LWM as mentioned in Section 6.4.1.7. When the proposed flood retention facility is not impounding water, smaller LWM (i.e., smaller than 3 feet by 15 feet) would be moved downstream through the conduits. This would happen during flows that are less than major flood conditions, causing the LWM to be moved a shorter distance downstream than under No Action Alternative conditions. During impoundment, LWM would accumulate in the temporary reservoir and smaller LWM would move downstream during drawdown (Anchor QEA 2019a). Wood larger than 3 feet by 15 feet would be captured by log booms upstream of the flood retention facility or by steel racks at the facility. This wood would be captured, cut up, and disposed (Anchor QEA 2019a). Some wood, if deemed suitable for habitat restoration projects, would be preserved and trucked out of the reservoir area (Anchor QEA 2019a). Some of the LWM collected in the temporary reservoir during inundation could deposit above the active channel during free run of the Chehalis River and would not be transported downstream over the life of the flood retention facility. Overall, there would be less LWM in the study area as a result of Alternative 1. The importance of LWM in forming critical fish habitat elements is described in Section 6.4.1.6.

Over a 30-year time period, assuming impoundment approximately once every 7 years, geomorphology modeling predicts a net accumulation of up to 240,000 tons of sediment within the temporary reservoir footprint with an increase in fine sediment (Corps 2020d). Additional sediment would be expected to accumulate over the 55-year life of the project. Fine sediment would accumulate in the temporary reservoir during impoundment and would move downstream during drawdown. In this case, fine sediment in accumulated gravel deposits would have the opportunity to be flushed through the reservoir footprint during years when there is no impoundment and surficial substrate would be relatively free from fines (WGD and Anchor QEA 2017). The cycle of flushing would be critical to maintaining usable spawning habitat for salmonids, and general habitat quality for other native fish and mussel species.

Some of the sediment collected in the temporary reservoir during inundation could deposit above the active channel during free run of the Chehalis River and would not be transported downstream over the life of the flood retention facility. Root decay of trees removed from the inundation zone would cause some landslides over time, which would add to the amount of fine sediment in the river and stream channels within the temporary reservoir footprint. Increased fine sediment movement during less than major floods could result in more active channel migration within the impounded area compared to existing conditions.

The geomorphology modeling also predicts a net reduction of approximately 70,000 tons of sediment storage over time below the proposed FRE facility to approximately RM 81.6. Downstream of RM 81.6, the model predicts low to medium impacts from changes in sediment transport. The decrease in sediment downstream could be caused by the decreased load from above the proposed FRE facility, increased erosion, or both (Corps 2020d). This would also correspond with an increase in fine sediment down to RM 86 and a reduction in LWM down to RM 75 (Corps 2020d).

Operation of the proposed FRE facility would also result in lower peak flows because major or greater flows would be contained behind the FRE facility. This condition would impact habitat function in various ways. Not allowing the river to flow freely during these peak flow events would prevent scouring of the riverbed within the temporary reservoir and immediately downstream of the facility in the Chehalis River 100-year floodplain study area. Scouring of the riverbed impacts fish species by disrupting the benthic community, which is a prey resource for salmonid and native fish. Also, scouring could disrupt spawning beds or eggs placed in spawning beds prior to a flood condition. Therefore, reducing scour could be a possible benefit.

However, without peak flows, some channel-forming and habitat-forming processes would be hindered. These higher flows would not move sand and gravel around creating conditions that would allow vegetation to grow on the gravel. The vegetation could then stabilize the gravel and create a more defined channel with a narrower width (Brooker 1985). When this occurs, meandering channels are not able to form. Floods also cleanse spawning gravel, redistribute silt, and cause bank avulsions that are a major source of spawning gravel (Ferguson 2020). As such there would be less spawning and rearing habitat in this area. Lower peak flows would also reduce the amount of floodplain inundation in the Chehalis River 100-year floodplain study area. Less flood inundation would mean fewer times the river would connect to off-channel habitat, again reducing the amount of habitat for native species, including lamprey that use off-channel wetlands that are seasonally connected to the river. This could impact important rearing habitat for salmon (Henning et al. 2006) and for the native species that use these off-channel areas. Therefore, reducing peak flows would have a high adverse impact on some habitat-forming processes.

6.4.3.6 Climate Variability

As noted in Section 5.4, precipitation patterns could change and become more extreme in the future, for example, as the result of climate variability. If the frequency and amount of rain increased, a major (10-year) or catastrophic (100-year) flood could occur more frequently. This would increase the frequency that the FRE facility would operate and impound water compared to the No Action Alternative. This would result in more frequent adverse impacts in the footprint of the temporary reservoir mainly from loss of habitat and reduced fish passage compared to the No Action Alternative. This would also more negatively impact aquatic habitat (as described in Sections 6.4.3.1 through 6.4.3.5).

Including climate variability would also increase the habitat benefits associated with operation of the FRE facility. For example, with increased major or greater flooding under the No Action Alternative, bed scour in the higher gradient areas of the Chehalis River 100-year Floodplain Study Area (i.e., between RM 98 and RM 108) would be greater than what is described in Section 6.4.3.5. Therefore, impounding water behind the FRE facility may result in improved conditions because major or greater flooding would no longer occur and bed scour would be reduced. Similarly, with less bed scour, macroinvertebrates would not be disturbed as often under Alternative 1 compared to the No Action Alternative.

6.4.4 Aquatic Species – Operational Impacts

Operational impacts on aquatic species would range from low to high. High impacts on aquatic species would occur mainly as the result of indirect impacts caused by the loss or impairment of habitat. These indirect impacts on modeled salmonids, other fish, freshwater shellfish, plants, and marine mammals are described in Sections 6.4.4.1 through 6.4.4.3.

6.4.4.1 Modeled Salmonids

Operation of the proposed FRE facility could result in low to high impacts on salmonids in the flood retention facility project area, the Chehalis River 100-year floodplain, and the Chehalis Basin overall. Salmonid survival in these areas and at the basin-scale would be adversely affected compared to the No Action Alternative. The impacts of Alternatives 1 and 2 would be generally worse in years when the FRE facility is impounding water. When the FRE facility is impounding water, the impacts would be mainly because of the loss of spawning and rearing habitat and blocked downstream and reduced upstream fish passage. When the FRE facility is not impounding water, the impacts would be mainly because of temperature increases in the river, decrease in the supply of terrestrial prey species, and anticipated reductions in fish passage survival.

The indirect impacts on salmonids from habitat changes were modeled using EDT and integrated EDT-LCMs.[2] The modeling was done to evaluate how habitat changes could impact salmonid habitat potential measured as changes in abundance, productivity, and diversity (see Section 6.2.1 for definition of these terms). The modeling also evaluates how the habitat potential may change over time. Results

[2] As noted in Section 6.2, EDT covers the entire Chehalis Basin and modeled the effects of the proposed action from RM 98 to RM 114.

are provided for RM 108 to RM 114 of the flood retention facility project area, RM 98 to RM 108 of the Chehalis River 100-year floodplain study area, and for the Chehalis Basin overall (Figure 6.4-1). Outside of these areas, the potential impacts on modeled salmonids are addressed qualitatively.

The following subsections summarize the results of the fish modeling at the scale of the flood retention facility project area, the Chehalis River 100-year floodplain study area, and the Chehalis Basin (WRIAs 22 and 23).

6.4.4.1.1 *Flood Retention Facility Project Area*

As noted in Section 5, the flood retention facility project area is an important spawning area for spring-run and fall-run Chinook salmon. Operations would adversely affect salmonids in this area based on the following assumptions for how the FRE facility would adversely affect habitat.

During 2-year flow years, fish modeling assumed habitat in the mainstem Chehalis River and tributaries within the temporary reservoir footprint above the proposed FRE facility would be altered by ongoing vegetation management and previous impoundment events (ICF 2019; Appendix A, Attachment A). Specifically, habitat within the reservoir footprint was assumed to be degraded for riparian function (e.g., increased water temperature between May and October) and reduced supply of prey resources. Passage of adult and juvenile fish at the facility was slightly reduced because of the assumption that negotiating the conduits would be more difficult than during free-flowing conditions (ICF 2019; Appendix A, Attachment A).

During an impoundment event, the modeling assumed that all salmon spawning and egg production within the temporary reservoir footprint would be eliminated for that year. Spawning in this area would resume in subsequent years after the fine sediment is flushed out by flows following the impoundment event. The modeling also assumed habitat above the footprint of the temporary reservoir (RM 114 and above) would be unchanged. Production of the modeled species could continue in streams above the reservoir footprint and adult and juvenile life stages could freely pass through the reservoir. Reduced survival of adult fish was assumed to occur during a closure event from going through the CHTR facility. Additionally, within the temporary reservoir footprint, bed scour, LWM, embeddedness (i.e., the extent to which sand, and gravel substrate is surrounded by or covered by fine sediment), riparian condition and benthic invertebrates were all hypothesized to be degraded. Downstream of the proposed flood retention facility, LWM was assumed to be reduced, and temperature was assumed to increase if impoundment occurred in the fall. However, bed scour was assumed to be reduced because of attenuation of the flood by the proposed FRE facility (ICF 2019; Appendix A, Attachment A).

The results of EDT modeling are summarized in Table 6.4-10 for all four species. All individual EDT results for the different scenarios are discussed by species below and are shown in Figures 6.4-1 through 6.4-4. Additional detail is provided in Appendix A, Attachment A. Results from the EDT-LCMs are summarized in Table 6.4-11. Additional information on these results is presented in Appendix A, Attachment B.

As explained further in Appendix A, Attachments A and B, the results for the 10-year and 100-year floods are generally similar. This is because, in EDT, river flows were used to determine average monthly channel widths. Flows for the entire year in which a 10-year and 100-year flow event occurred were used to derive channel widths in the model. As such, the 10-year and 100-year floods were brief episodic events within their respective flow years. EDT uses flow and the resulting channel width as a monthly average that is not responsive to brief, episodic events such as a flood lasting a few days unless it affects the monthly average flow and channel width. Because of this, the flood scenarios (2-year, 10-year, and 100-year) do not represent a progression of increasing average flows and channel width did not change substantially between a 10-year and 100-year flood scenario.

Table 6.4-10
Changes in Habitat Potential for Modeled Salmonids in the Flood Retention Facility Project Area (RM 108 to RM 114) During Operations

		ALTERNATIVE 1 COMPARED TO THE NO ACTION ALTERNATIVE					
		2-YEAR FLOOD		10-YEAR FLOOD		100-YEAR FLOOD	
SPECIES	METRIC	2040	2080	2040	2080	2040	2080
Spring-run Chinook salmon	Abundance	-40%	-37%	-100%	-100%	-100%	-100%
	Diversity	-31%	-21%	-100%	-100%	-100%	-100%
	Productivity	-19%	-19%	-91%	-90%	-91%	-90%
Fall-run Chinook salmon	Abundance	-22%	-22%	-64%	-64%	-68%	-67%
	Diversity	-46%	-38%	-74%	-70%	-75%	-68%
	Productivity	-15%	-15%	-24%	-25%	-26%	-26%
Coho salmon	Abundance	-23%	-24%	-43%	-37%	-44%	-37%
	Diversity	-27%	-27%	-26%	-24%	-23%	-25%
	Productivity	-6%	-6%	-12%	-7%	-10%	-7%
Steelhead	Abundance	-14%	-14%	-18%	-16%	-21%	-20%
	Diversity	-13%	-10%	-17%	-13%	-20%	-15%
	Productivity	-3%	-5%	-3%	-5%	-2%	-4%

Table 6.4-11 provides a summary of the integrated EDT-LCMs results and shows the median estimate of abundance during the operation of the flood retention facility between 2030 and 2080 compared to the No Action Alternative. Table 6.4-11 also provides the amount of yearly variation in the estimate of median abundance. The yearly variation is a measure of how stable the median abundance estimates are expected to be. A large range indicates that the estimates are not stable and not likely to occur each year. A small range indicates that the estimates are more stable and likely to occur each year.

Table 6.4-11

Summary of Long-term Salmonid Abundance and Variation Above the Proposed Flood Retention Facility

	NO ACTION ALTERNATIVE		ALTERNATIVES 1 AND 2: FLOOD RETENTION FACILITY	
SALMON SPECIES	MEDIAN OF YEARLY ABUNDANCE ESTIMATES[1]	PERCENT OF ESTIMATED YEARLY ABUNDANCE VARIATION[2]	MEDIAN OF YEARLY ABUNDANCE ESTIMATES[1]	PERCENT OF ESTIMATED YEARLY ABUNDANCE VARIATION[2]
Spring-run Chinook	70 to 75 fish	about 6%	about 15 fish	over 100%
Fall-run Chinook	180 to 195 fish	about 3%	135 to 140 fish	about 45%
Coho	810 to 870 fish	about 4%	525 to 550 fish	about 17%
Steelhead	820 to 935 fish	about 1%	670 to 780 fish	about 5%

Notes:

Results are from the integrated EDT-NOAA LCMs.

1. Range of median values in years 63 to 99 (late-century).
2. Percent of estimated yearly abundance variation is based on the range of possible estimates of habitat potential (abundances) as a percent of the median yearly values for years 63 through 99 (late-century).

A summary of the salmonid modeling results for RM 108 to RM 114 by species is provided in the following subsections. These results represent the overall effect of Alternative 1. This considers the impacts of the proposed FRE facility that are predicted by EDT to happen when the temporary reservoir is holding water (approximately once every 7 years) and the other years when it is not. It also considers the results of the EDT-LCMs integrated models for how the species would be affected over time.

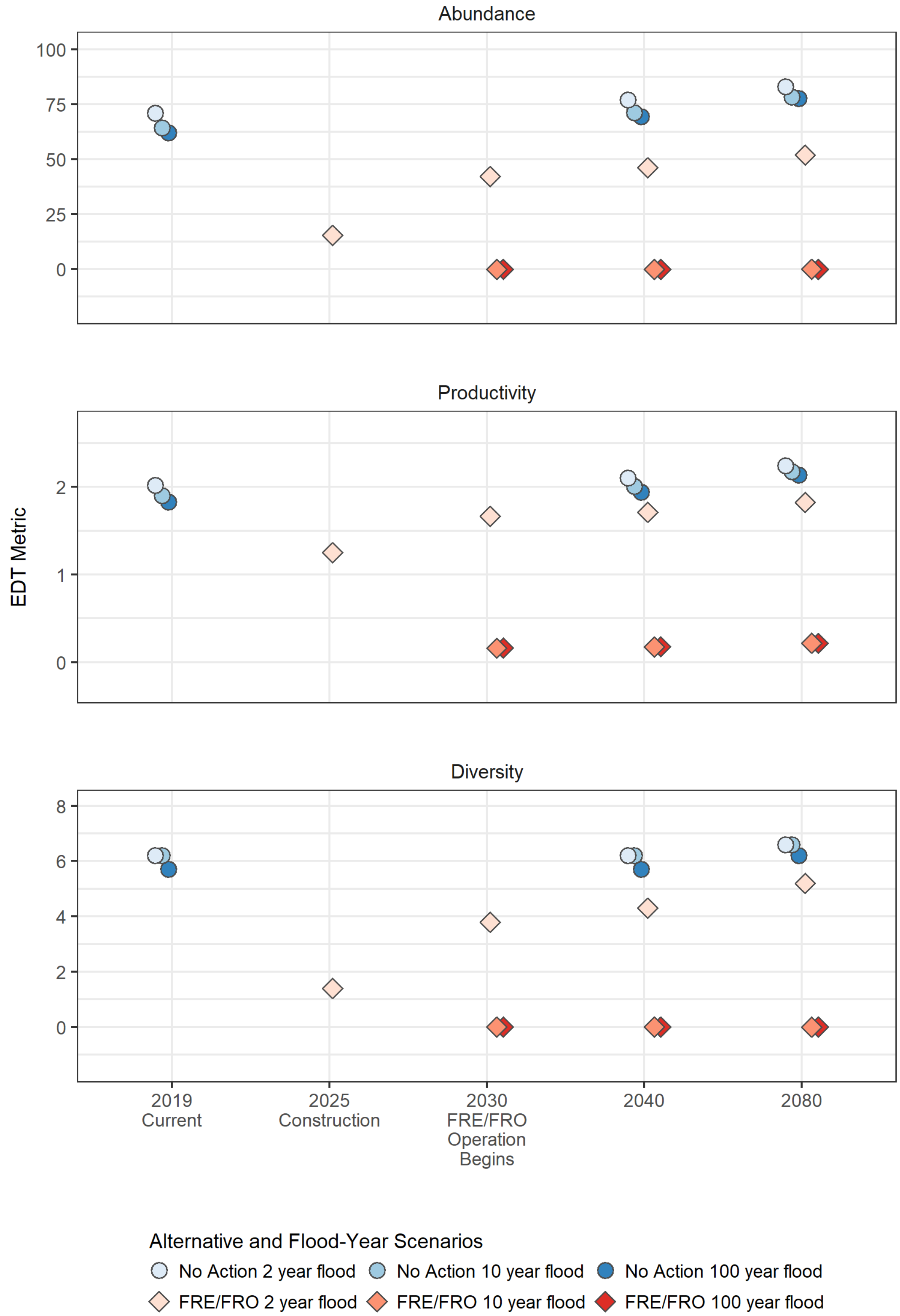
Spring-run Chinook Salmon

Alternative 1 would have a high impact on spring-run Chinook salmon in the flood retention facility project area. The impact would mainly occur as the result of adverse effects on habitat potential from RM 108 to RM 114 from operations. In years when the FRE facility impounds water, habitat potential in this area would decline by 90% to 100% (Table 6.4-10, Figure 6.4-1). This means in years when the FRE facility was operating, there could potentially be no spring-run Chinook salmon production in the river between RM 108 to RM 114. This would occur approximately once every 7 years. In years when the FRE facility is not impounding water, habitat potential in this area would decline by 19% to 40%. This condition would occur most of the time.

Over time, assuming that flooding happens at a time when the most detrimental impacts on the species could occur (i.e., during spawning), abundance in this area would decline from 70 to 75 fish under the No Action Alternative to about 15 fish under Alternative 1 (Table 6.4-11, Figure 6.4-1). This estimate considers both conditions when the flood retention facility would and would not impound water. The long-term estimated abundance of 15 fish is higher than the estimate for a year when an impoundment happens. During an impoundment year, EDT abundance is assumed to be zero fish because of productivity values much less than one. Productivity values less than one but greater than zero mean that the fish are not replacing themselves and the population is shrinking. The long-term prediction assumes productivities less than one result in some fish production during those years rather than no fish production. Also, the long-term prediction assumes that spawning would occur within the footprint of the temporary reservoir in the years when no impoundment happened. Over the long-term, most years would not have impoundment. The long-term estimate of abundance considers this.

It is unclear whether an abundance of 15 fish would be a biologically sustainable population. A viable population is one that has little to no risk of extinction over the next 100 years as a result of genetic change, demographic randomness, or normal levels of environmental variability (McElhany et al. 2000). In addition, a viable population should also be able to withstand catastrophic events and long-term demographic and evolutionary changes (McElhany et al. 2000). It is unclear whether such a small population of Chinook salmon above the proposed flood retention facility would be sustainable under these criteria. These results indicate that there is little difference between flood years in estimates of abundance from operating the flood retention facility after the initial reduction caused by construction.

Figure 6.4-1
EDT Modeling Results for Spring-Run Chinook Salmon: Above the Flood Retention Facility



If a back-to-back flood occurs, modeling shows a reduction in abundance a few years after the back-to-back event occurs, after which the habitat potential recovers to approximately 15 fish. There is little variation associated with this temporary decrease, meaning that it is likely to occur. This temporary reduction in habitat potential does not occur under the No Action Alternative, indicating that the reduction is associated with the operation of the proposed flood retention facility.

The reductions in habitat potential during a major or greater flood are the maximum changes expected and result from the assumption that there would be complete destruction of spawning habitat in the temporary reservoir when the flood retention facility impounds water. This is because the model assumed a storm would occur at some point between September and February. This timing covers spawning, egg incubation, hatching, and emergence prior to smolt outmigration for spring-run Chinook salmon (Figure 5.3-1). If a storm were to occur during any of these months, it is assumed that spawning habitat would be destroyed, eggs and alevins living in the gravel would suffocate, and most newly emerged fry would not survive reservoir conditions. The 100% drop in habitat potential during major or greater flood conditions is mainly because all spawning was assumed to occur in the mainstem within the temporary reservoir footprint for this species (Appendix A). The reduction in habitat potential during a major or greater flood is predicted to occur approximately once every 7 years. As such, not all year classes would experience this level of impact.

Impacts to spring-run Chinook salmon would also be expected to occur even when the temporary reservoir is not impounding water, which would occur most of the time. These impacts would be less severe than during a major or greater storm and are related to adverse effects on aquatic habitat that would occur over time as the result of decreased riparian shading in the footprint of the temporary reservoir, reductions in LWM recruitment, and reduced fish passage survival. In addition, TSS is expected to increase when the temporary reservoir releases water, resulting in a high increase in turbidity during drawdown.

The removal of trees is expected to cause the river temperature to increase and dissolved oxygen levels to decrease within the temporary reservoir during 2-year flow conditions, especially between May and October. This could negatively impact spring-run Chinook salmon during the summer holding period prior to spawning. During this time, the adults search for cold water to help them survive through the summer. The increased temperature condition would occur every summer over the operational period. Another impact from the reduction of trees in the temporary reservoir is reduced prey resources for salmonids from the lack of terrestrial insects dropping into the water. The reduction in LWM would reduce the number of pools and reduce holding and hiding areas for adult and juvenile fish. Periodic turbidity increases could cause fish to avoid otherwise suitable habitat, reduce foraging success, cause damage to gills, and reduce swimming speed (Lehman et al. 2017; Wenger et al. 2017).

Fall-run Chinook Salmon

Alternative 1 would have a high impact on fall-run Chinook salmon in the flood retention facility project area. The impact would mainly occur as the result of adverse effects on habitat potential from RM 108 to RM 114 (Figure 6.4-2). In years when the FRE facility impounds water, habitat potential in this area would decline by 24% to 75% (Table 6.4-10). This means that in years when the FRE facility was operating, there would be less fall-run Chinook salmon production in the river between RM 108 to RM 114. This would occur approximately once every 7 years. In years when the FRE facility is not impounding water, habitat potential in this area would decline by 15% to 46%. This would occur most of the time. Over time, abundance in this area would decline from 180 to 195 fish under the No Action Alternative to about 135 to 140 fish under Alternative 1 (Table 6.4-11). This estimate considers both conditions when the flood retention facility would and would not impound water. These results indicate that there is little difference between flood years in estimates of abundance from operating the facility after the initial reduction caused by construction.

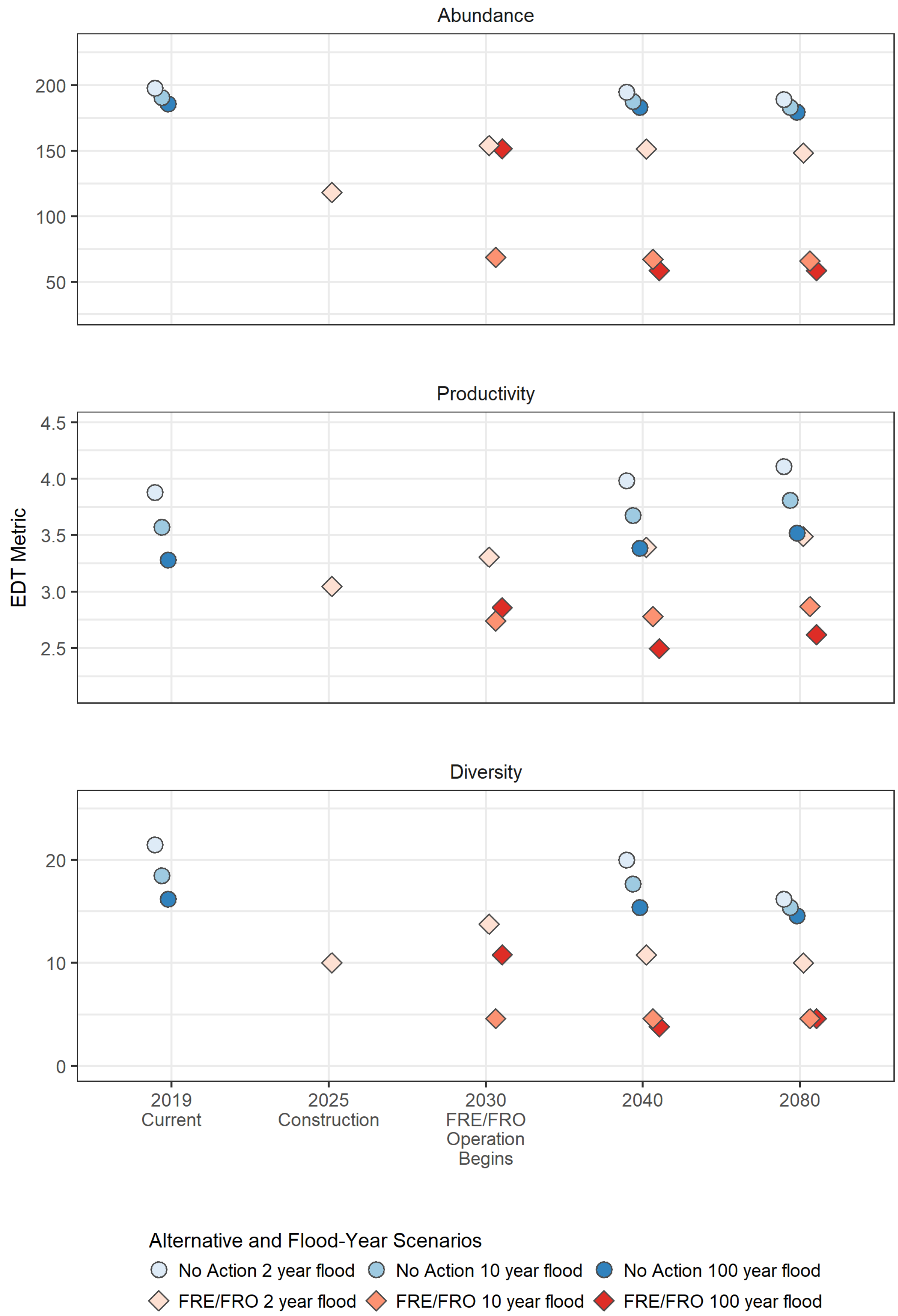
For a recurring flood, a reduction of abundance equal to approximately 50 fish (approximately 30% of the mid-century population) is observed a few years after the back-to-back event occurs. This temporary reduction in abundance occurs because there are 2 years in a row when spawning within the temporary reservoir footprint is not successful. This reduction is not estimated under No Action Alternative conditions, indicating that it is associated with the operation of the flood retention facility. A few years after the back-to-back flood, the habitat potential is estimated to recover to approximately 140 fish.

The potential impacts in non-impoundment years would occur over time as the result of decreased riparian shading in the footprint of the temporary reservoir. In addition, impacts would occur from reductions in LWM recruitment, and reduced fish passage survival. TSS is also expected to increase when the temporary reservoir releases water, resulting in a high increase in turbidity during drawdown. These impacts would occur over time regardless of whether the FRE facility impounded water and would be less overall compared to impacts that would occur in the years when the FRE facility was impounding water.

For fall-run Chinook salmon, the maximum reduction in habitat potential during major or greater flood conditions is mainly attributed to the reduction in spawning within the temporary reservoir. For fall-run Chinook salmon, 66% of spawning above the proposed flood retention facility was assumed to occur within the reservoir footprint (Appendix A, Attachment A). A portion of the spawning was also assumed to occur above the temporary reservoir footprint, which would result in some production when the proposed flood retention facility is impounding water. Therefore, the reduction in habitat potential is not as severe as with spring-run Chinook salmon. The maximum reduction in habitat potential described above would only occur during a year when a major or greater flood occurs that would trigger the flood retention facility to capture and hold floodwater in the temporary reservoir. As such, not all year classes would experience this level of impact.

The abundance and diversity associated with the 100-year flood condition with operation of the flood retention facility (in 2030) is close to the 2-year condition and substantially higher than the 10-year flood condition. These results are attributed to the flows used to represent the 10-year flood condition in the EDT model. The average monthly flow for the 10-year flood condition was generated from the 2009 water year while the average 2-year and 100-year flows were generated from the 2011 water year and 1996 water year, respectively. Channel widths were narrower for the 10-year flood condition because the average flows were lower for most months of the year, particularly the fall and spring, than the 2-year and 100-year flood conditions (McMullen 2019). The flows and channel widths are directly related to the amount of available habitat such that lower flows result in smaller channel widths and less available habitat.

Figure 6.4-2
EDT Modeling Results for Fall-Run Chinook Salmon: Above the Flood Retention Facility



Coho Salmon

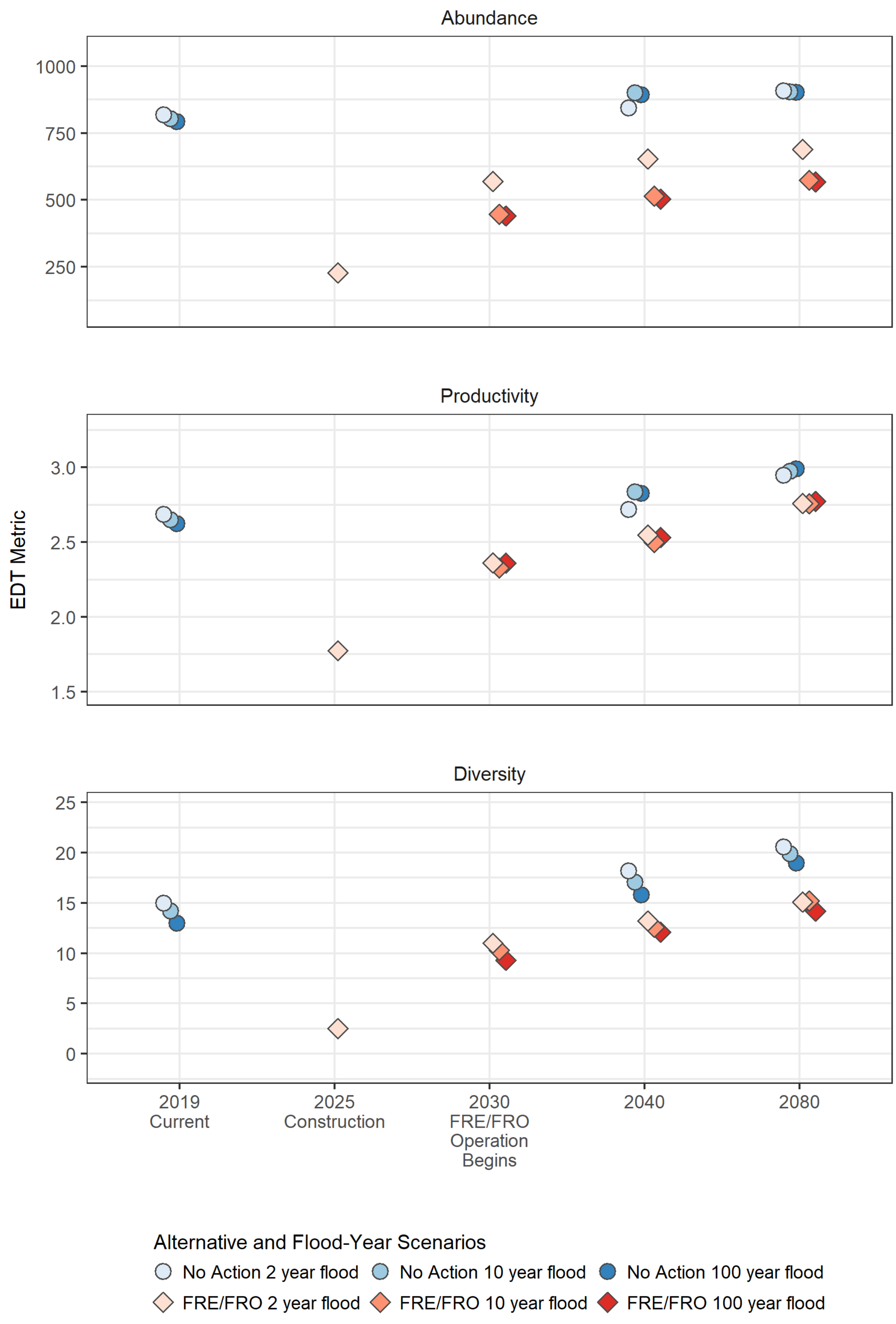
Alternative 1 would have a high impact on coho salmon in the flood retention facility project area. The impact would mainly occur as the result of adverse effects on habitat potential from RM 108 to RM 114 (Figure 6.4-3). In years when the FRE facility impounds water, habitat potential in this area would decline by 7% to 44% (Table 6.4-10). This means in years when the FRE facility was operating, there would be less coho salmon production in the river between RM 108 to RM 114. This would occur approximately once every 7 years. In years when the FRE facility is not impounding water, habitat potential in this area would decline by 6% to 27%. This would occur most of the time. Abundance in this area over time would decline from 810 to 870 fish under the No Action Alternative to about 525 to 550 fish under Alternative 1 (Table 6.4-11). This estimate considers both conditions when the flood retention facility would and would not impound water. These results indicate that there is little difference between flood years in estimates of abundance from operating the facility after the initial reduction caused by construction. However, there is a slight increase in abundance in the late-century that also occurs under the No Action Alternative. The slight increase in abundance is associated with other factors beside the proposed flood retention facility, mainly as a result of assumed riparian tree growth in managed forests.

For a recurring flood, a slight reduction in estimated abundance could occur a few years after the back-to-back event and then the population recovers to approximately 525 fish. This temporary reduction in abundance is not estimated under No Action Alternative conditions, indicating that it is associated with the operation of the flood retention facility.

The impacts are not as severe with coho salmon as with Chinook salmon because there are more coho salmon spawning in sub-basins above the proposed flood retention facility that would not be impacted by the presence of the temporary reservoir behind the flood retention facility. The greatest reduction in habitat potential described above would only occur during a year that a major or greater flood occurs that would trigger flood retention. As such, not all year classes would experience this level of impact.

The potential impacts in non-impoundment years would occur over time as the result of decreased riparian shading in the footprint of the temporary reservoir. In addition, impacts would occur from reductions in LWM recruitment and reduced fish passage survival. TSS is also expected to increase when the temporary reservoir releases water, resulting in a high increase in turbidity during drawdown. These impacts would occur over time regardless of whether the FRE facility impounded water and would be less overall compared to impacts that would occur in the years when the FRE facility was impounding water.

Figure 6.4-3
EDT Modeling Results for Coho Salmon: Above the Flood Retention Facility



Steelhead

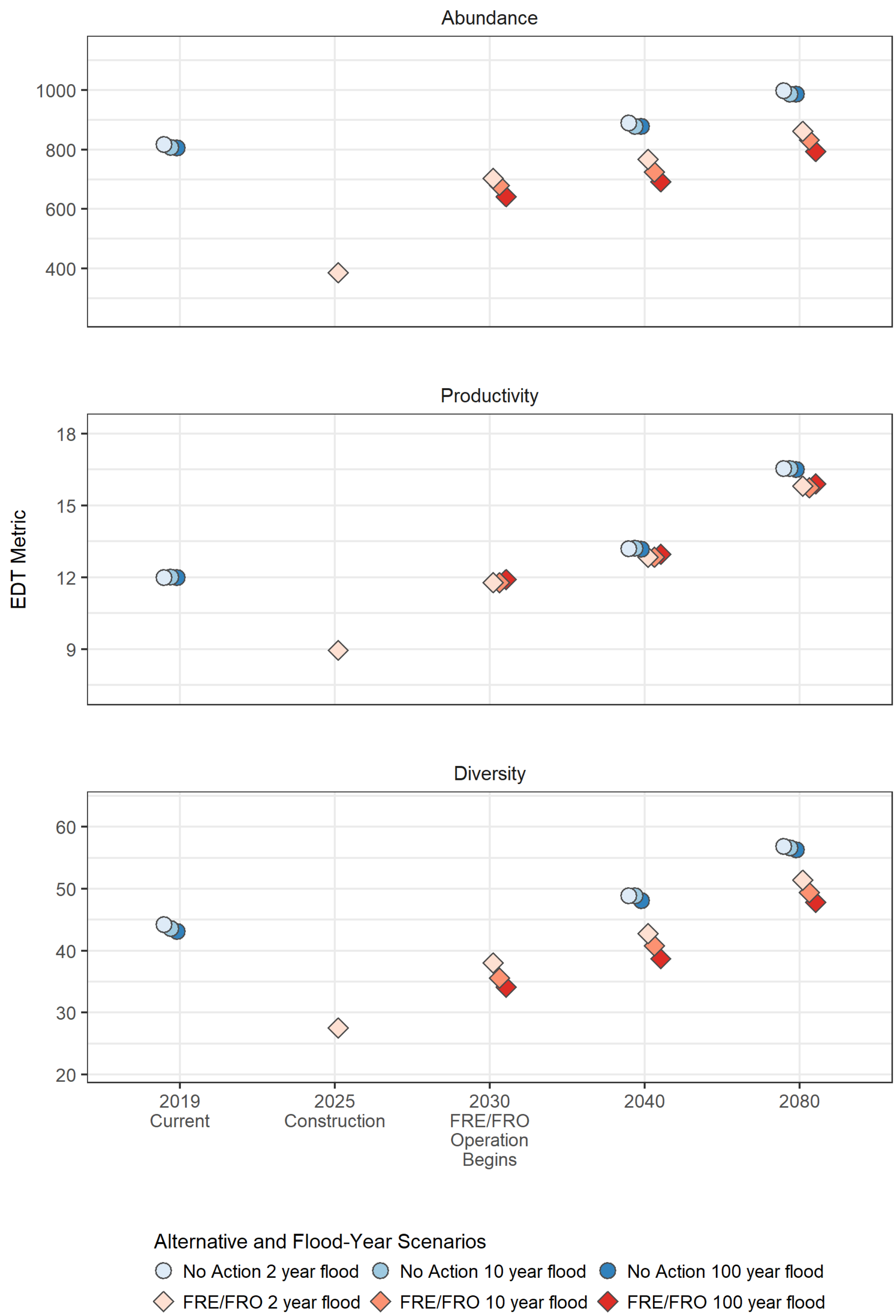
Alternative 1 would have a high impact on steelhead in the flood retention facility project area. The impact would mainly occur as the result of adverse effects on habitat potential from RM 108 to RM 114 (Figure 6.4-4). In years when the FRE facility impounds water, habitat potential in this area would decline by 2% to 21% (Table 6.4-10). This means that, in years when the FRE facility was operating, there would be less steelhead production in the river between RM 108 to RM 114. This would occur approximately once every 7 years. As such, not all year classes would experience this level of impact. In years when the FRE facility is not impounding water, habitat potential in this area would decline by 3% to 14%. This would occur most of the time. Assuming that flooding happens at a time when the most detrimental impacts on the species could occur (i.e., during spawning), abundance in this area over time would decline from 820 to 935 fish under the No Action Alternative to about 670 to 780 fish under Alternative 1 (Table 6.4-11). This estimate considers both conditions when the flood retention facility would and would not impound water. These results indicate that there is little difference between flood years in abundance from operating the flood retention facility after the initial reduction associated with construction.

The trend of increasing abundance through time occurs under both No Action Alternative and Alternative 1 conditions, suggesting that the trend is not related to the proposed project. The trend is a result of the assumption of riparian tree growth through time in managed forests. For a recurring flood, almost no reduction in estimated abundance is expected to occur for all alternatives.

As with the other salmon species, these reductions in habitat potential would occur as a result of the habitat degradation that is expected to occur in the temporary reservoir footprint for all flood conditions (2-year, 10-year, and 100-year) as described in Section 6.4.3. Habitat potential likely increases overall between current and late-century for steelhead because only 30% of steelhead spawning occurs in the temporary reservoir footprint (Appendix A, Attachment A) in the area above the proposed flood retention facility. Spawning occurs above the temporary reservoir footprint in managed forest habitat that is expected to improve by late-century. Steelhead also spawn later than other modeled salmon so that most of their spawning period occurs outside of the time when winter storms are assumed to occur (September through February).

The potential impacts in non-impoundment years would occur over time as the result of decreased riparian shading in the footprint of the temporary reservoir. In addition, impacts would occur from reductions in LWM recruitment, and reduced fish passage survival. TSS is also expected to increase when the temporary reservoir releases water, resulting in a high increase in turbidity during drawdown. These impacts would occur over time regardless of whether the FRE facility impounded water and would be less overall compared to impacts that would occur in the years when the FRE facility was impounding water.

Figure 6.4-4
EDT Modeling Results for Steelhead: Above the Flood Retention Facility



6.4.4.1.2 Chehalis River 100-year Floodplain Study Area

As noted previously, the Chehalis River 100-year floodplain study area also provides important habitat for salmonids. Within this area, spawning habitat for the modeled species mainly occurs between RM 98 and RM 108. Impacts in this area are not as severe as in the area above the proposed flood retention facility for all modeled species, except for steelhead.

The results of EDT modeling are summarized in Table 6.4-12 for all four species. Individual EDT results are discussed by species below and are shown in Figures 6.4-5 through 6.4-8. Additional detail is provided in Appendix A, Attachment A. Results from the integrated EDT-LCMs are summarized in Table 6.4-13. Additional information on these results is presented in Appendix A, Attachment B.

The decreases to habitat potential shown in Tables 6.4-12 and 6.4-13 are attributed to habitat degradation that occurs immediately downstream of the flood retention facility. The movement of substrate from upstream to downstream is expected to be reduced because of increased retention of substrate in the temporary reservoir during major or greater flood conditions. Furthermore, the material that is moved is expected to be smaller down to RM 86. This could degrade spawning habitat by not providing the gravels required for building egg nests. The amount of LWM that moves from upstream to downstream would also be decreased, which would reduce habitat complexity within this area down to RM 75. Temperature is expected to increase immediately downstream of the flood retention facility down to approximately the Elk Creek confluence (RM 100) during the 2-year flood condition between May and October and during a major flood or greater if the flood occurs in the fall.

In some scenarios shown in Table 6.4-12, habitat potential improves in this section of river. The improvements are most likely because Alternative 1 would improve habitat conditions by reducing bed scour that would otherwise occur during a major or greater flood. The impoundment of water above the flood retention facility attenuates the downstream flow, which causes less bed scour to occur.

Table 6.4-12
Changes in Habitat Potential for Modeled Salmonids in the Chehalis River 100-Year Floodplain Study Area (RM 98 to RM 108) During Operations

		ALTERNATIVE 1 COMPARED TO NO ACTION ALTERNATIVE					
		2-YEAR FLOOD		10-YEAR FLOOD		100-YEAR FLOOD	
SPECIES	METRIC	2040	2080	2040	2080	2040	2080
Spring-run Chinook salmon	Abundance	-8%	-11%	-15%	-21%	-10%	+5%
	Diversity	-50%	-60%	-40%	-33%	+100%	+100%
	Productivity	+5%	+2%	+4%	-1%	+6%	+13%
Fall-run Chinook salmon	Abundance	-10%	-7%	-14%	-14%	-1%	+13%
	Diversity	0%	0%	0%	-13%	0%	+100%
	Productivity	-13%	-13%	+10%	+7%	+34%	+80%
Coho salmon	Abundance	+7%	+1%	-1%	+2%	+13%	+41%

		ALTERNATIVE 1 COMPARED TO NO ACTION ALTERNATIVE					
		2-YEAR FLOOD		10-YEAR FLOOD		100-YEAR FLOOD	
SPECIES	METRIC	2040	2080	2040	2080	2040	2080
	Diversity	-20%	0%	+100%	+200%	+200%	+400%
	Productivity	+3%	+1%	-1%	0%	-1%	+6%
Steelhead	Abundance	-30%	-62%	-65%	-100%	-57%	+9%
	Diversity	-78%	-75%	-75%	-100%	-75%	-43%
	Productivity	-12%	-21%	-20%	-83%	-17%	+9%

Table 6.4-13 provides a summary of the integrated EDT-LCMs and includes estimates of the median abundance during the operation of the flood retention facility between 2030 and 2080 compared to the No Action Alternative. The table also provides the amount of yearly variation in the estimate of median abundance. The yearly variation is a measure of how stable the estimates are expected to be. A large range indicates that the estimate is not stable and that it is not likely to occur each year. A small range indicates that the estimate is more stable and more likely to occur each year.

A summary of the salmonid modeling results for RM 98 and RM 108 by species is provided in the following subsections. These results represent the overall impact of Alternative 1. The results consider the impacts of the proposed FRE facility that are predicted by EDT to happen when the temporary reservoir is holding water (approximately once every 7 years) and the other years when it is not. It also considers the results of the EDT-LCM integrated models for how the species would be affected over time.

Table 6.4-13

Summary of Long-term Salmonid Abundance and Variation from Rainbow Falls to the Proposed Flood Retention Facility

	NO ACTION ALTERNATIVE		ALTERNATIVES 1 AND 2: FLOOD RETENTION FACILITY	
SALMON SPECIES	MEDIAN OF YEARLY ABUNDANCE ESTIMATES[1]	PERCENT OF ESTIMATED YEARLY ABUNDANCE VARIATION[2]	MEDIAN OF YEARLY ABUNDANCE ESTIMATES[1]	PERCENT OF ESTIMATED YEARLY ABUNDANCE VARIATION[2]
Spring-run Chinook	35 to 40 fish	about 6%	30 to 35 fish	about 8%
Fall-run Chinook	200 to 225 fish	about 11%	185 to 200 fish	about 13%
Coho	about 60 fish	about 13%	about 60 fish	about 10%
Steelhead	about 15 fish	about 7%	down to 0 fish	none

Notes:
Results are from the integrated EDT-NOAA LCMs.
1. Range of median values in years 63 through 99 (late-century).
2. Percent of estimated yearly abundance variation is based on the range of possible estimates of habitat potential (abundances) as a percent of the median yearly values for years 63 through 99 (late-century).

Spring-run Chinook Salmon

Alternative 1 would have a medium impact on spring-run Chinook salmon in the Chehalis River 100-year floodplain study area from RM 98 to RM 108 (Figure 6.4-5). In years when the FRE facility impounds water, habitat potential in this area would change by +4% to -40% (Table 6.4-12) in the mid- and late-century 10-year flood scenarios. This means that, in years when the FRE facility is operating because of a 10-year flood, there would typically be fewer spring-run Chinook salmon, fewer life history and spawning area combinations that contribute to an increase in abundance (i.e., diversity), and no real change in productivity in the river between RM 98 and RM 108. This would occur approximately once every 7 years. In mid- and late-century 100-year flood scenarios, habitat potential in this area would change by -10% to +100%. The +100% increase in habitat potential is related to diversity of life histories and habitats in the floodplain, while declines are for abundance and much smaller increases (+5% to +13%) are related to productivity.

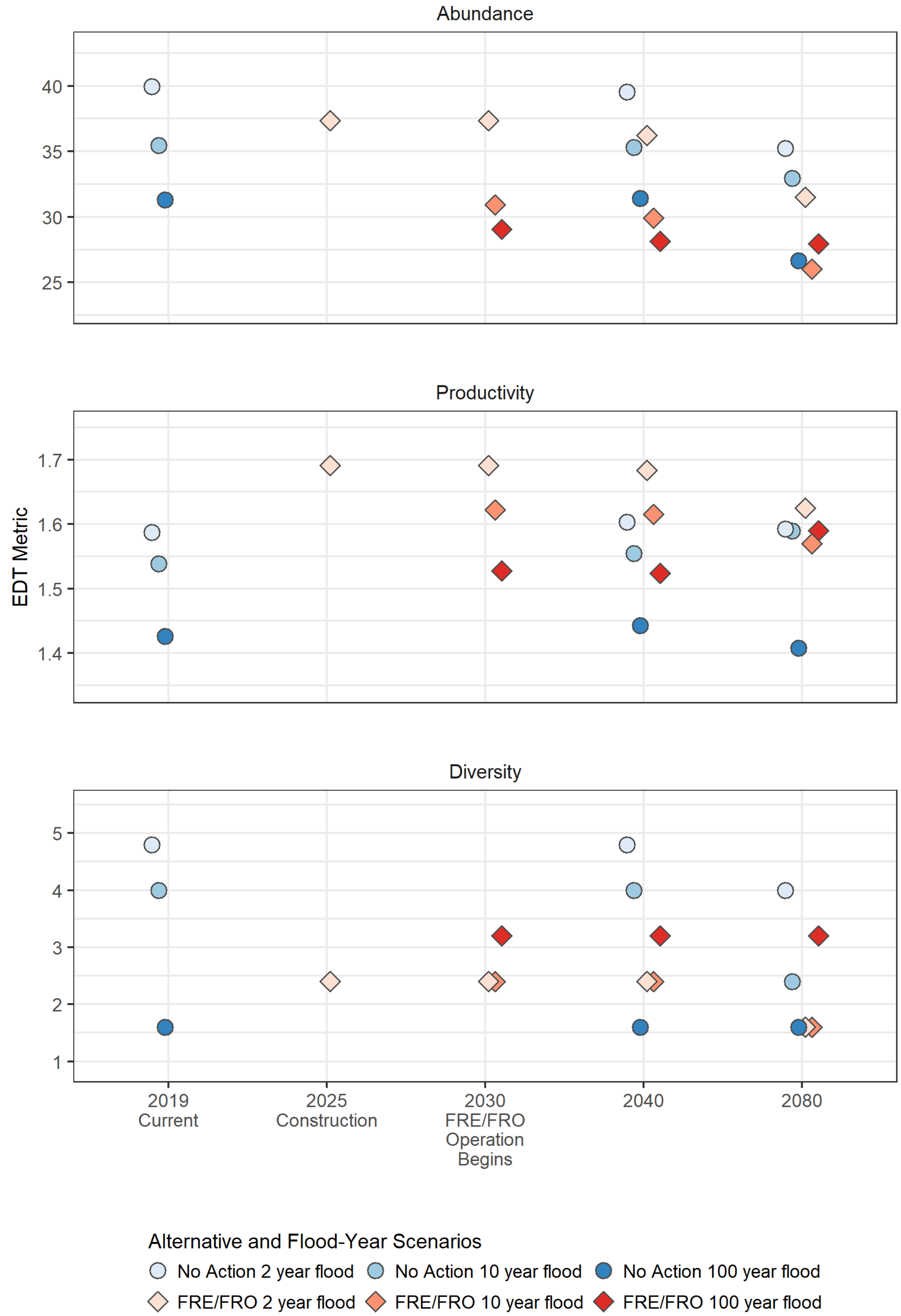
In years when the FRE facility is not impounding water, habitat potential in this area would change by +5% to -60%. This would occur most of the time. Over the long term, assuming that flooding happens at a time when the most detrimental impacts on the species could occur (i.e., during spawning), abundance in this area over time could slightly decline from 35 to 40 fish under the No Action Alternative to 30 to 35 fish under Alternative 1 (Table 6.4-13). This considers both conditions when the flood retention facility would and would not impound water. Below RM 98 to RM 75, there would be a low impact, based on the limited changes to habitat-forming processes described in Section 6.4.3.5.

Spring-run Chinook salmon estimated abundance decreases slightly a few years after a recurring flood, after which the population was predicted to recover to the same abundance level as before the back-to-back floods.

The reduction in habitat potential shown in Table 6.4-12 is a result of habitat degradation that occurs in this study area, including increased temperatures between May and October down to RM 100 (ICF 2019; Appendix A, Attachment A; Corps 2020c), decreased dissolved oxygen, increased amount of fine material as substrate, and reduced LWM. Spring-run Chinook salmon would experience the summer increases in temperature during summer holding periods prior to spawning. Spring-run Chinook salmon that spawn in the mainstem Chehalis River between RM 98 and RM 78.5 were not assumed to be affected by the project during modeling, but some habitat-related impacts could occur in this area.

In the mid- and/or late-century, productivity, diversity, and abundance for the 100-year flood condition with the flood retention facility was higher than under the No Action Alternative. This increase in habitat potential is attributed to reduced bed scour from flood attenuation (ICF 2019; Appendix A, Attachment A) during the 100-year flood.

Figure 6.4-5
EDT Modeling Results for Spring Chinook Salmon: Below the Flood Retention Facility



Fall-run Chinook Salmon

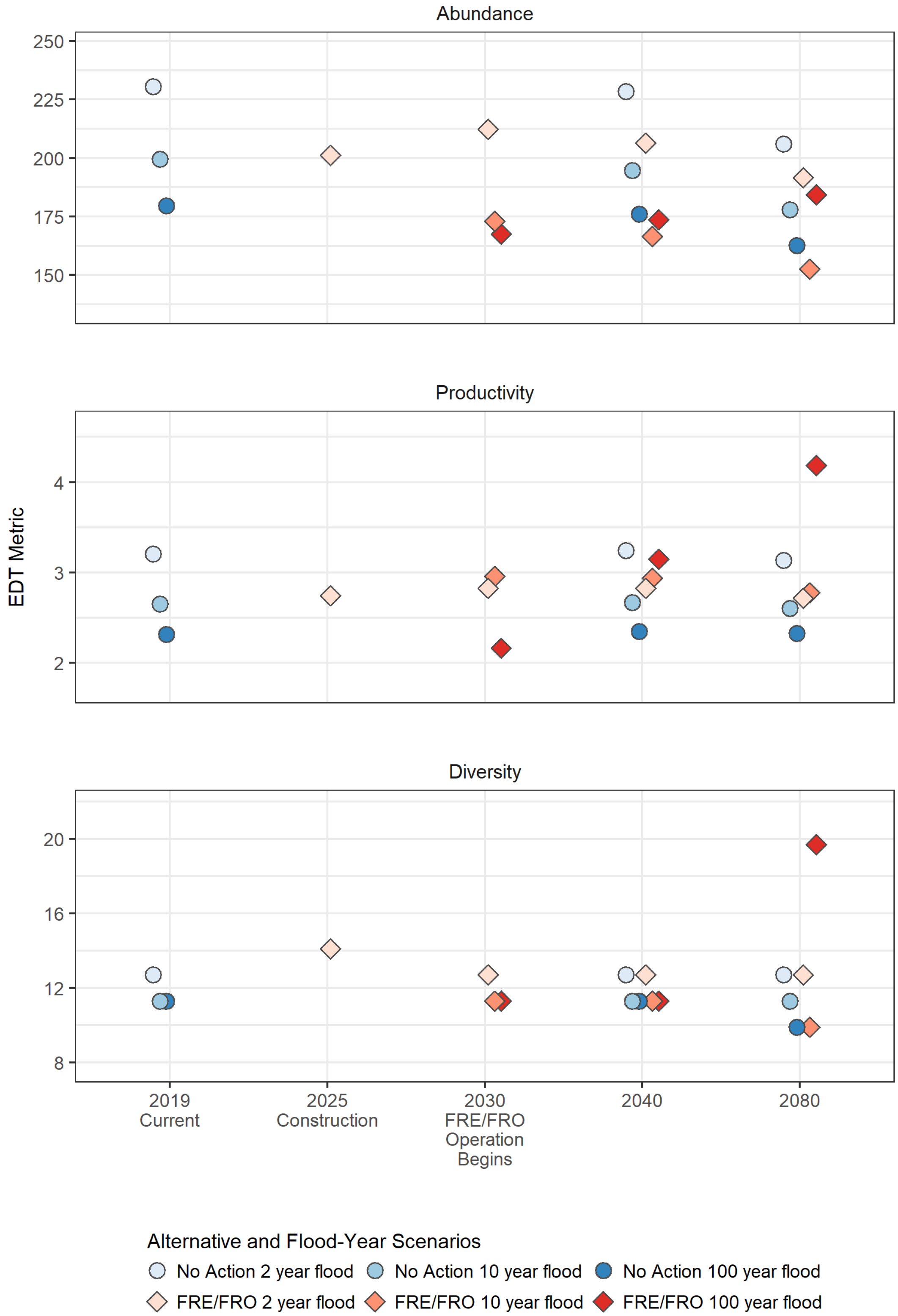
Alternative 1 would have a medium impact on fall-run Chinook salmon in the Chehalis River 100-year floodplain study area from RM 98 to RM 108. In years when the FRE facility impounds water, habitat potential in this area would change by +100% to -14% (Table 6.4-12). The +100% increase in habitat potential is related to diversity of life histories and habitats in the floodplain, while declines of up to 14% are in abundance. This would occur approximately once every 7 years. In years when the FRE facility is not impounding water, habitat potential in this area would change by up to -13%. This would occur most of the time. Over the long term, assuming that flooding happens at a time when the most detrimental impacts on the species could occur (i.e., during spawning), abundance in this area over time could slightly decline from 200 to 225 fish under the No Action Alternative to 185 to 200 fish under Alternative 1 (Table 6.4-13). This considers both conditions when the flood retention facility would and would not impound water. Below RM 98, there would be a low impact.

Under both No Action Alternative and flood retention facility conditions, there is a small decrease in abundance after recurring floods, but it recovers to the same habitat potential as before the back-to-back floods.

The reductions in habitat potential shown in Table 6.4-12 are attributed to habitat degradation that occurs from RM 98 to RM 108, including increased temperatures between March and October down to RM 100 (ICF 2019; Appendix A, Attachment A; Corps 2020c) and long-term changes in habitat-forming processes (i.e., overall decrease in amount of material moving downstream, smaller substrate size, encroachment of riparian zone decreasing river channel width, and decreased supply of LWM; Corps 2020d), as discussed in Section 6.4.3. Fall-run Chinook salmon also spawn in the mainstem Chehalis River between RM 98 and RM 76.2. This area was not assumed to be affected by the project during modeling, but some habitat-related impacts could occur in this area.

The increases in productivity during major or greater floods in mid- and late-century are attributed to reduced bed scour from flood attenuation (Appendix A, Attachment A). Similarly, the increases in abundance and diversity during a 100-year flood in late-century are also attributed to reduced bed scour from flood attenuation (ICF 2019; Appendix A, Attachment A).

Figure 6.4-6
EDT Modeling Results for Fall Chinook Salmon: Below the Flood Retention Facility



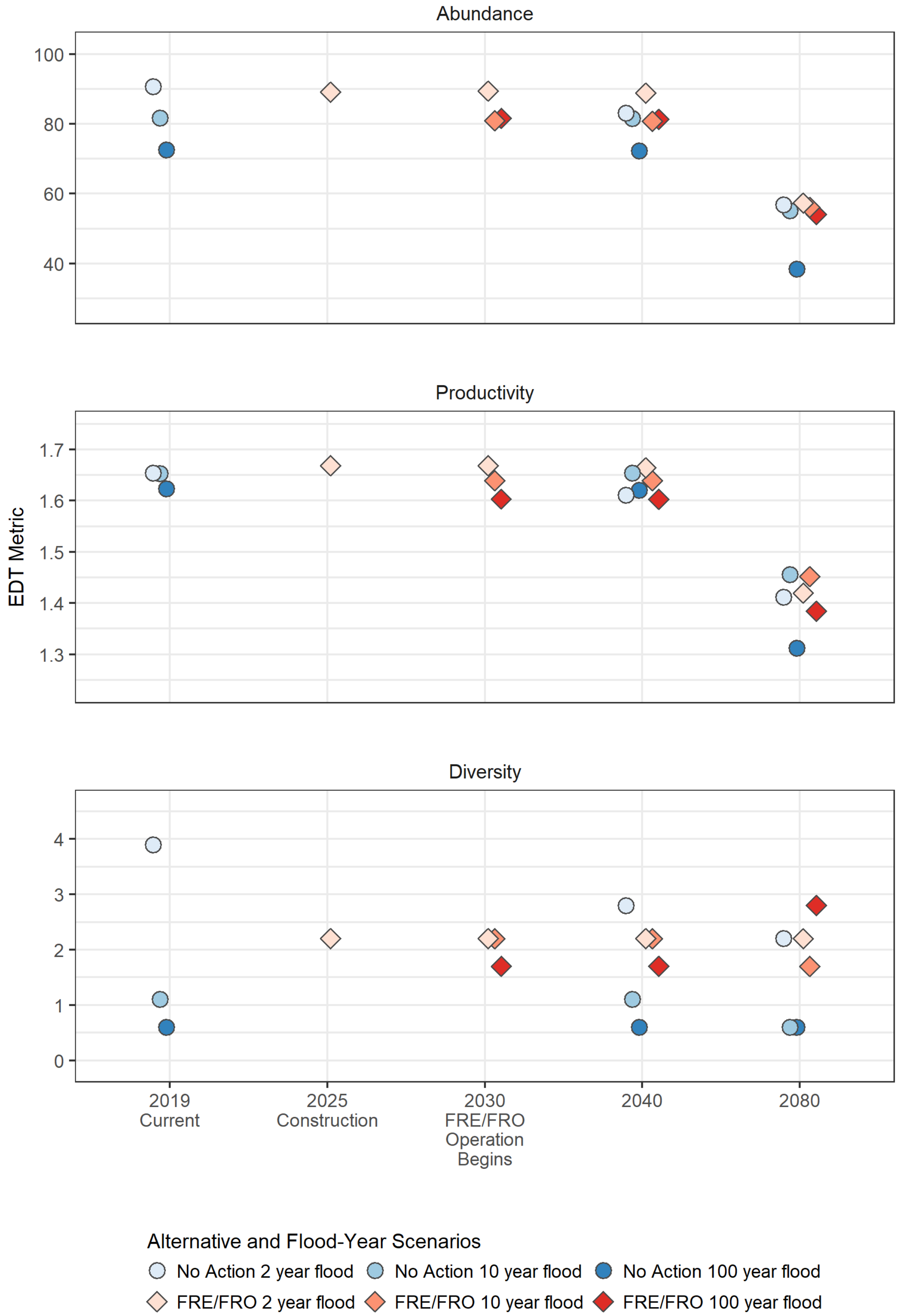
Coho Salmon

Alternative 1 would have a low impact on coho salmon in the Chehalis River 100-year floodplain study area from RM 98 to RM 108. In years when the FRE facility impounds water, habitat potential in this area would change by +400% to -1% (Table 6.4-12). Abundance was predicted to either slightly decrease up to 1% or to increase up to 41%. Productivity was predicted to show a small increase or decrease. Diversity was predicted to increase by up to 400% compared to the No Action Alternative. Although the percentage change in diversity is large, the absolute numbers did not change by much. This is because the existing numbers under the No Action Alternative are quite low (Figure 6.4-7). Although this is a large percent increase under Alternative 1, it still means diversity is low. This would occur approximately once every 7 years.

In years when the FRE facility is not impounding water, habitat potential in this area would change by +7% to -20%. The increase in abundance is very small (approximately five fish or less; Figure 6.4-7) and does not indicate a substantial increase. Similarly, the increases in productivity and diversity are both very small (less than 0.1). Therefore, these changes are not likely substantial enough to affect the species during the years when the facility is not impounding water. This would occur most of the time. Over the long term, even assuming that flooding happens at a time when the most detrimental impacts on the species could occur (i.e., during spawning), abundance in this area over time would stay around 60 fish under the No Action Alternative and Alternative 1 (Table 6.4-13). This considers both conditions when the flood retention facility would and would not impound water. Coho salmon also showed no change in abundance in years when back-to-back floods occurred. Below RM 98, there would be a negligible impact.

The slight decreases in habitat potential shown in Table 6.4-12 are a result of habitat degradation that occurs in this study area, including increased temperatures between March and October down to RM 100 (ICF 2019; Appendix A, Attachment A; Corps 2020c) and changes in habitat-forming processes (i.e., overall decrease in amount of material moving downstream, smaller substrate size, encroachment of riparian zone decreasing river channel width, and decreased supply of LWM; Corps 2020d) as discussed in Section 6.4.3. The increases in abundance and productivity during 100-year floods in mid- and/or late-century are attributed to reduced bed scour from flood attenuation (Appendix A, Attachment A).

Figure 6.4-7
EDT Modeling Results for Coho Salmon: Below the Flood Retention Facility

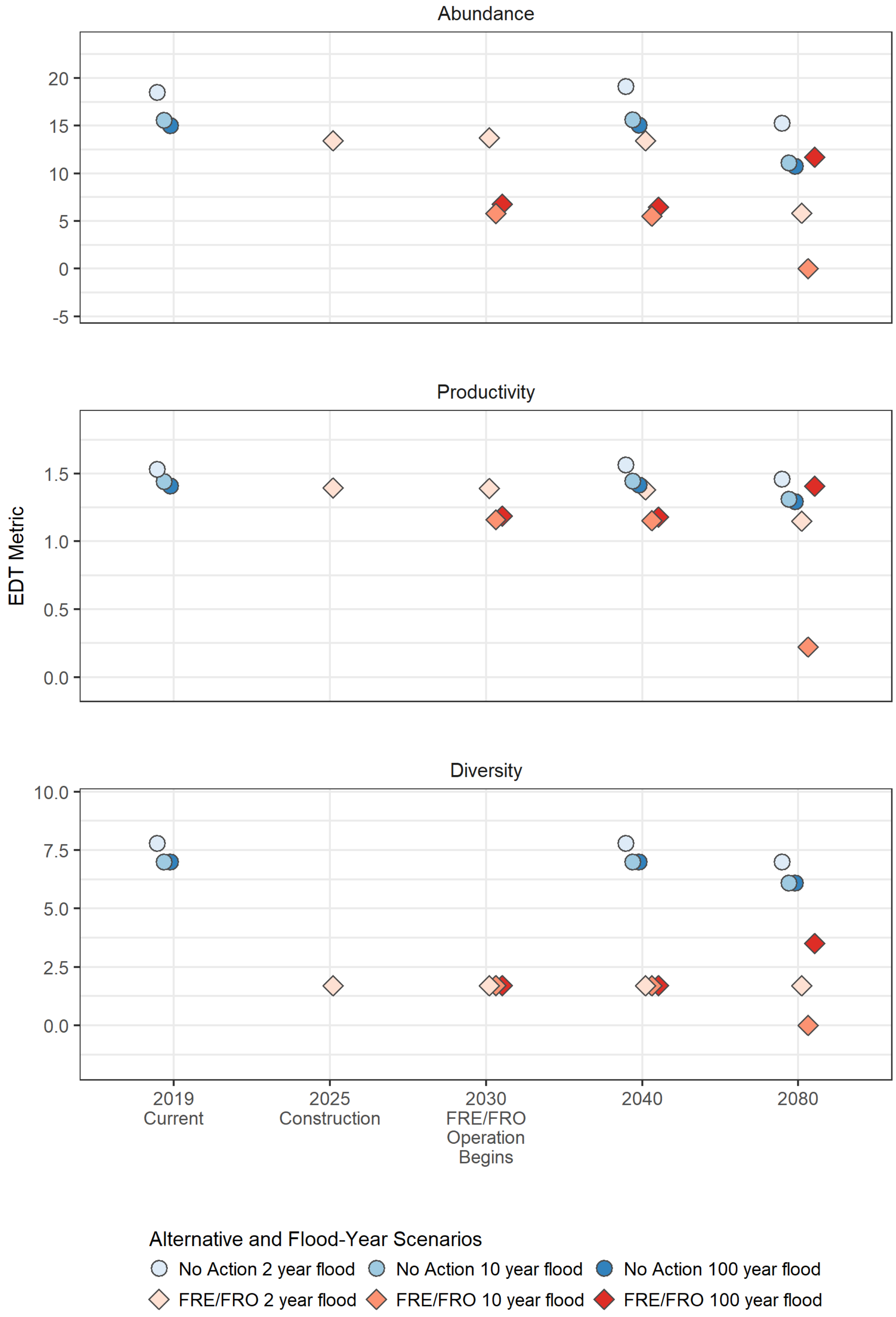


Steelhead

Alternative 1 would have a high impact on steelhead in the Chehalis River 100-year floodplain project area from RM 98 to RM 108. In years when the FRE facility impounds water, habitat potential in this area would change by +9% to -100% (Table 6.4-12). There would be a 100% decrease in abundance. This means that, in years when the FRE facility was operating, there would be no steelhead production in the river between RM 98 to RM 108. This would occur approximately once every 7 years. In years when the FRE facility is not impounding water, habitat potential in this area would decline by 12% to 78%. This would occur most of the time. Over the long term, assuming that flooding happens at a time when the most detrimental impacts on the species could occur (i.e., during spawning), abundance in this area would decline from 15 fish under the No Action Alternative to no fish under Alternative 1 (Table 6.4-13). This considers both conditions when the flood retention facility would and would not impound water. Steelhead show no change in abundance related to years when back-to-back floods occur. Below RM 98, there would be a low impact.

The reductions in habitat potential are a result of habitat degradation that occurs from RM 98 to RM 108, including increased temperatures between March and October down to RM 100 (ICF 2019; Appendix A, Attachment A; Corps 2020c) and changes in habitat-forming processes (i.e., overall decrease in amount of material moving downstream, smaller substrate size, encroachment of riparian zone decreasing river channel width, and decreased supply of LWM; Corps 2020d) as discussed in Section 6.4.3. The increases in productivity and abundance in late-century during a 100-year flood relative to the No Action Alternative are attributed to reduced bed scour from flood attenuation (ICF 2019; Appendix A, Attachment A).

Figure 6.4-8
EDT Modeling Results for Steelhead: Below the Flood Retention Facility



Downstream of Rainbow Falls (RM 98 to RM 33)

Below Rainbow Falls, there are changes to habitat-forming processes. These changes are related to bed substrate and riverbed elevation down to RM 81.6 and a reduced supply of LWM down to RM 75. The influence of the proposed FRE facility on these processes would decrease in line with distance downstream of the facility. This is because the effects of the FRE facility on water and sediment inputs and transport is expected to be muted by tributary inputs and grade controls at RM 62 and RM 65 (WGD and Anchor QEA 2012, 2014). However, because salmonid spawning habitat occurs mainly above Rainbow Falls, these impacts are expected to be low for spring-run and fall-run Chinook salmon and steelhead, and negligible for coho salmon.

6.4.4.1.3 Chehalis Basin Scale

At the scale of the Chehalis Basin, the EDT results show a minimal decrease or no change in habitat potential for all modeled species except spring-run Chinook salmon (Table 6.4-14). These species would only have low impacts at this scale. The potential impacts on spring-run Chinook salmon would be high.

Overall, the results at the Chehalis Basin scale vary by species because of the competing effects of various actions that would either improve or degrade aquatic habitat conditions. Examples of improvements that are assumed to occur regardless of the proposed action include increased riparian growth in managed forests, culvert removals, and restoration activities. Examples of activities that would degrade aquatic habitat are mainly related to land use change because of increased population growth (Appendix A, Attachment A). These effects vary at spatial scales that impact which species are most affected by the actions (Appendix A, Attachment A).

Table 6.4-14 shows the estimated percent change in habitat potential from operation of the flood retention facility. Overall, changes in habitat potential vary by species with abundance changes ranging from +1% (coho salmon) to decreases of 2% for spring-run Chinook salmon when the flood retention facility is impounding water. Abundance changes range from no change (steelhead) to +2% (spring-run Chinook salmon and coho salmon) when the facility is not impounding water. There were no productivity changes for any species, except spring-run Chinook salmon, which had up to a 3% increase in productivity. Changes in diversity range from no change (fall-run Chinook and coho salmon) up to a 13% decrease for spring-run Chinook salmon. Diversity is expected to decrease for spring-run Chinook salmon when the flood retention facility both is and is not impounding water.

Table 6.4-14
Changes in Habitat Potential for Salmon Species in the Chehalis Basin During Operation of the Flood Retention Facility

		ALTERNATIVE 1 COMPARED TO NO ACTION ALTERNATIVE					
		2 YEAR FLOOD		10 YEAR FLOOD		100 YEAR FLOOD	
SPECIES	METRIC	2040	2080	2040	2080	2040	2080
Spring-run Chinook Salmon	Abundance	+2%	+1%	-2%	0%	-2%	0%
	Diversity	-6%	-4%	-13%	-11%	-10%	-9%
	Productivity	+1%	+1%	+2%	+3%	+2%	+3%
Fall-run Chinook Salmon	Abundance	+1%	+1%	0%	+1%	0%	+1%
	Diversity	0%	0%	0%	0%	0%	0%
	Productivity	0%	0%	0%	0%	0%	0%
Coho Salmon	Abundance	+2%	+1%	0%	+1%	0%	+1%
	Diversity	0%	0%	0%	0%	0%	0%
	Productivity	0%	0%	0%	0%	0%	0%
Steelhead	Abundance	0%	0%	0%	0%	0%	0%
	Diversity	-1%	0%	-1%	-1%	-1%	-1%
	Productivity	0%	0%	0%	0%	0%	0%

All EDT model results for the Chehalis Basin are shown in Figures 6.4-9 through 6.4-12. Specifically, the results show a minimal change in abundance, no change in productivity, and either a slight decrease or no change in diversity for fall-run Chinook salmon, coho salmon, and steelhead for all time periods compared to the No Action Alternative. The effect of FRE facility operations would be less pronounced at the basin scale because there are larger numbers of fish that spawn, rear, and forage in other areas of the Chehalis Basin that would not be affected.

For spring-run Chinook, there is up to a 2% decline in abundance, up to a 13% decline in diversity, and up to a 3% increase in productivity at the basin scale throughout the time period compared to the No Action Alternative when the flood retention facility is impounding water. This is expected to occur approximately once every 7 years. In addition, diversity is estimated to decrease by up to 6% and abundance and productivity are expected to slightly increase when the facility is not impounding water, which would occur most of the time. This more pronounced impact on spring-run Chinook salmon is attributed to the species having a smaller population compared to the other modeled species and relying on the habitat above and below the proposed flood retention facility for spawning. In addition, spring-run Chinook salmon spawn in fewer sub-basins compared to other modeled species. As such decreases in diversity (i.e., life history and spawning area combinations that contribute to abundance) even when the flood retention facility is not impounding water is important to spring-run Chinook salmon as described in more detail below.

As shown in Figure 5.3-2 and described in Section 6.4.2.1.3, spring-run Chinook salmon have the most limited spawning distribution and smallest population of the modeled salmonid species within the Chehalis Basin. This suggests that impacts to any of these spawning areas individually could have a substantial impact on the species at the basin level. As discussed in Sections 5.3.3.1.2 and 6.4.2.1.3, the total basin-wide population of spring-run Chinook is likely smaller than estimated. However, because EDT reflects relative changes in habitat potential at each snap-shot in time, it is still appropriate to make relative evaluations of the species at the basin level as well as the sub-basin level.

The life-history advantage to spring-run Chinook salmon, compared to the fall-run life history, is likely related to exclusive access to habitat, as discussed in Section 5.3.3.1.2. As with construction, operation of the flood retention facility is expected to reduce diversity by restricting access to the uppermost portion of the spring-run Chinook salmon spawning habitat during impoundment. This is expected to occur approximately once every 7 years. A permanent CHTR facility would be constructed to move adults around the construction area to spawning areas above the temporary reservoir during impoundment, but fish passage survival would be reduced.

The spawning and rearing habitat within the temporary reservoir and immediately downstream would also be degraded from the operation of the flood retention facility even when it is not impounding water. These modifications would reduce the quantity and/or quality of spring-run Chinook salmon spawning and rearing habitat when the facility is not impounding water, which would be most of the time. These impacts could lead to increased intermingling of the spring-run and fall-run Chinook salmon in the Chehalis Basin. This is important for determining impacts because recent studies have suggested that the genetic variation that controls run timing may be unrecoverable once lost (Thompson et al. 2019c). Because these modifications would occur both with and without impoundment and diversity is modeled to decrease by between 4% and 13%, these operational impacts are expected to be high at the Chehalis Basin scale.

As shown in Figure 5.3-2, spawning areas for fall-run Chinook salmon are more expansive than for spring-run Chinook salmon. Also, as shown in Figure 5.3-3, spawning areas for coho salmon and steelhead occur in almost all available areas of the basin, including above the proposed flood retention facility site. Because of the expansive spawning areas throughout the Chehalis Basin, and the estimated low change in habitat potential for all metrics, impacts to fall-run Chinook salmon, coho salmon, and steelhead from operations are expected to be low at the Chehalis Basin scale compared to the No Action Alternative.

Figure 6.4-9
EDT Modeling Results for Spring-Run Chinook Salmon: All Sub-basins

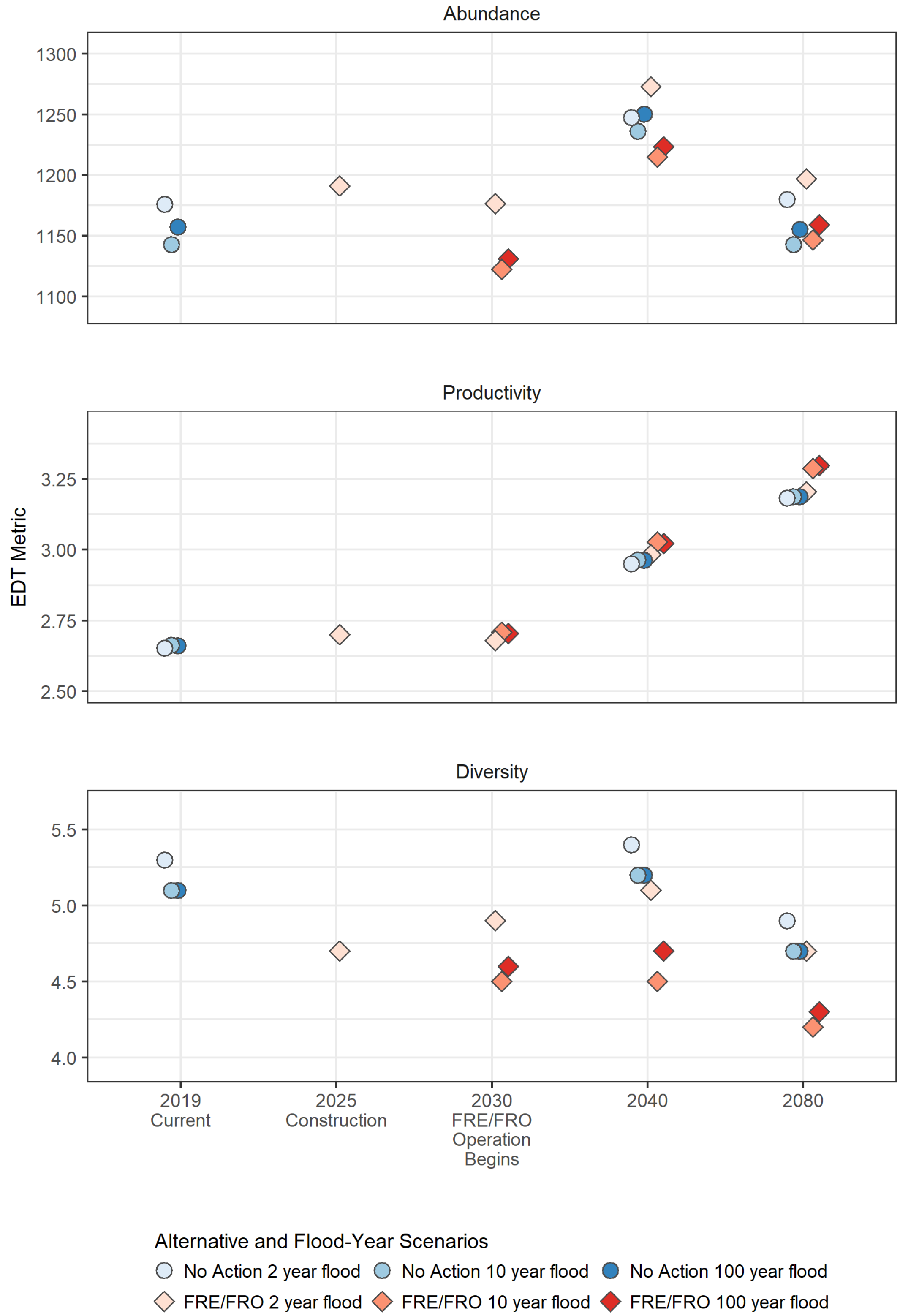


Figure 6.4-10
EDT Modeling Results for Fall-Run Chinook Salmon: All Sub-basins

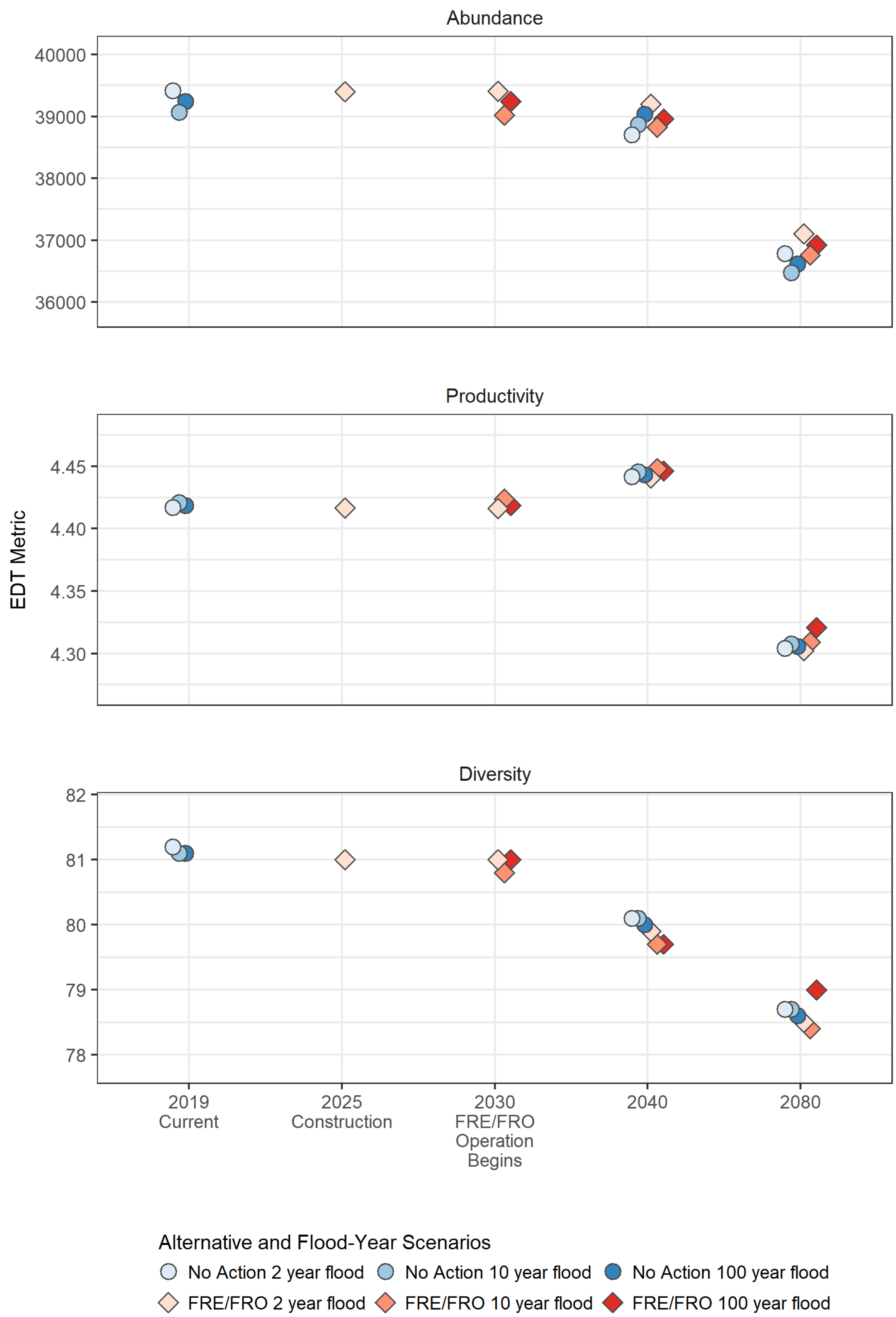


Figure 6.4-11
EDT Modeling Results for Coho Salmon: All Sub-basins

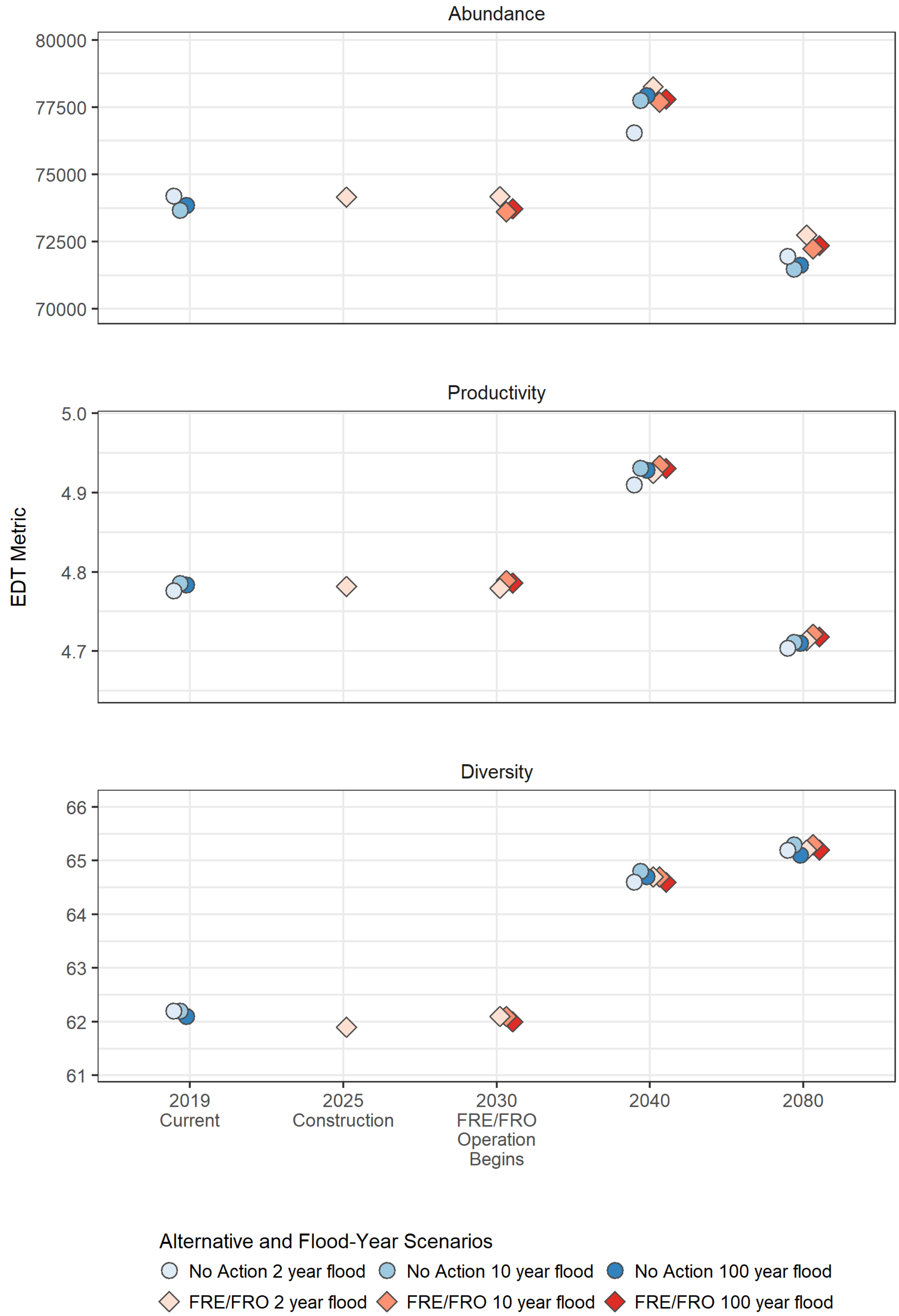
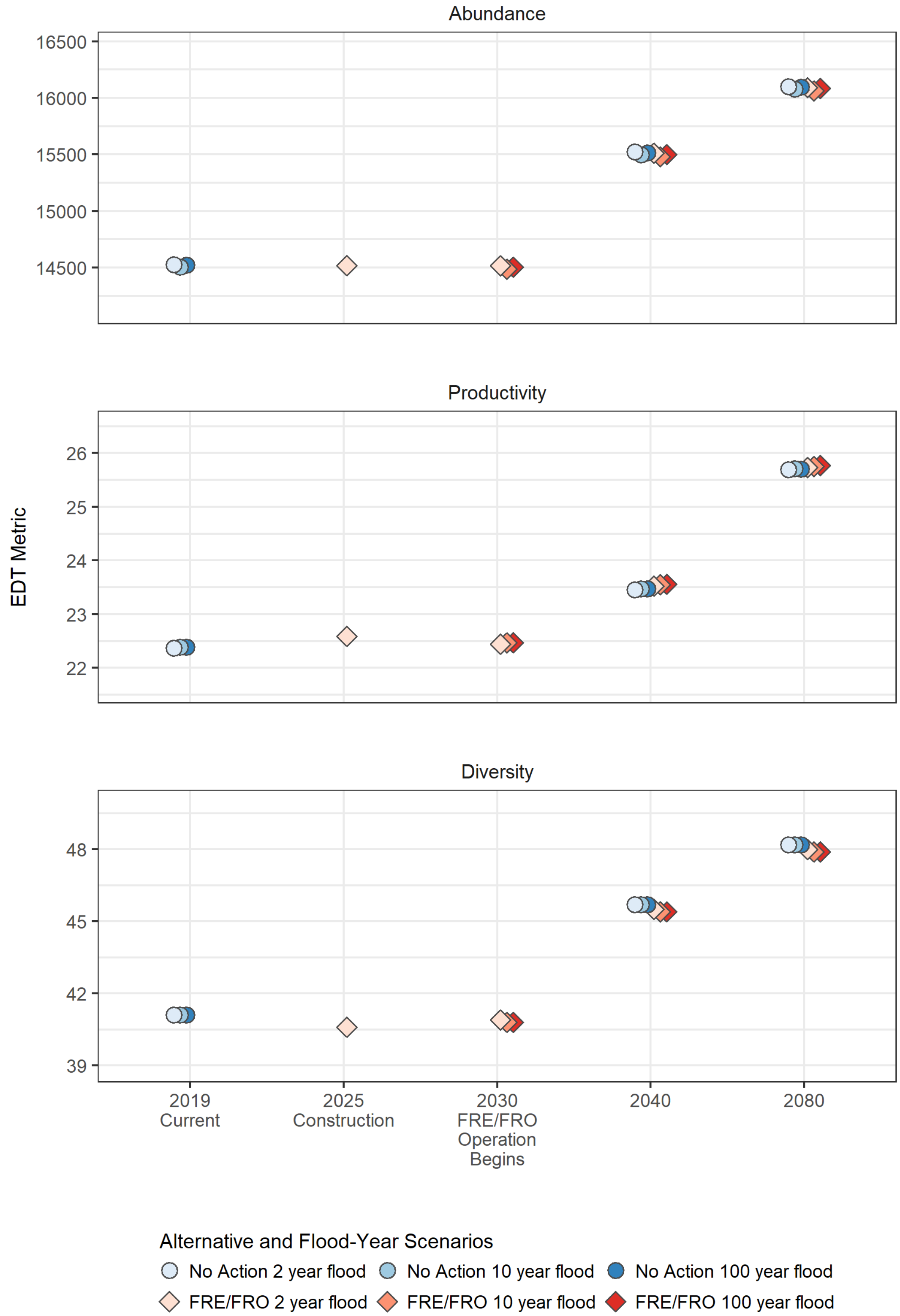


Figure 6.4-12
EDT Modeling Results for Steelhead: All Sub-basins



6.4.4.2 Other Fish, Freshwater Mussels, and Plants

The habitat changes resulting from Alternative 1 that are described in Section 6.4.3 also have impacts on species other than the modeled salmonids. Lamprey, other native species, non-native species, freshwater mussels, plants, and special-status species could also experience low to high impacts during operation.

6.4.4.2.1 Habitat Loss and Impairment

During a major or catastrophic flood, the temporary reservoir would fill and empty within 32 days. These conditions would occur approximately once every 7 years. When these conditions occur, low to high disturbance, injury, or killing of aquatic species could occur from destruction of redds and eggs in the temporary reservoir footprint, fish stranding as reservoir water draws back down, and fish impingement during gate closure. The destruction of egg nests and eggs or larvae could have a high impact on lamprey and other native fish species that may have spawned prior to impoundment. However, non-salmonid native fish, including shiner, sculpin, dace, and pikeminnow species have higher abundance and more habitat near and below RM 98 in the study area. Therefore, impacts on these species would be low to medium. Stranding and impingement are expected to have low impacts to salmonids, lamprey, and other native fishes because BMPs would be implemented to minimize impacts to fish.

6.4.4.2.2 Increased Water Temperatures and Decreased Dissolved Oxygen

Temperature increases and associated dissolved oxygen decreases that could impact aquatic species are expected to occur during operation of the flood retention facility during 2-year flow conditions between May and October. Impacts could also occur during major or greater flood conditions, when water would be impounded in the temporary reservoir. These impacts from temperature are expected to be low if reservoir inundation occurs in the spring and medium if it occurs in the fall. The dissolved oxygen impacts are expected to be medium during 2-year flow conditions and low during impoundment since the state water quality criterion would be not exceeded. The temperature increases and dissolved oxygen decreases would occur within the temporary reservoir footprint and downstream of the proposed flood retention facility downstream to the Elk Creek confluence near RM 100. Impacts to other salmonids, lamprey, other native species, freshwater mussels and plants from an increase in water temperature and decrease in dissolved oxygen are described in Sections 6.4.2.2.2 and 6.4.2.2.3. The impacts of temperature on aquatic species are expected to be high and the impacts of decreased dissolved oxygen are expected to be low.

6.4.4.2.3 Increase in Total Suspended Solids and Turbidity

TSS and turbidity increases caused by reservoir drawdown could have impacts to aquatic species as described in Section 6.4.2.2.4 and below but are expected to be low because they will be temporary and occur infrequently.

Turbidity can cause fish to avoid otherwise suitable habitat, reduce foraging success, cause damage to gills, and reduce swimming speed (Lehman et al. 2017; Wenger et al. 2016). For aquatic plants, turbidity can reduce light availability needed for photosynthesis. In mussels, higher turbidity can lower the speed at which the mussel can filter food from the water and change gill structure (Tuttle-Ravcraft and Ackerman 2019).

6.4.4.2.4 Changes in Habitat-Forming Processes

Changes in habitat-forming processes include an increase in sediment deposition in the temporary reservoir during and after impoundment, an increase in fine material down to RM 86, overall decrease in sediment downstream to RM 80, and decreased supply of LWM down to RM 75. Changes to habitat-forming processes because of the operation of the flood retention facility would happen continuously over time, as described in Section 6.4.3.5. These changes could have low to high impacts to spawning, rearing, and foraging habitat for salmonid and non-salmonid native fishes within the temporary reservoir and downstream of the flood retention facility to RM 75. Impacts to salmonids are expected to be high to RM 98 and medium to negligible between RM 98 and RM 75 because most salmonid spawning habitat occurs above RM 98, but some Chinook spawning habitat occurs down to RM 76.2. Impacts to non-salmonid native species, freshwater mussels, and plants would be high to RM 98 and medium between RM 98 and 75.

The increase in the amount of fine sediment in the temporary reservoir could impact spawning and rearing habitat for fish, freshwater mussels, and plants. Similarly, the decrease in sediment and increase in fine sediment downstream of the flood retention facility could also impact spawning and rearing habitat for aquatic species. The impacts to aquatic species because of the increased amount of fine sediment are described in more detail in Section 6.4.2.2. Additionally, over time and in conjunction with other impacts described in this section, increases in fine sedimentation could give advantages to fish, mussel, and plant species that prefer mud and sand substrate over gravel and cobble substrate, thereby altering the current aquatic community. Species that prefer muddy or silty bottoms include the freshwater floater mussels, or invasive fish like carp. The impacts over the long-term operation of the FRE facility are expected to be more severe than during construction. Fine sediment could fill in river and stream channels that would degrade spawning and rearing habitat for salmonids, lamprey, and other native fishes by covering the sand and gravel with fine sediment. Fine sediment could also suffocate freshwater mussels and plants that cannot move to avoid the impact. Therefore, these conditions are expected to be a high impact on aquatic species.

The decrease in sediment transported downstream of the flood retention facility to RM 80 would limit the supply and movement of sand and gravel substrate within this area of the river. The lack of sediment could also impact the production of benthic invertebrates, which are prey for fishes. The reduction in sand and gravel substrate and prey resources could decrease the productivity and abundance of salmonid and native fish species. The reduction in sand and gravel substrate could also impact freshwater mussels that often settle on this type of substrate and aquatic plants that attach to larger substrate sizes. The decrease in sediment transported downstream could also increase erosion in the channel. However, the erosion is expected to cause less than 0.2 foot of change in water depth (Corps 2020d).

The impacts to aquatic species from the decreased supply and transport of LWM in the temporary reservoir and downstream of the flood retention facility are described in Section 6.4.2.2.6. During operation, this impact is expected to be similar as the impact during construction, but it would last longer.

Reduced channel width and floodplain connection could impact the distribution and habitat potential of aquatic species, particularly fishes. The straightening of the channel because of lack of movement of sand and gravel within the channel would cause deepening of the channel and a decrease in pool-riffle sequences that are important habitat for fish spawning (Brooker 1985). With less spawning and rearing habitat within the main river channel, fish species could overlap more and compete for habitat. This could reduce the abundance of some species, depending on the location within the river. Similarly, if there are fewer flow events that connect the river to off-channel habitats, the native species that use that habitat will have less space to spawn and rear.

6.4.4.2.5 Reduced Supply of Prey Resources and Decrease in Overhanging Vegetation

Continued removal of trees in the temporary reservoir could impact aquatic species by reducing availability of terrestrial prey resources and overhanging vegetation cover. Impacts to aquatic species as a result of these changes would be similar to those described in Section 6.4.2.2.7.

6.4.4.2.6 Reduced Fish Passage

During a 2-year flood scenario, fish passage and survival is expected to decrease from upstream and downstream migration through the flood retention facility conduits, compared to existing Chehalis River instream conditions (Table 6.4-15). Adult upstream fish passage total survival is expected to be between 92% and 96% for salmonids and lamprey. Juvenile and adult downstream fish passage total survival is expected to be between 64% and 79% (Table 6.4-15). Juvenile upstream performance values are estimated low since no formal guidelines exist (HDR 2017). Juvenile downstream fish passage total survival is expected to be around 85% for most salmonids and 95% for steelhead and lamprey. Justification for the fish passage performance and survival values is provided in Section 3.3.2.2 of Appendix A.

Table 6.4-15
Fish Passage Performance and Survival Values for Flood Retention Operations via Conduits

TARGET SPECIES	PERFORMANCE	SURVIVAL	TOTAL SURVIVAL
ADULT UPSTREAM			
Spring-run Chinook Salmon	95%	99%	94%
Fall-run Chinook Salmon	95%	99%	94%
Coho Salmon	95%	99%	94%
Steelhead	97%	99%	96%
Coastal Cutthroat Trout	93%	99%	92%
Pacific Lamprey	97%	99%	96%
JUVENILE UPSTREAM			
Spring-run Chinook Salmon	65%	99%	64%
Fall-run Chinook Salmon	65%	99%	64%
Coho Salmon	65%	99%	64%
Steelhead	80%	99%	79%
Coastal Cutthroat	65%	99%	64%
Pacific Lamprey	--	--	--
ADULT DOWNSTREAM			
Spring-run Chinook Salmon	--	--	--
Fall-run Chinook Salmon	--	--	--
Coho Salmon	--	--	--
Steelhead (kelts)	98%	75%	74%
Coastal Cutthroat (kelts)	98%	80%	78%
Pacific Lamprey	--	-	-
JUVENILE DOWNSTREAM			
Spring-run Chinook Salmon	100%	85%	85%
Fall-run Chinook Salmon	100%	85%	85%
Coho Salmon	100%	85%	85%
Steelhead	100%	95%	95%
Coastal Cutthroat Trout	100%	85%	85%
Pacific Lamprey	100%	95%	95%

Notes:
--: No data are available or the species/life stage will not use passage in the given direction.
Performance, Survival, and Total Survival values for all species and life-stages through the conduits were taken from the *Chehalis Basin Strategy: Conceptual Combined Dam and Fish Passage Design Report*, Appendix G (HDR 2017). The definitions of Performance, Survival, and Total Survival in relation to fish passage are given in Section 3.3.1 of Appendix A.

During a major or greater flood in which the temporary reservoir forms, higher impacts to fish passage rates and survival could occur than under a 2-year flood. Adult and juvenile upstream total survival through the CHTR is expected to range from 54 to 90% (Table 6.4-16). The CHTR would be designed to comply with NMFS and WDFW fish passage guidelines that are geared towards commonly managed salmonid species. As such, coastal cutthroat are expected to have poorer survival than other salmonids through the CHTR. Although a specialized lamprey ladder would be included in the CHTR design, less available information on lamprey passage means that performance was conservatively estimated to be lower than for salmonids. Other native species are not expected to pass above the FRE facility during impoundment. These impacts would be temporary and uncommon since inundation is only expected to occur approximately once every 7 years and passage through the conduits would resume within 32 days. Therefore, these impacts would be considered low to medium.

No downstream fish passage for adults or juveniles is planned during temporary reservoir inundation. Because no passage would be provided, delays in migration could occur for up to 32 days. Migrating fish would have to remain in the reservoir or areas upstream of the reservoir until the reservoir drawdown was complete. After drawdown, the fish would be able to pass through the conduits. Delays in migration can cause juvenile salmonids to experience poorer downstream conditions such as warmer temperatures and lower flows, increase exposure to predation, and potentially reduce ocean survival (Freshwater et al. 2016, Marschall et al. 2011). Delays in migration to kelts in poor physical condition after spawning could result in increased mortality (Hatch et al. 2013).

During the summer, adults and juvenile salmonids, lamprey, and other native fish are expected to be able to make daily or seasonal upstream and downstream behavioral movements through the conduits. The proposed temporary retention facility is not expected to be impounding water during the summer so the CHTR would not be in operation.

Table 6.4-16
Fish Passage Performance and Survival Values for Flood Retention Operations during a 10-year or 100-year Flood via the Collection, Handling, Transport, and Release Facility

TARGET SPECIES	PERFORMANCE	SURVIVAL	TOTAL SURVIVAL
ADULT UPSTREAM			
Spring-run Chinook Salmon	93%	98%	90%
Fall-run Chinook Salmon	93%	98%	90%
Coho Salmon	93%	98%	90%
Steelhead	93%	98%	90%
Coastal Cutthroat	55%	98%	54%
Pacific Lamprey	60%	90%	54%
Western Brook Lamprey	60%	90%	54%
JUVENILE UPSTREAM			
Spring-run Chinook Salmon	93%	98%	90%
Fall-run Chinook Salmon	93%	98%	90%
Coho Salmon	93%	98%	90%
Steelhead	93%	98%	90%
Coastal Cutthroat	55%	98%	54%

Notes:
Performance and Total Survival values for upstream adult passage of EDT modeled species (spring-run Chinook salmon, fall-run Chinook salmon, coho salmon, and steelhead) via the CHTR facility accounts for 1% delayed mortality, as described in Section 3.3.2.2.2 of Appendix A. Detailed calculations are provided in Attachment H of Appendix A. Performance, Survival, and Total Survival values for all upstream juveniles and for upstream adult Coastal Cutthroat and Pacific Lamprey were taken from the Chehalis Basin Strategy: Conceptual Combined Dam and Fish Passage Design Report, Appendix G. The definitions of Performance, Survival, and Total Survival in relation to fish passage are given in Section 3.3.1 of Appendix A.

6.4.4.3 Marine Mammals

Based on modeled declines in spring-run Chinook salmon abundance compared to the No Action Alternative, when the flood retention facility is impounding water there are expected to be low impacts to downstream marine mammal predators that rely on Chinook salmon for prey. This would occur approximately once every 7 years. When the facility is not impounding water (most of the time), there would be no impact on marine mammals since modeled salmonid abundance is expected to not change or slightly increase compared to the No Action Alternative.

During impoundment, the impact on marine mammals is related to the basin-wide EDT predictions of up to a 2% decline in spring-run Chinook salmon abundance. A recent memorandum reported that total Chinook salmon spawners above the proposed flood retention facility contribute less than 5% to the Chehalis Basin and Grays Harbor escapement (number of fish that go out to the ocean and return to spawn) (Table 6.4-17; Ronne 2019). As such, this impact is expected to be low.

Table 6.4-17
Contributions of Upper Chehalis River Basin Escapement (Above the Proposed Flood Retention Facility) to the Chehalis Basin and Grays Harbor Escapement Totals

SPECIES	CHEHALIS BASIN	GRAYS HARBOR
Spring-run Chinook salmon	1.2%	N/A[1]
Fall-run Chinook salmon	3.4%	2.4%
Steelhead	15.7%	12.7%
Coho salmon	2.7%	2.4%

Notes:
Source: Ronne 2019
1. No additional contributions for spring-run Chinook salmon from Humptulips or South Bay rivers

6.4.4.4 Climate Variability

As noted in Section 5.4, precipitation patterns and air temperatures could change and become more extreme in the future. Under these conditions, it is possible that the proposed FRE facility would operate more frequently. This would result in more frequent impacts on all aquatic species in the vicinity of the FRE facility, mainly from the loss of aquatic habitat and reduced fish passage when the temporary reservoir was impounding water. These habitat impacts are discussed in Section 6.4.3.6.

As noted in Section 6.4.3.6, the degree to which aquatic species would be adversely affected compared to the No Action Alternative is difficult to predict. However, Alternative 1 would further degrade habitat compared to the No Action Alternative from increased water temperature and lower dissolved oxygen levels. These changes would worsen the already adverse impacts of increased climate variability over time.

6.5 Alternative 2: Flood Retention Only (FRO) Facility and Airport Levee Improvements

This section describes the potential for impacts to occur under Alternative 2 relative to Alternative 1.

The FRO facility would be identical to the FRE facility except that the FRO facility would have a smaller foundation, resulting in possible differences in impacts related to construction. The operation of the two flood retention facilities would be identical. The Airport Levee Improvements under Alternative 2 would be identical to those under Alternative 1. Therefore, no difference in impacts is expected relative to the Airport Levee Improvements.

Construction of Alternative 2 would result in slightly less direct and indirect impact on aquatic species and habitat as Alternative 1. Because the footprint of the FRO facility would be slightly smaller than the FRE facility, fill placement impacts on the Chehalis River from construction of the downstream stilling basin would be approximately 0.21 acre less than what would occur with the FRE facility. Alternative 2 would be expected to complete construction approximately 9 months earlier than Alternative 1, so temporary impacts would not last as long. All other construction impacts on aquatic species and habitat from fill placement and vegetation removal activities would be the same as those that would occur with Alternative 1.

7 REQUIRED PERMITS AND APPROVALS

This section provides a list of anticipated permits and approvals specific to the protection of aquatic species and habitat. The permits and approvals listed in this section are generally associated with the impacts identified in Chapter 6. Relevant best management practices, development standards, or other actions that would be required by these regulations and/or permits are also provided.

7.1 Federal

Federal permits would include the following:

- **CWA Section 404 Permit (Corps).** Construction of the proposed project would result in a discharge of fill into the aquatic environment. A Department of the Army permit under CWA Section 404 would be required. This permit requires demonstration of avoidance and minimization, an alternatives analysis and selection of the least environmentally damaging practicable alternative, and compensatory mitigation for unavoidable impacts.
- **CWA Section 401 Water Quality Certification (Ecology).** This certification would be required to ensure that the proposed project would not violate state water quality standards.
- **CWA Section 402 National Pollutant Discharge Elimination System, Construction Stormwater General Permit (Ecology).** Construction of Alternatives 1 and 2 would disturb 1 acre or more of land through clearing, grading, excavating, or stockpiling fill material. This action requires a Construction Stormwater General Permit. This permit requires the preparation of a Stormwater Pollution Prevention Plan and temporary erosion and sediment control plan to identify BMPs to reduce impacts from construction stormwater.
- **ESA Section 7 Consultation (NMFS/USFWS)**. Issuance of a Department of the Army Permit under CWA Section 404 is a federal action that would require interagency consultation with the NMFS/USFWS regarding aquatic species and their critical habitat under Section 7 of the ESA. Interagency consultation is performed to ensure that the proposed project would not jeopardize the existence of any listed species or their critical habitat. Bull trout critical habitat occurs in the lower reach of the study area up to between RM 40 and RM 50. Bull trout, Pacific eulachon, and water howellia are listed species that could be present in the study area. However, none have been found in the study area during recent surveys. Pacific eulachon spawning habitat is not expected to be in the study area (Section 5.3.2.1.1). Water howellia habitat exists within the Chehalis River 100-year floodplain study area (Section 5.3.2.1.3).
- **Tribal Critical Area Permits**. The Confederated Tribes of the Chehalis Reservation (Chehalis Tribe) and Quinault Indian Nation retain sovereign rights that are guaranteed under treaties and federal laws. For activities on tribal lands, tribal laws may require critical area permits and approvals. No construction activities are expected to occur on tribal land. Therefore, these permits are not expected to be required.

7.2 State

State of Washington permits would include the following:

- **Hydraulic Project Approval (WDFW).** Construction of the proposed project would occur in or near the Chehalis River, a water of the state, which requires a hydraulic project approval. This permit would specify conditions of construction, such as timing of in-water work and monitoring requirements.
- **Aquatic Use Authorization (WDNR).** Activities that occur in or on state-owned aquatic lands may require an Aquatic Use Authorization (e.g., Aquatic Lands Lease) from WDNR. Aquatic Use Authorizations are legal contracts, not permits. These contracts specify the terms and conditions of the use and allow certain property rights to the lessee in exchange for rent.
- **Coastal Zone Management Act**. Federal actions (e.g., issuance of a permit) that may affect any land use, water use, or natural resources in the coastal zone must be consistent with the state Coastal Zone Management Plan, which is in place to protect, restore, and responsibly develop the state's marine shorelines in Puget Sound and Pacific Ocean coast. Grays Harbor County is a county within the coastal zone.

7.3 Local

Local permits would include the following:

- **Shoreline Substantial Development Permit (Lewis County).** The proposed project would involve new development in the shoreline area of the Chehalis River that is regulated by the Washington State Shoreline Management Act and the Lewis County Shoreline Master Program. This action would require a Shoreline Substantial Development Permit.
- **Land Use Permit (Lewis County).** This permit is required for land development actions or changes in land use in Lewis County. Permit would require compliance with Lewis County’s critical areas ordinance.
- **Land Use Permit (City of Chehalis).** This permit is required for land development actions or changes in land use in the City of Chehalis. The permit would require compliance with the City of Chehalis’s critical areas ordinance.

8 REFERENCES

Anchor QEA (Anchor QEA, LLC), 2012. *Chehalis Flood Authority Fish Study*. Appendix C: Water Quality Evaluations.

Anchor QEA, 2014. *Water Quality Studies Final Report*. Prepared for the Washington State Office of Financial Management. September 2014.

Anchor QEA, 2016. *Proposed Flood Retention Facility Pre-Construction Vegetation Management Plan*.

Anchor QEA, 2018a. *Sound and Vibration Characterization Report*. Lower Granite Adult Passage Evaluation. January 2018.

Anchor QEA, 2018b. *Chehalis River Basin Flood Damage Reduction Project: Wetland, Water, and OHWM Delineation Report*. Prepared for the U.S. Army Corps of Engineers, Washington Department of Ecology, and Washington Department of Fish and Wildlife. December 2018.

Anchor QEA, 2019a. Memorandum to: Chehalis River Basin Flood Damage Reduction Project NEPA EIS Team. Regarding: Chehalis NEPA EIS Alternatives and Assumptions. June 24, 2019.

Anchor QEA, 2019b. *Reservoir Water Quality Report*. Prepared for the Washington Department of Ecology and U.S. Army Corps of Engineers. April 2019.

Anderson, P.D., D.J. Larson, and S.S. Chan, 2007. "Riparian Buffer and Density Management Influences on Microclimate of Young Headwater Forests of Western Oregon." *Forest Science* 53(2):254-269.

ASEPTC (Aquatic Species Enhancement Plan Technical Committee), 2014. *Aquatic Species Enhancement Plan. Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species*. Accessed October 7, 2019. Accessed at: http://chehalisbasinstrategy.com/wp-content/uploads/2015/09/Aquatic-Species-Restoration-Program-Report_Final.pdf.

Ashcraft, S., C. Holt, M. Zimmerman, M. Scharpf, and N. Vanbuskirk, 2017. *Final Report: Spawner Abundance and Distribution of Salmon and Steelhead in the Upper Chehalis River, 2013-2017*. FPT 17-12. Olympia, Washington: Washington Department of Fish and Wildlife.

ASRPSC (Aquatic Species Restoration Plan Steering Committee), 2019. *Chehalis Basin Strategy Aquatic Species Restoration Plan. Phase I: November 2019*. Publication No. 19-06-009.

Beecher, H. (Washington Department of Fish and Wildlife), 2015. Regarding: Weighted Usable Area for species. Email to: Robert Montgomery (Anchor QEA). November 5, 2015.

Bergendorf, D., 2002. *The Influence of In-Stream Habitat Characteristics on Chinook Salmon* (Oncorhynchus tshawytscha). Prepared for the NOAA Northwest Fisheries Science Center, Seattle, Washington.

Blevins, E. (Xerces Society), 2018. *Western Ridged Mussel* (Gonidea angulata). Presentation to the Chehalis Basin Strategy Science Review Team. May 23, 2018.

BOEM (Bureau of Ocean Energy Management), 2012. *Effects of Noise on Fish, Fisheries, and Invertebrates in the U.S. Atlantic and Arctic from Energy Industry Sound-Generating Activities*. Workshop Report. December 2012.

Brooker, M.P., 1985. "The Impact of River Channelization: The Ecological Effects of Channelization." *The Geographical Journal* 151(1):63–69. Accessed at: https://www.jstor.org/stable/633280?seq=1.

Brown, S.K., T.R. Seamons, C. Holt, S. Ashcraft, and M. Zimmerman, 2017. *Population Genetic Analysis of Chehalis River Basin Chinook Salmon* (Oncorhynchus tshawytscha). FPT 17-13. Olympia, Washington: Washington Department of Fish and Wildlife.

Bumbaco, K.A., K.D. Dello, and N.A. Bond, 2013. "History of Pacific Northwest heat waves: Synoptic pattern and trends." *Journal of Applied Meteorology and Climatology* 52(7):1618–1631. Accessed at: https://dx.doi.org/10.1175/jamc-d-12-094.1.

Caldwell, B., J. Pacheco (Ecology), H. Beecher, T. Hegy, and R. Vadas (WDFW), 2004. *Chehalis River Basin WRIAs 22 and 23 Fish Habitat Analysis Using the Instream Flow Incremental Methodology*. Technical Report 04-11-006. March 2004.

Cascadia (Cascadia Consulting Group), 2018. *Southern Resident Orca Task Force*. November 2018.

Chowdhury, M.M.R., T.J. Marjomaki, and J. Taskinen, 2019. "Effect of Glochidia Infection on Growth of Fish: Freshwater Pearl Mussel (*Margaritifera margaritifera*) and Brown Trout (*Salmo trutta*)." *Hydrobiologia* 2019. Accessed at: https://doi.org/10.1007/s10750-019-03994-4.

Corps (U.S. Army Corps of Engineers), 2020a. *Chehalis River Basin Flood Damage Reduction Project NEPA EIS Discipline Report for Wetlands and Other Waters*. September 2020.

Corps, 2020b. *Chehalis River Basin Flood Damage Reduction Project NEPA EIS Discipline Report for Terrestrial Species and Habitat*. September 2020.

Corps, 2020c. *Chehalis River Basin Flood Damage Reduction Project NEPA EIS Discipline Report for Water Quality and Quantity*. September 2020.

Corps, 2020d. *Chehalis River Basin Flood Damage Reduction Project NEPA EIS Discipline Report for Geomorphology*. September 2020.

Cramer, M.L., editor, 2012. *Stream Habitat Restoration Guidelines*. Copublished by the Washington Departments of Fish and Wildlife, Natural Resources, Transportation and Ecology, Washington State Recreation and Conservation Office, Puget Sound Partnership, and the U.S. Fish and Wildlife Service.

CRBFCZD (Chehalis River Basin Flood Control Zone District), 2019. *Proposed Flood Retention Dam Construction Schedule Supplemental Information*. Submitted to the Washington Department of Ecology and the U.S. Army Corps of Engineers. September 2019.

Davidson, S.L., and B.C. Eaton, 2015. "Simulating Riparian Disturbance: Reachscale Impacts on Aquatic Habitat In Gravel Bed Streams." *Water Resources Research* 51(9):7590–7607. Accessed at: https://dx.doi.org/10.1002/2015WR017124.

Dibble, E.D., 2009. "Impact of Invasive Aquatic Plants on Fish." *Biology and Control of Aquatic Plants: A Best Management Practices Handbook*. Marietta, Georgia: Aquatic Ecosystem Restoration Foundation; pp. 9–19.

Dolloff, C.A., and M.L. Warren, 2003. "Fish Relationships with Large Wood in Small Streams." *American Fisheries Society Symposium* 37:179–193.

Easterling, D.R., K.E. Kunkel, J.R. Arnold, T. Knutson, A.N. LeGrande, L.R. Leung, R.S. Vose, D.E. Waliser, and M.F. Wehner, 2017. "Precipitation change in the United States." *Climate Science Special Report: Fourth National Climate Assessment, Volume I*. Editors, D.J. Wuebbles, D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock. Washington, DC: U.S. Global Change Research Program, pp. 207-230. Accessed at: https://dx.doi.org/10.7930/J0H993CC.

Ecology (Washington Department of Ecology), 2001. *Upper Chehalis River Basin Temperature Total Maximum Daily Load*. Publication No. 99-52. July 2001.

Ecology, 2006. *Native Plants for Aquatic Gardens and Aquariums*. January 2006. Accessed at: https://fortress.wa.gov/ecy/publications/documents/0603004.pdf.

Ecology, 2017. *Chehalis Basin Strategy Final Programmatic EIS*. June 2017. Accessed at: http://chehalisbasinstrategy.com/programmatic-eis/.

Ecology, 2019a. *Aquatic Plant Identification Manual for Washington's Freshwater Plants*. Accessed October 25, 2019. Accessed at: https://fortress.wa.gov/ecy/gisresources/lakes/AquaticPlantGuide/SpeciesIndex.html.

Ecology, 2019b. *Washington State Water Quality Atlas*. Accessed November 11, 2019. Accessed at: https://fortress.wa.gov/ecy/waterqualityatlas/StartPage.aspx.

Edwards, A.R., and M.S. Zimmerman, 2018. *Grays Harbor Fall Chum Abundance and Distribution, 2017*. FPA 18-09. Olympia, Washington: Washington Department of Fish and Wildlife.

Elliot, B., T. Tschetter, and L. Karpack, 2019. Memorandum regarding: Chehalis River Existing Conditions RiverFlow2D Model Development and Calibration. February 28, 2019.

Engle, R.O., W.R. Brigon, and J. Salicky, 2010. *Evaluation of a Resistance Board Weir in the White Salmon River for Capture of Lower Columbia River Fall-Run Chinook Salmon* (Oncorhynchus tshawytscha) *for Transport During the Year of Condit Dam Removal*. Vancouver, Washington: U.S. Fish and Wildlife Service, Columbia River Fisheries Office.

EPA (U.S. Environmental Protection Agency), 2019. "Watershed Change: Agents of Watershed Change Module." *Watershed Academy Web.* Last updated August 20, 2019; accessed November 23, 2019. Accessed at: https://www.epa.gov/watershedacademy/online-training-watershed-management.

Ferguson, J., 2020. *How Do Fish React to Floods?* Prepared for the Office of the Chehalis Basin. January 2020.

Ferguson, J.W., B.P. Sandford, R.E. Reagan, L.G. Gilbreath, E.B. Meyer, R.D. Ledgerwood, and N.S. Adams, 2007. "Bypass System Modification at Bonneville Dam on the Columbia River Improved the Survival of Juvenile Salmon." *Transactions of the American Fisheries Society* 136(6):1487–1510.

Freshwater, C., M. Trudel, T.D. Beacham, L. Godbout, C.E.M. Neville, S. Tucker, and F. Juanes, 2016. "Divergent Migratory Behaviours Associated with Body Size and Ocean Entry Phenology in Juvenile Sockeye Salmon." *Canadian Journal of Fisheries and Aquatic Sciences* 73(12):1723–1732.

Gadomski, D.M., C.A. Barfoot, J.M. Bayer, and T.P. Poe, 2001. "Early Life History of the Northern Pikeminnow in the Lower Columbia River Basin." *Transactions of the American Fisheries Society* 130:250–262.

Georgakakos, A., P. Fleming, M. Dettinger, C. Peters-Lidard, T.C. Richmond, K. Reckhow, K. White, and D. Yates, 2014. "Ch. 3: Water Resources." *Climate Change Impacts in the United States: The Third National Climate Assessment*. Editors, J.M. Melillo, T.C. Richmond, and G.W. Yohe. Washington, D.C.: U.S. Global Change Research Program; pp. 69–112.

GHLE (Grays Harbor Lead Entity), 2011. *The Chehalis Basin Salmon Habitat Restoration and Preservation Strategy for WRIA 22 and 23*. Updated June 30, 2011.

Grimm, N.B., S.H. Faeth, N.E. Golubiewski, C.L. Redman, J. Wu, X. Bai, and J.M. Briggs, 2008. "Global Change and the Ecology of Cities." *Science* 309:756–760.

Hatch, D., and R. Branstetter, 2002. *Kelt Reconditioning: A Research Project to Enhance Iteroparity in Columbia Basin Steelhead* (Oncorhynchus mykiss). Prepared by the Columbia River Inter-Tribal Fish Commission for the U.S. Department of Energy Bonneville Power Administration, Division of Fish and Wildlife.

Hatch, D.R., D.E. Fast, W.J. Bosch, J.W. Blodgett, J.M. Whiteaker, R. Branstetter, and A.L. Pierce, 2013. "Survival and Traits of Reconditioned Kelt Steelhead *Oncorhynchus mykiss* in the Yakima River, Washington." *North American Journal of Fisheries Management* 33(3):615–625.

Hayes, M., J. Tyson, K. Douville, and R. Vadas, Jr., 2018. *2018 Chehalis ASRP Instream Amphibian Survey Report*. May 24, 2018.

Hayes, M., J. Tyson, J. Layman, and K. Douville, 2019. *Intensive Study of Chehalis Floodplain Off-Channel Habitats*. Olympia, Washington: Washington State Department of Fish and Wildlife, Fish Program, Fish Science Division. March 26, 2019.

HDR (HDR Engineering, Inc.), 2017. *Chehalis Basin Strategy Combined Dam and Fish Passage Conceptual Design Report*. Prepared for the State of Washington Recreation and Conservation Office and Chehalis Basin Work Group. June 2017.

HDR, 2018. *Chehalis Basin Strategy Combined Dam and Fish Passage Supplemental Design Report: FRE Alternative*. Prepared for the State of Washington Recreation and Conservation Office and Chehalis Basin Work Group. September 2018.

Henning, J., R.E. Gresswell, and I.A. Fleming, 2006. "Juvenile Salmonid Use of Freshwater Emergent Wetlands in the Floodplain and Its Implications for Conservation Management." *North American Journal of Fisheries Management* 26:367–376.

Henning, J., R.E. Gresswell, and I.A. Fleming, 2007. "Use of Seasonal Freshwater Wetlands by Fishes in a Temperate River Floodplain." *Journal of Fish Biology* 71:476–492.

Hershey, A.E., G.A. Lamberti, D.T. Chaloner, and R.M. Northington, 2010. "Aquatic Insect Ecology." *Ecology and Classification of North American Freshwater Invertebrates*. Third Edition. Academic Press; pp. 659–694.

Hill, A. (Anchor QEA), 2019. Regarding: Chehalis flow plots. Email to: Sydney Gonsalves and Elizabeth Green. Friday, November 1, 2019.

ICF (ICF International, Inc.), 2019. *Procedure for Rating Water Temperature in the Chehalis ASRP EDT Model*. March 21, 2019.

Keefer, M.L., G.A. Taylor, D.F. Garletts, G.A. Gauthier, T.M. Pierce, and C.C. Caudill, 2010. "Prespawn Mortality in Adult Spring-Run Chinook Salmon Outplanted Above Barrier Dams." *Ecology of Freshwater Fish* 19(3):361–372.

Kendall, N., and M. Zimmerman, 2018. *Validation of Habitat Preferences for Select Native Freshwater Fishes in the Chehalis River, Washington State*. FPT 18-02. Olympia, Washington: Washington Department of Fish and Wildlife.

Kovalenko, K.E., S.M. Thomaz, and D.M. Warfe, 2012. "Habitat Complexity: Approaches and Future Directions." *Hydrobiologia* 685(1):1–17.

Kuehne, L.M., and J.D. Olden, 2016. "Environmental Drivers of Occupancy and Detection of Olympic Mudminnow." *Transactions of the American Fisheries Society* 145:17–26.

Langness, O.P., L.L. Lloyd, S.M. Schade, B.J. Cady, L.B. Heironimus, and B.W. James (WDFW Columbia River Management Unit); P.E. Dionne, A.M. Claiborne, and M.P. Small (WDFW Marine Resources and Science Division); and C. Wagemann (Quileute Nation), 2018. *Studies of Eulachon in Oregon and Washington*. FPT 18-07. September 28, 2018.

Lehman, B., D.D. Huff, S.A. Hayes, and S.T. Lindley, 2017. "Relationships Between Chinook Salmon Swimming Performance and Water Quality in the San Joaquin River, California." *Transactions of the American Fisheries Society* 146(2):349–358.

Lestelle, L.C., 2005. *Guidelines for Rating Level 2 Environmental Attributes in Ecosystem Diagnosis and Treatment (EDT)*. Jones & Stokes Associates, Inc. July 2005.

Lestelle, L., M. Zimmerman, C. McConnaha, and J. Ferguson, 2019. Memorandum regarding: Spawning Distribution of Chehalis Spring-Run Chinook Salmon and Application to Modeling. April 8, 2019.

Liedtke, T.L., M.S. Zimmerman, R.G. Tomka, C. Holt, and L. Jennings, 2016. *Behavior and Movements of Adult Spring-Run Chinook Salmon* (Oncorhynchus tshawytscha) *in the Chehalis River Basin, Southwestern Washington, 2015*. U.S. Geological Survey Open-File Report 2016-1158. Accessed at: http://dx.doi.org/10.3133/ofr20161158.

Lindley, ST., D.L. Erickson, M.L. Moser, G. Williams, O.P. Langness, B.W. McCovey, Jr., M. Belchik, D. Vogel, W. Pinnix, J.T. Kelly, J.C. Heublein, and A.P. Klimley, 2011. "Electronic Tagging of Green Sturgeon Reveals Population Structure and Movement among Estuaries." *Transactions of the American Fisheries Society* 140:108–122.

Marschall, E.A., M.E. Mather, D.L. Parrish, G.W. Allison, and J.R. McMenemy, 2011. "Migration Delays Caused by Anthropogenic Barriers: Modeling Dams, Temperature, and Success of Migrating Salmon Smolts." *Ecological Applications* 21(8):3014–3031.

May, C., C. Luce, J. Casola, M. Chang, J. Cuhaciyan, M. Dalton, S. Lowe, G. Morishima, P. Mote, A. Petersen, G. Roesch-McNally, and E. York, 2018. "Northwest." *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II*. Editors, D.R. Reidmiller, C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart. Washington, DC: U.S. Global Change Research Program, pp. 1036–1100. Accessed at: https://dx.doi.org/10.7930/NCA4.2018.CH24.

McElhany, P., M.H. Rucklelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt, 2000. *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units.* NOAA Technical Memorandum NMFS-NWFSC-42. Accessed at: https://www.nwfsc.noaa.gov/assets/25/6190_06162004_143739_tm42.pdf.

McMullen, Laura (ICF), 2019. Personal communication with Elizabeth Greene (Anchor QEA). October 21, 2019.

Navy (U.S. Navy), 2011. "Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) website for Navy Training Activities in the Gulf of Alaska." Updated May 2011. Accessed at: http://www.goaeis.com/.

Nedeau, E.J., A.K. Smith, J. Stone, and S. Jepsen, 2009. *Freshwater Mussels of the Pacific Northwest*. Second Edition. Portland, Oregon: The Xerces Society. Accessed at: www.xerces.org/western-freshwater-mussels/.

NMFS (National Marine Fisheries Service), 2011. *Anadromous Salmonid Passage Facility Design*. Portland, Oregon: National Marine Fisheries Service, Northwest Region.

NOAA (National Oceanic and Atmospheric Administration), 1999. *Essential Habitat Descriptions for Chinook and Coho Salmon*. Appendix A: EFH. August 1999.

NOAA, 2005a. *Green Sturgeon* (Acipenser medirostris) *Status Review Update*. NOAA Fisheries, Santa Cruz Laboratory, Southwest Fisheries Science Center. February 2005.

NOAA, 2005b. Endangered and Threatened Species; Designation of Critical Habitat for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho; Final Rule. Docket No. 030716175–5203–04; I.D. No. 070303A. 50 CFR Part 226. September 2, 2005.

NOAA, 2010. *Environmental Assessment Issuance of a Protected Species Conservation and Recovery Grant to the Washington Department of Fish and Wildlife (Award File NA10NMF4720037) to Conduct Research on Green Sturgeon on the West Coast of the United States*. May 6, 2010.

NOAA, 2019a. "West Coast Salmon and Steelhead Listing." Accessed July 15, 2019. Accessed at: https://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/salmon_and_steelhead_listings.html.

NOAA, 2019b. "NOAA National Marine Fisheries Habitat Conservation Mapper." Accessed July 15, 2019. Accessed at: https://www.habitat.noaa.gov/protection/efh/efhmapper/index.html#.

NOAA, 2019c. "Green Sturgeon Overview." Accessed October 24, 2019. Accessed at: https://www.fisheries.noaa.gov/species/green-sturgeon.

NOAA, 2019d. "Understanding Essential Fish Habitat." Accessed November 8, 2019. Accessed at: https://www.fisheries.noaa.gov/insight/understanding-essential-fish-habitat.

NOAA, 2019e. "NOAA National Marine Fisheries ESA Threatened & Endangered Species List." Accessed at: https://www.fisheries.noaa.gov/national/endangered-species-conservation/esa-threatened-endangered-species.

Normandeau (Normandeau Associates), 2012. *Chehalis River Fish Study: PHABSIM Instream Flow Study*. Appendix D. April 2012.

Ostberg, C.O., D.M. Chase, M.C. Hayes, and J.J. Duda, 2018. "Distribution and Seasonal Differences in Pacific Lamprey and Lampetra spp eDNA Across 18 Puget Sound Watersheds." *PeerJ* 6:e4496. Accessed at: https://dx.doi.org/10.7717/peerj.4496.

Pacheco, J. (Washington Department of Ecology), 2019. Regarding: Chehalis 2012 Instream Flow Study. Email to Larissa Rohrbach and John Ferguson (Anchor QEA), and Marie Winkowski (WDFW). June 18, 2019.

Pearson, M., 2004. *Using Recovery Science and Recovery Action in Mutual Support: A Case Study of Habitat Restoration for the Salish Sucker.* Paper presented at Proceedings of Species at Risk 2004 Pathways to Recovery Conference (Victoria B.C.); March 2–6, 2004.

Perry, G., J. Lundquist, and R.D. Moore, 2016. *Review of the Potential Effects of Forest Practices on Stream Flow in the Chehalis River Basin*. Accessed at: https://depts.washington.edu/mtnhydr/people/Perry_Chehalis_forest_streamflow.pdf.

Peterson, T.C., R.R. Heim, Jr., R. Hirsch, D.P. Kaiser, H. Brooks, N.S. Diffenbaugh, R.M. Dole, J.P. Giovannettone, K. Guirguis, T.R. Karl, R.W. Katz, K. Kunkel, D. Lettenmaier, G.J. McCabe, C.J. Paciorek, K.R. Ryberg, S. Schubert, V.B.S. Silva, B.C. Stewart, A.V. Vecchia, G. Villarini, R.S. Vose, J. Walsh, M. Wehner, D. Wolock, K. Wolter, C.A. Woodhouse, and D. Wuebbles, 2013. "Monitoring and Understanding Changes in Heat Waves, Cold Waves, Floods and Droughts in the United States: State of Knowledge." *Bulletin of the American Meteorological Society* 94:821–834. Accessed at: https://dx.doi.org/10.1175/BAMS-D-12-00066.1.

Poytress, W.R., J.J. Gruber, J.P. Van Eenennaam, and M. Gard, 2015. "Spatial and Temporal Distribution of Spawning Events and Habitat Characteristics of Sacramento River Green Sturgeon." *Transactions of the American Fisheries Society* 144:1129–1142.

Pribyl, A.L., J.S. Vile, and T.A. Friesen, 2004. *Population Structure, Movement, Habitat Use, and Diet of Resident Piscivorous Fishes in the Lower Willamette River*. Oregon Department of Fish and Wildlife. June 2004.

Rieman, B.E., and J.D. McIntyre, 1993. *Demographic and Habitat Requirements for Conservation of Bull Trout*. General Technical Report INT-302. Ogden, Utah: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. September 1993.

Ronne, L., 2019. Memorandum regarding: Contribution of Steelhead, Coho and Chinook from Upper Chehalis Basin Above the Proposed Dam Site to the Grays Harbor Populations. January 22, 2019. Olympia, Washington: Washington Department of Fish and Wildlife.

Ronne, L., N. Vanbuskirk, C. Holt, and M. Zimmerman, 2018. *Spawner Abundance and Distribution of Salmon and Steelhead in the Upper Chehalis River, 2017-2018*. FPT 18-09. Olympia, Washington: Washington Department of Fish and Wildlife.

Ronne L., N. VanBuskirk, and M. Litz, 2020. *Spawner Abundance and Distribution of Salmon and Steelhead in the Upper Chehalis River, 2019 and Synthesis of 2013-2019*. FPT 20-06. Olympia, Washington: Washington Department of Fish and Wildlife.

Santos, N.R., J.V.E. Katz, P.B. Moyle, and J.H. Viers, 2014. "A Programmable Information System for Management and Analysis of Aquatic Species Range Data in California." *Environmental Modelling & Software* 53:13–26.

Schroeder, K., 1996. *A Review of Capture Techniques for Adult Anadromous Salmon*. Portland, Oregon: Oregon Department of Fish and Wildlife, Fish Division. March 1996.

Seamons, T., C. Holt, S. Ashcraft, and M. Zimmerman, 2017. *Population Genetic Analysis of Chehalis River Watershed Winter Steelhead* (Oncorhynchus mykiss). FPT 17-14. Olympia, Washington: Washington Department of Fish and Wildlife.

Seamons, T.R., C. Holt, L. Ronne, A. Edwards, and M. Scharpf, 2019. *Population Genetic Analysis of Chehalis River Watershed Coho Salmon* (Oncorhynchus kisutch). Olympia, Washington: Washington Department of Fish and Wildlife, Fish Program, Fish Science Division. June 27, 2019.

Sharp, F.R. (President, Quinault Indian Nation), 2016. Letters to: M. Bellon, Director, Washington Department of Ecology. Regarding: Quinault Indian Nation Treaty Rights and Usual and Accustomed Areas, Chehalis Basin Strategy Programmatic Environmental Impact Statement, Quinault Indian Nation Preliminary Comments and Information. April 6, 2016, and May 13, 2016.

Simon, B. (WSDA), and M. Peoples (WDFW), 2006. *Integrated Aquatic Plant Management Plan for the Chehalis River Basin*. December 16, 2006.

Sloat, M.R., G.H. Reeves, and K.R. Christiansen, 2018. "Stream Network Geomorphology Mediates Predicted Vulnerability of Anadromous Fish Habitat to Hydrologic Change in Southeast Alaska." *Global Change Biology* 23:604–620. Accessed at: https://dx.doi.org/10.1111/gcb.13466.

Smith, C.J., and M. Wenger, 2001. *Salmon and Steelhead Habitat Limiting Factors. Chehalis Basin and Nearby Drainages Water Resource Inventory Areas 22 and 23*. Washington State Conservation Commission Final Report. May 2001.

Steel, A.E., M.J. Thomas, and A.P. Klimley, 2019. "Reach Specific Use of Spawning Habitat by Adult Green Sturgeon (*Acipenser medirostris*) Under Different Operation Schedules at Red Bluff Diversion Dam." *Journal of Applied Ichthyology* 35(1):22–29.

Stream Bryophyte Group, 1999. "Roles of Bryophytes in Stream Ecosystems." *Journal of the North American Benthological Society* 18(2):151–184.

Talbot, C.J, E.M. Bennett, K. Cassell, D.M. Hanes, E.C. Minor, H. Pearl et al. 2018. "The impact of flooding on aquatic ecosystem services." *Biogeochemistry* 141: 439-461.

Thompson, T.Q., S.M. Rourke, and M.R. Miller, 2019a. *Genetic Analyses in the Chehalis River, WA Provide Insight for Monitoring Spring-Run Chinook*.

Thompson, T.Q., S.M. Rourke, S.K. Brown, T. Seamons, M. Zimmerman, and M.R. Miller, 2019b. *Run-Type Genetic Markers and Genomic Data Provide Insight for Monitoring Spring-Run Chinook Salmon in the Chehalis Basin, Washington*.

Thompson, T.Q., M.R. Bellinger, S.M. O'Rourke, D.J. Prince, A.E. Stevenson, A.T. Rodrigues, M.R. Sloat, C.F. Speller, D.Y. Yang, V.L. Butler, and M.A. Banks, 2019c. "Anthropogenic Habitat Alteration Leads to Rapid Loss of Adaptive Variation and Restoration Potential in Wild Salmon Populations." *Proceedings of the National Academy of Sciences* 116(1):177–186.

Troffe, P.M., 1999. *Freshwater Fishes of the Columbia Basin in British Columbia.* November 1999. Accessed October 26, 2019. Accessed at: https://royalbcmuseum.bc.ca/exhibits/living-landscapes/cbasin/peter_myles/toc.html.

Tuttle-Raycraft, S., and J.D. Ackerman, 2019. "Living the High Turbidity Life: The Effects of Total Suspended Solids, Flow, and Gill Morphology on Mussel Feeding." *Limnology and Oceanography* 64(6). Accessed at: https://doi.org/10.1002/lno.11202.

USDA (U.S. Department of Agriculture), 2011. *Fact Sheet: White Sturgeon* (Acipenser transmontanus). April 2011.

USFWS (U.S. Fish and Wildlife Service), 1983. *Habitat Suitability Index Models: Longnose Dace*. FWS/OBS-82/10.33. April 1983.

USFWS, 2004. *Biological and Conference Opinion on the Effects to the Bull Trout* (Salvelinus confluentus) *and Bull Trout Proposed Critical Habitat from Continued Implementation of Forest Service Land and Resource Management Plans and Bureau of Land Management Resource Management Plans as amended by the 1994 Northwest Forest Plan Record of Decision as amended by the October 24, 2003, Supplemental Environmental Impact Statement regarding Aquatic Conservation Strategy Clarification Amendments to the 1994 Northwest Forest Plan Record of Decision*. Revised March 18, 2004.

USFWS, 2008. *Fact Sheet: Pacific Lamprey* (Lampetra tridentata). Portland, Oregon: U.S. Fish and Wildlife Service. January 2008.

USFWS, 2010. Endangered and Threatened Wildlife and Plants; Revised Designation of Critical Habitat for Bull Trout in the Coterminous United States; Final Rule. Docket No. FWS–R1–ES–2009-0085. 50 CFR Part 17.USFWS, 2019a. "Endangered Species Information." Accessed November 31, 2019. Accessed at: http://www.fws.gov/endangered/.

USFWS, 2019b. "Information for Planning and Conservation." Accessed November 31, 2019. Accessed at: https://ecos.fws.gov/ipac/.

USFWS, 2019c. "Species Fact Sheet, Water Howellia, *Howelia aquatilis*." Accessed October 17, 2019. Accessed at: https://www.fws.gov/wafwo/species/Fact%20sheets/Waterhowellia_factsheet.pdf.

USFWS, 2019d. "USFWS Threatened & Endangered Species Active Critical Habitat Report." *Environmental Conservation Online System.* Accessed October 24, 2019. Accessed at: https://ecos.fws.gov/ecp/report/table/critical-habitat.html.

USFWS, 2019e. "Species Fact Sheet, River Lamprey, *Lampetra ayresii*." Accessed October 26, 2019. Accessed at: https://www.fws.gov/wafwo/species/Fact%20sheets/Riverlampreyfinal.pdf.

USFWS, 2019f. "Freshwater Fish of America." Accessed October 30, 2019. Accessed at: https://www.fws.gov/fisheries/freshwater-fish-of-america.html.

USFWS, 2020. "Listing and Critical Habitat Frequently Asked Questions." Last updated January 30, 2020; accessed April 6, 2020. Acessed at: https://www.fws.gov/endangered/what-we-do/critical-habitats-faq.html.

USGS (U.S. Geological Survey), 2019a. "Water Science School: Temperature and Water." Accessed November 25, 2019. Accessed at: https://www.usgs.gov/special-topic/water-science-school/science/temperature-and-water?qt-science_center_objects=0#qt-science_center_objects.

USGS, 2019b. National Climate Change Viewer (NCCV). Accessed at: https://www2.usgs.gov/landresources/lcs/nccv/viewer.asp.

Vose, R.S., D.R. Easterling, K.E. Kunkel, A.N. LeGrande, and M.F. Wehner, 2017. "Temperature changes in the United States." *Climate Science Special Report: Fourth National Climate Assessment, Volume I*. Editors, D.J. Wuebbles, D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock. Washington, DC: U.S. Global Change Research Program; pp. 185-206. Accessed at: https://dx.doi.org/10.7930/J0N29V45.

Watershed GeoDynamics (WGD) and Anchor QEA, 2012. *Chehalis River Fish Study: Appendix B: Geomorphology/Sediment Transport/Large Woody Debris Report.* Prepared for the Chehalis River Basin Flood Authority. April 2012.

WGD and Anchor QEA, 2014. *Geomorphology and Sediment Transport Technical Memorandum*. June 2014.

WGD and Anchor QEA, LLC, 2017. *Chehalis Basin Strategy Geomorphology, Sediment Transport, and Large Woody Debris Report*. Reducing Flood Damage and Restoring Aquatic Species Habitat. June 2017.

WDFW (Washington Department of Fish and Wildlife), 2008. "Priority Habitat and Species List." Published August 2008; updated January 2019. Accessed at: https://wdfw.wa.gov/publications/00165.

WDFW, 2009. *Compiled White Papers for Hydraulic Project Approval Habitat Conservation Plan (HCP).* March 2009.

WDFW, 2013. *Water Crossing Design Guidelines Manual*. Olympia, Washington: Washington Department of Fish and Wildlife.

WDFW, 2019a. "State Listed Species." Revised June 2019. Accessed at: https://wdfw.wa.gov/sites/default/files/2019-06/threatened%20and%20endangered%20species%20list.pdf.

WDFW, 2019b. "PHS on the Web." Accessed July 15, 2019. Accessed at: http://apps.wdfw.wa.gov/phsontheweb/.

WDFW, 2019c. "Salmon Conservation and Reporting Engine (SCoRE) interactive mapping tool." Accessed July 29, 2019. Accessed at: https://fortress.wa.gov/dfw/score/score/maps/map_wria.jsp.

WDNR (Washington State Department of Natural Resources), 2005. *Forest Practices Habitat Conservation Plan*. December 2005.

WDNR, 2017. "List of Animal Species with Ranks. Natural Heritage Program." October 2017. Accessed October 8, 2019. Accessed at: https://www.dnr.wa.gov/NHPlists.

WDNR, 2019. "2019 Washington Vascular Plant Species of Special Concern List." Natural Heritage Program. July 25, 2019. Accessed October 8, 2019. Accessed at: https://www.dnr.wa.gov/NHPlists.

Weichmann, C., 2018. "An Ecological Assessment of Water Howellia and its Habitat." *Sage Notes* 40(1). March 2018.

Wenger, A.S., E. Harvey, S. Wilson, C. Rawson, S.J. Newman, D. Clarke, B.J. Saunders, N. Browne, M.J. Travers, J.L. Mcilwain, and P.L. Erftemeijer, 2017. "A Critical Analysis of the Direct Effects of Dredging on Fish." *Fish and Fisheries* 18(5):967-985.

WEST (WEST Consultants), 2014. *Chehalis Basin Ecosystem Restoration General Investigation Study Baseline Hydrology and Hydraulics Modeling*. Prepared for the U.S. Army Corps of Engineers, Seattle District. January 2014.

Wilson, J., B. Glaser, D. Rawding, and T. Buehrens, 2018. *Monitoring of Grays River Fall-Run Chinook Salmon Using an Instream Weir, 2008-2010*. Ridgefield, Washington: Washington Department of Fish and Wildlife. November 2018.

Winkowski, M., and N. Kendall, 2018. *Validation of Habitat Preferences for Select Native Freshwater Fishes in the Chehalis River, Washington State.* FPT 18-02. April 2018. Accessed at: https://wdfw.wa.gov/publications/01983.

Winkowski, J., and M.S. Zimmerman, 2019. *Chehalis River Smolt Production, 2018*. FPA 19-01. Olympia, Washington: Washington Department of Fish and Wildlife.

Winkowski, M., N. Kendall, and M. Zimmerman, 2016. *Upper Chehalis Instream Fish Study 2015*. FPT 16-11. Olympia, Washington: Washington Department of Fish and Wildlife.

Winkowski, J.J., E.J. Walther, and M.S. Zimmerman, 2018a. *Summer Riverscape Patterns of Fish, Habitat, and Temperature Across the Chehalis River Basin*. FPT 18-01. Olympia, Washington: Washington Department of Fish and Wildlife.

Winkowski, J.J., E.J. Walther, and M.S. Zimmerman, 2018b. *Summer Distribution and Movements of Juvenile Salmonids in the South Fork Newaukum River, 2016*. FPT 18-05. Olympia, Washington: Washington Department of Fish and Wildlife.

Winkowski, M., N. Kendall, and E. Cropper, 2019a. *Movement and Home Range Study of Select Native Fishes in the Chehalis River, Washington State*. Olympia, Washington: Washington Department of Fish and Wildlife, Fish Program, Fish Science Division. June 2019.

Winkowski, M., E. Cropper, and N. Kendall, 2019b. *Chehalis Basin Fish Density Study – Pilot Study 2018 Interim Results Summary*. Olympia, Washington: Washington Department of Fish and Wildlife.

WSE (Watershed Science and Engineering), 2019a. Memorandum to: Bob Montgomery, Anchor QEA. From: Bob Elliot, Tim Tschetter, and Larry Karpack. Regarding: Chehalis River Existing Conditions RiverFlow2D Model Development and Calibration. February 28, 2019.

WSE, 2019b. Memorandum to: Bob Montgomery, Anchor QEA. From: Larry Karpack and Colin Butler. Regarding: Chehalis River Basin Hydrologic Modeling. February 28, 2019.

Wydoski, R.S., and R.R. Whitney, 2003. *Inland Fishes of Washington*. Second Edition. Bethesda, Maryland: American Fisheries Society.

Appendix A
Salmonid Modeling Report

Chehalis River Basin Flood Damage Reduction Project

—— NEPA Environmental Impact Statement ——

—Fish Impact Modeling Report—

US Army Corps of Engineers®

September 2020

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ACRONYMS AND ABBREVIATIONS

Applicant	Chehalis River Basin Flood Control Zone District
ASRP	Aquatic Species Restoration Plan
cfs	cubic feet per second
CHTR	collection, handling, transport, and release
Corps	U.S. Army Corps of Engineers
CWA	Clean Water Act
Ecology	Washington Department of Ecology
EDT	Ecosystem Diagnosis and Treatment
EIS	Environmental Impact Statement
fps	feet per second
FPTS	Fish Passage Technical Subcommittee
FRE	Flood Retention Expandable
FRO	Flood Retention Only
ICF	ICF International, Inc.
LCM	Lifecycle model
LLO	low-level outlet
LCM	NOAA Lifecycle model
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PEIS	Programmatic Environmental Impact Statement
PHABSIM	physical habitat simulation
PSU	Portland State University
QIN	Quinault Indian Nation
RM	river mile
SEPA	State Environmental Policy Act

T&T	trap and transport
USGS	U.S. Geological Survey
VSP	Viable Salmonid Population
WUA	Weighted Usable Area

1 INTRODUCTION

The Chehalis River Basin Flood Control Zone District (Applicant) is proposing to construct the Chehalis River Basin Flood Damage Reduction Project (proposed project) in Lewis County, Washington. Project construction would require a Department of the Army Permit under Section 404 of the Clean Water Act (CWA; proposed action). On January 31, 2018, the Seattle District of the U.S. Army Corps of Engineers (Corps) determined that the proposed action has the potential to result in significant impacts on the environment, requiring the preparation of an environmental impact statement (EIS) to comply with the National Environmental Policy Act (NEPA).

As part of the NEPA EIS process, impacts of the proposed action on aquatic species and habitat were evaluated and described in the *Chehalis River Basin Flood Damage Reduction Project NEPA Environmental Impact Statement Discipline Report for Aquatic Species and Habitat* (Corps 2020a), to which this document is appended. A key component of the impact evaluation was salmonid habitat impact modeling, which used the Ecosystem Diagnosis and Treatment (EDT) and the integrated EDT-National Oceanic and Atmospheric Administration (NOAA) Lifecycle models (integrated EDT-LCMs). The EDT model, which has been customized specifically for the Chehalis Basin since 2003 and is the best available tool, estimated the impacts of habitat alteration on salmon and steelhead species on a reach scale and Chehalis Basin scale relative to existing conditions at a specific point in time (ICF 2017). The integrated EDT-LCMs were used to evaluate how the salmonid populations respond through time.[1] Another component of the impact evaluation was physical habitat simulation (PHABSIM) modeling that was completed on a subset of native and non-native species. This model was also customized specifically for the Chehalis Basin.

Figure 1-1 shows the overall structure of the Chehalis Basin EDT model, and an overview of the model is provided in the "EDT Model Overview" section of the EDT modeling report (Attachment A). Output metrics from EDT (life-stage and reach-specific productivity and capacity) were provided as inputs to the integrated EDT-LCMs. Additional information on the integration of EDT into the LCMs is provided in the "Integration of EDT and LCM" section of Attachment B and Section 3.3.2.5 of Attachment A. The integrated EDT-LCMs are age-structured population models that estimated salmon and steelhead species' population dynamics over time on a sub-basin scale. This is referred to as the integrated modeling approach. The integrated modeling approach takes advantage of the strengths of both models, where EDT estimates the effects of an action on habitat, and the LCMs incorporate the effects of variability of floods and sequential flood retention events into the analyses. An overview of the

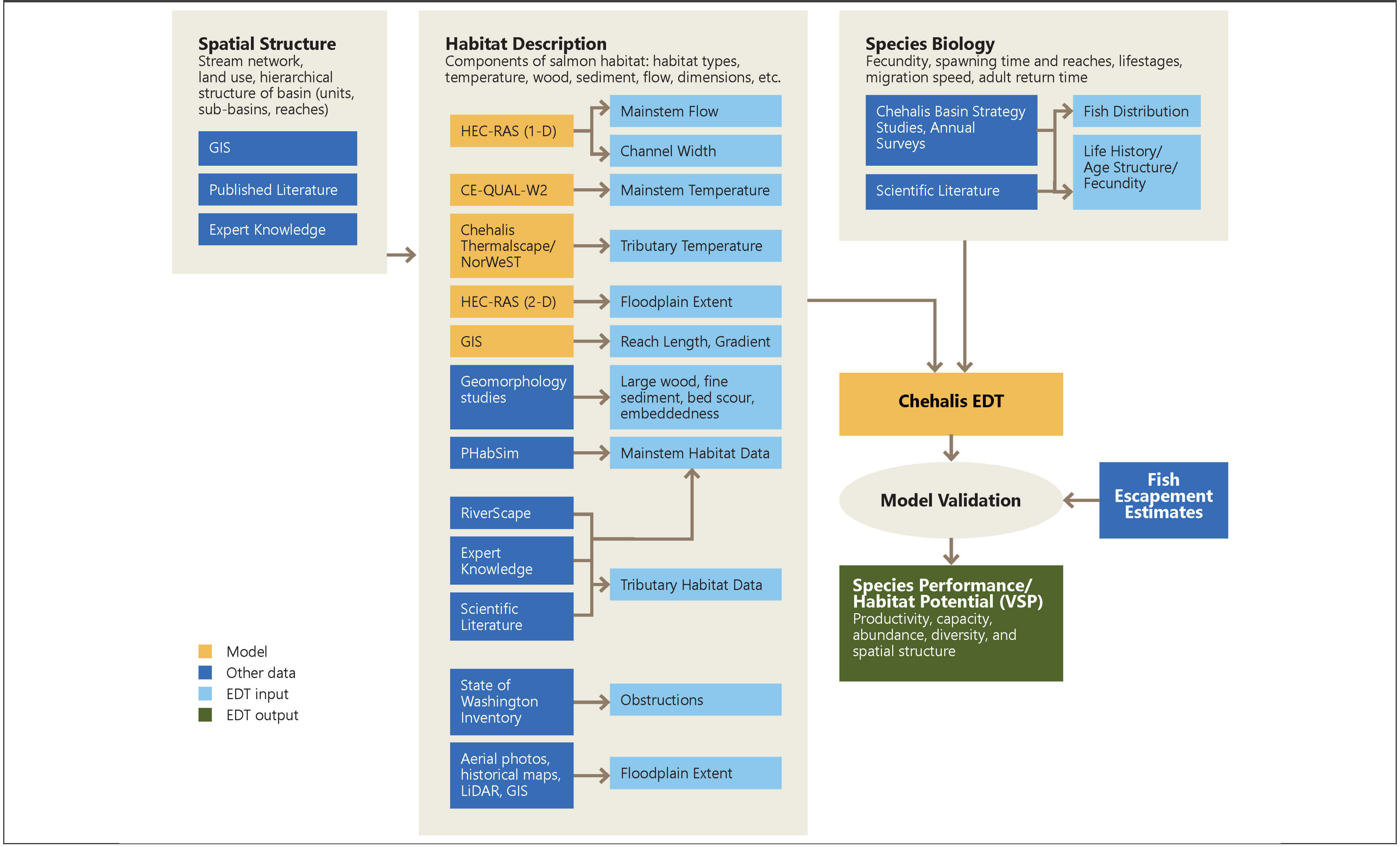
[1] In a previous phase of the project during the 2013 to 2015 biennium, SHIRAZ was used to evaluate impacts to salmonids within the mainstem Chehalis River. The model was a mainstem-only model that incorporated life-cycle effects into the analysis to evaluate variability across years in addition to generating point estimates of abundance (EDT). Since SHIRAZ was a mainstem-only model, it could not be used to assess effects of ASRP actions basin-wide. As such, WDFW funded NOAA to develop a basin-wide habitat and LCM in the 2015-2017 biennium. To be consistent with the ASRP, the NEPA EIS used EDT and the integrated EDT-LCMs for evaluation.

integrated EDT-LCMs is provided in the "LCM Model Overview" section of the integrated EDT-LCMs modeling report (Attachment B).

These two models are being used to answer the following questions:

- What are the impacts to salmon (spring-run Chinook salmon, fall-run Chinook salmon, coho salmon) and steelhead abundance, productivity, and diversity from habitat changes resulting from the construction and operation of the flood retention facility relative to the No Action Alternative at specific snap-shots in time (2025, 2030, 2040, and 2080)?
- What are the impacts on and associated variability of salmon (spring-run Chinook salmon, fall-run Chinook salmon, coho salmon) and steelhead population abundance from habitat changes identified in EDT that occur due to construction and operation of the flood retention facility through time with varying flood conditions between 2-, 10-, and 100-year conditions?

Figure 1-1
Chehalis Basin EDT Model Structure



The Chehalis Basin EDT model was first constructed in 2003 and was refined and expanded as part of the Chehalis Basin Strategy Programmatic Environmental Impact Statement (PEIS) and Aquatic Species Restoration Plan (ASRP) processes in 2014, 2016, 2018, and 2019. Through the PEIS and ASRP processes, EDT modeling input parameters were developed collaboratively over several years, involving expert opinion, research, and application of information from site-specific field studies. These previously developed parameters provided the starting point for determining NEPA EIS-specific EDT modeling input parameters. The NOAA LCMs are existing models that have been adapted for the Chehalis Basin to provide an estimate of salmonid population dynamics over time using EDT outputs as input parameters.

This document summarizes the technical coordination and decision-making processes used to identify input parameters and conditions to use in the salmonid impact models for the NEPA EIS. This document also identifies key points of coordination that occurred with the Quinault Indian Nation (QIN) as a NEPA cooperating agency and the Washington Department of Ecology (Ecology) relative to the State Environmental Policy Act (SEPA). The QIN was a cooperating agency until August 2019. This document also provides the modeling methods, results, uncertainty and validation, and conclusions for the EDT (Attachment A) and integrated EDT-LCMs (Attachment B).

Additionally, this document describes PHABSIM modeling that was completed to evaluate impacts of the proposed project on spawning and rearing habitat for a subset of native and non-native species.

2 SALMONID MODELING INPUT PARAMETER DECISION-MAKING PROCESS

The input parameter decision-making process for the salmonid impact models consisted of a series of technical meetings with ICF International, Inc. (ICF) and NOAA, coordination meetings with Ecology, and additional technical meetings as needed. These meetings are described in more detail below.

2.1 Meetings

2.1.1 Technical Meetings

A series of four 2-hour technical meetings were held on an approximately weekly basis from June 4, 2019 to June 21, 2019. The purpose of the technical meetings was to agree on input parameters and decisions needed to run the EDT and NOAA LCM models for the NEPA EIS. Critical attendees and supporting attendees who were at the technical meetings are listed in Table 2-1.

For Corps decisions needed on input parameters, ICF provided the inputs that had been used in previous Chehalis Basin EDT modeling efforts for the ASRP and the PEIS, which evaluated the Flood Retention Only (FRO) facility as a starting point. The NEPA team reviewed each initial input parameter, researched topics to determine whether the initial inputs were reasonable and relevant to the NEPA analysis, and updated or adjusted parameters as needed, and the Corps made an initial decision on each input parameter. Each initial decision was discussed during one of the technical meetings and, in some cases, meetings with others (Ecology, Office of the Chehalis Basin, and National Marine Fisheries Service [NMFS]) were held to gather additional information that factored into the final decision made by the Corps.

Table 2-1
Salmonid Impact Modeling Technical Meeting Series Attendees

ATTENDEES	
CRITICAL	
Chip McConnaha	EDT Modeling Lead, ICF
Laura McMullen	EDT Modeling Lead, ICF
Tim Beechie	LCM Modeling Lead, NOAA
Jeff Jorgenson	LCM Modeling Lead, NOAA
Greg Hoffman	Fisheries Technical Lead, Corps
Elizabeth Greene	Fisheries Technical Lead, Anchor QEA
Sydney Gonsalves	Fisheries Team and notetaker, Anchor QEA
AS AVAILABLE	
Janelle Leeson	NEPA EIS Project Manager, Corps
Tad Deshler	NEPA EIS Project Management, Corps
Kim Marcotte	NEPA EIS Manager, Anchor QEA
Marc Auten	NEPA EIS Deputy Manager, Anchor QEA
Heather Page	Overall NEPA/SEPA Project Manager, Anchor QEA

The following topics were covered at the technical meetings (full meeting notes are provided in Attachment C of this document):

- Technical Meeting 1: Overall introduction to the process and overall review of decisions that need to be made by the Corps on input parameters for EDT and NOAA LCM models.
- Technical Meeting 2: Discussed general model decisions, project description/alternatives, scenarios to model, geographic extent, species, timeframe, and other modeling inputs to EDT in more detail.
- Technical Meeting 3: Discussed EDT attributes and No Action Alternative conditions.
- Technical Meeting 4: Discussed inputs specific to FRE facility alternative conditions: spatial, fish passage, survival rates, reservoir degradation, integration of EDT and NOAA LCM models.

2.1.2 Ecology Coordination Meetings

Consistent with the Memorandum of Understanding between the Corps and Ecology, these agencies have agreed to coordinate on the approach to salmonid impact modeling. One 1-hour meeting on June 4, 2019 and one 1.5-hour meeting on June 21, 2019, occurred between the Corps and Ecology. Attendees at each meeting are listed in Table 2-2 and specifics discussed at each meeting are summarized below and in the meeting notes provided in Attachment C:

- Ecology Coordination Meeting 1: Reviewed fish passage survival rates developed for the FRO facility, determined if the same values should be applied to the Flood Retention Expandable (FRE) facility, and discussed assumptions for applying survival rates to the construction phase of the project.

- Ecology Coordination Meeting 2: Reviewed general modeling decisions and salmon passage assumptions.

Table 2-2
Salmonid Impact Modeling NEPA/SEPA Coordination Meeting Attendees

ATTENDEES	
MEETING 1 (JUNE 4, 2019)	
Janelle Leeson	NEPA EIS Project Manager, Corps
Diane Butorac	SEPA EIS Project Manager, Ecology
Neala Kendall	Fisheries Biologist, WDFW
Greg Hoffman	Fisheries Technical Lead, Corps
Elizabeth Greene	Fisheries Technical Lead, Anchor QEA
Sydney Gonsalves	Fisheries Team and notetaker, Anchor QEA
MEETING 2 (JUNE 21, 2019)	
Greg Hoffman	Fisheries Technical Lead, Corps
Elizabeth Greene	Fisheries Technical Lead, Anchor QEA
John Ferguson	SEPA Fisheries Technical Lead, Anchor QEA
Sydney Gonsalves	Fisheries Team and notetaker, Anchor QEA

2.1.3 Additional Technical Meetings

A technical meeting was held with Ed Meyer, NOAA fish passage engineer, to discuss salmon survival expectations when salmon are traveling through the diversion tunnel. This meeting occurred on June 24, 2019. NEPA EIS team members in attendance were Greg Hoffman (Corps), Elizabeth Greene (Anchor QEA), and Sydney Gonsalves (Anchor QEA).

To understand how habitat degradation assumptions for the No Action Alternative were developed for the ASRP, a technical meeting was held with Chrissy Bailey from the Office of the Chehalis Basin. Ms. Bailey discussed and provided information on the methods used to determine habitat degradation assumptions for the ASRP. NEPA EIS team members in attendance were Greg Hoffman (Corps) and Elizabeth Greene (Anchor QEA).

2.2 Quinault Indian Nation Coordination

As a cooperating agency under NEPA and consistent with the terms of the Cooperating Agency Memorandum of Agreement, the Corps sought input relative to the QIN's area of technical expertise on the EIS. To this end, the Corps provided an opportunity for the QIN to comment on the input assumptions and parameters prior to running EDT. However, the QIN declined to comment. The Corps continued to work with the QIN throughout July and August to solicit technical input relevant to the salmonid impact modeling effort for Corps consideration. The Corps convened a meeting with QIN and the EDT modelers on August 6, 2019 to review the EDT model results. The Corps convened another meeting on August 14, 2019 with the QIN and the integrated EDT-LCMs modelers to discuss how EDT results would be integrated into the LCMs. The QIN withdrew as a cooperating agency on September 22, 2019.

3 SALMONID MODELING INPUT PARAMETER DECISIONS

Modeling input parameter decisions were made by the Corps for the three alternatives being evaluated in the NEPA EIS: two action alternatives (FRE facility and FRO facility) and a No Action Alternative. The two action alternatives are operationally identical and are represented by one model run. Additional details about these alternatives are available in the project memorandum on EIS alternatives and assumptions (Anchor QEA 2019).

3.1 General Modeling Decisions

A summary of general modeling related decisions on input parameters is provided in Table 3-1. A full modeling decision matrix, including notes and rationale, is provided in Attachment D. Additional general modeling information is included in Section 3.2 of Attachment A.

Table 3-1
General Modeling Decision Summary Table

MODEL	CATEGORY	CORPS DECISION
EDT/NOAA LCM	Alternatives for Model	No Action Alternative/FRE facility/FRO facility; 2-year (normal flow), 10-year flood, 100-year flood scenarios, construction, and a back-to-back flood in which a 10-year flood occurs in one year and a 100-year flood occurs in the next year
EDT	Timeframes	Current/construction (2025 to 2030), mid-century (2040), late century (2080); overall EIS analysis period is 2025 through 2080
EDT	Geographic Extent	Chehalis River and tributaries above and below the proposed flood retention facility site down to Grays Harbor, and tributaries that flow directly into Grays Harbor, but does not include Grays Harbor. This is a larger area than the study area because salmonids are anadromous and travel down to the mouth of the river and have spawning areas within tributaries below the study area. This geographical extent allows for impacts to be evaluated at the Chehalis Basin level.
EDT/NOAA LCM	Species	Spring-run Chinook salmon, fall-run Chinook salmon, coho salmon, and steelhead
EDT	Metrics	Include all four metrics (abundance, capacity, productivity, and diversity) as outputs
EDT	Marine Survival Estimates (Calibration Number)	Use numbers developed for the ASRP model
EDT	Flow Recurrence	2-year (normal flow), 10-year, 100-year flood levels with and without project, from HEC-RAS Model
EDT	Temperature Inputs	Use temperature data that have been used previously for

MODEL	CATEGORY	CORPS DECISION
		ASRP/PEIS, including a Portland State University (PSU) model update from 2017
EDT	Geomorphology Inputs	Use Geomorphology Ratings table, from geomorphology modeling (Attachment E)
EDT/NOAA LCM	Integrating EDT and NOAA LCM	EDT estimates of productivity and capacity for 2-year (normal), 10-year, and 100-year flood scenarios used as inputs to LCM; also include a back-to-back flood scenario in which a 10-year flood occurs in one year and a 100-year flood occurs in the next year

3.1.1 Rationale for Back-to-Back Floods

An analysis of U.S. Geological Survey (USGS) gage data at Ground Mound in the Chehalis Basin showed that year-to-year variability of maximum flows increased in more recent years compared to flows before 1990 (Attachment F, Figure 1), and that there were more frequent maximum flows above 38,000 cubic feet per second (cfs) (the proposed flow at the Grand Mound USGS gage that would trigger FRE facility gate closure). Since 1990, there have been two times when maximum flows reached or exceeded 38,000 cfs in 2 consecutive years: water years 1990 to 1991 and 2008 to 2009. Therefore, a scenario of back-to-back floods in which a 10-year flood occurs in one year and a 100-year flood occurs in the next year was included in the integrated EDT-LCMs to estimate impacts to the salmonid species when spawning in the inundation area is eliminated for 2 consecutive years. Modeling a back-to-back scenario provides information on an individual species' ability to recover from 2 years of no spawning within the inundation area.

3.2 No Action Alternative Conditions

The No Action Alternative represents the most likely future baseline conditions in the Chehalis Basin without the proposed project from 2025 through 2080. These conditions are compared to the action alternatives in the discipline report for aquatic species and habitat (Corps 2020a) to determine potential project impacts. Under the No Action Alternative, no flood retention facility or airport levee improvements would be constructed, and local flood damage reduction efforts would likely continue based on local planning and regulatory actions. The No Action Alternative includes projects and programs that have been planned and designed to address flood damage and are underway, and flood damage reduction programs and projects that have been constructed or are funded and permitted. Salmonid modeling decisions specifically related to the No Action Alternative are summarized in Table 3-2. Additional details of the No Action Alternative conditions are provided in Section 3.3.1 of Attachment A.

Table 3-2
No Action Conditions Related to Salmonid Impact Modeling Decisions

MODEL	CATEGORY	DECISION
EDT	Baseline	Use all assumptions used in ASRP (except future climate), including inclusion of the five ASRP early action reaches[1]. These assumptions include the following: • Tree growth within managed forests that will reduce temperature and increase large wood (positive impact on salmonids). • Removal of culverts under tribal injunction. Twelve Washington State Department of Transportation culverts removed by 2040 and 12 more by 2080 (positive impact on salmonids). • Salmonid habitat degradation due to human population increases. General change outside managed forests: 5% salmonid habitat degradation in 2040 and 10% salmonid habitat degradation in 2080 for attributes directly impacted by development. Focused change in high development areas (additional degradation of salmonid habitat potential in the model).
EDT	Geomorphology Inputs for 2-Year, 10-Year, and 100-Year Flood Scenarios	Use Geomorphology Ratings Tables provided in Attachment E, derived from geomorphology modeling. Geomorphology Ratings Tables are used as guidance, with deviations from it documented by the EDT modelers based on best professional judgment.

Note:
1. The ASRP early action reaches are the Skookumchuck, Satsop, Wynoochee, and Newaukum rivers and Stillman Creek.

3.3 Alternative 1 (Proposed Project): Flood Retention Expandable (FRE) Facility and Airport Levee Improvements

Alternative 1 would include construction of an FRE facility that would temporarily retain up to 65,000 acre-feet of water during a major (7-year) or greater flood. It is called an expandable facility because the foundation would be built such that it could support the future construction of a larger flood retention facility that could increase water storage up to 130,000 acre-feet. This future expansion may or may not occur. If pursued, it would be subject to a separate environmental review and permitting process.

Once constructed, the FRE facility would have five outlet conduits (low-level outlets [LLOs]) for the Chehalis River to pass through during normal flows and smaller floods. When a major flood or greater is predicted, gates on the LLOs would close and floodwater would be retained in a temporary reservoir upstream of the FRE facility. At all other times, the FRE facility would retain no water and allow all river flows to pass, with only minor restriction of river flow and pool accumulation at the upstream face of the facility. The minor restriction of river flow and pool accumulation would only occur when flows exceed 8,000 cfs, which is expected to occur once every 3 years, on average.

A collection, handling, transport, and release (CHTR) fish passage facility would also be constructed as part of the proposed project (HDR 2018a, 2018b). Assumptions about fish passage and all other modeling attributes for the open and closed state were considered separately as described below, in Attachment H, and in Sections 3.3.1 and 3.3.2. Additional details of the FRE facility conditions assumed for modeling are included in Section 3.3.2 of Attachment A.

Alternative 1 would also involve improvements to the existing levee around the Chehalis-Centralia Airport within the City of Chehalis, east of the Chehalis River and west of Interstate 5. Additional details about the levee construction are available in the project memorandum on EIS alternatives and assumptions (Anchor QEA 2019). Based on the modeling team's best professional judgment and previous modeling experience, the levee would have a minimal impact on salmonid habitat and was not included in modeling scenarios (Table 3-3).

Only a high level of detail was available as part of the mitigation framework when the modeling was occurring. As such, the level of detail about any mitigation that may be required was not sufficient to include in the modeling work.

Table 3-3
Alternative 1 Conditions Related to Salmonid Impact Modeling Decisions

MODEL	CATEGORY	DECISION
EDT	FRE Facility: Conditions and Assumptions	See FRE Facility Conditions Tables in Attachment G for additional input parameters and assumptions.
EDT	Construction	Include a construction phase from 2025 to 2030.
EDT	Spatial Components	Use three spatial components: above flood retention facility[1] footprint, within flood retention facility footprint, below flood retention facility footprint (mainstem to point of bedrock control near Adna; tributaries).
EDT	Fish Passage	See rationale for determining fish passage survival during Construction and Operation in Section 3.3.2 and Fish Passage Survival Rates Tables in Attachment H.
EDT	Airport Levee	Not included in the model.
EDT	Mitigation Framework	Not included in the model.

3.3.1 Previously Developed Fish Passage Survival Values

Fish passage survival values for multiple flood retention facility fish passage options were developed during a multi-year process by the Fish Passage Technical Subcommittee (FPTS) of the Chehalis Basin Strategy Flood Damage Reduction Technical Committee. The goal of the FPTS process was to develop survival values that could be used to inform EDT modeling and fish passage option assessments. The process is described in detail in Appendix G of the *Chehalis Basin Strategy Combined Dam and Fish Passage Conceptual Design Report* (HDR 2017).

The FPTS developed Total Survival values for each target species, life stage, and passage option. The Total Survival value was the product of the fish passage Performance and fish Survival inputs, as follows:

- Total Survival is the total estimated percentage of fish that successfully navigate and survive the proposed fish passage facility and contribute to upstream and/or downstream life histories being considered in the EDT population response modeling.
- Performance is the proportion of fish that are anticipated to successfully navigate the fish passage facility.
- Survival is the proportion of fish that are not harmed or perish while attempting to navigate the fish passage facility.

The total survival estimates developed by the FPTS were informed by data from existing facilities (where available) and lessons learned through years of similar facility operation and monitoring of fish passage survival at those facilities. These fish passage survival values were used as a starting point for determining fish passage survival values for the NEPA EIS during construction and operation of the flood retention facility.

3.3.2 Fish Passage Survival Analysis for Proposed Project

In the EDT model framework, only upstream passage of adult salmonids and downstream passage of juvenile salmonids is allowed. Therefore, only the species selected for modeling (spring-run Chinook salmon, fall-run Chinook salmon, coho salmon, and steelhead; Table 3-1) and the allowed direction of movement are considered in this section.

Only currently proposed fish passage options for the flood retention facility are considered in this memorandum. Project fish passage options are summarized in Table 3-4 for both the construction and operation phases of the proposed project.

Table 3-4
Summary of Salmonid Modeling Fish Passage Options for Proposed Project

PASSAGE TYPE	DIRECTION	LIFESTAGE	CONDITIONS
CONSTRUCTION			
Trap and Transport	Upstream	Adult	Downstream of construction site, fish are collected and then trucked to the free-flowing reach above construction
Diversion Tunnel	Downstream	Juvenile	Bypasses construction site using an approximately 1,600-foot tunnel
PERMANENT OPERATION			
Conduit	Upstream	Adult	Flood retention facility gates open, river is free-flowing through 200- to 300-foot conduits
Conduit	Downstream	Juvenile	Flood retention facility gates open, river is free-flowing through 200- to 300-foot conduits
CHTR	Upstream	Adult	Gates closed for flood retention, temporary reservoir forms, fish are collected below the facility and trucked to the free-flowing reach for release

3.3.2.1 Construction

The Applicant proposes to construct the FRE facility within 4.5 years. However, phasing may be required, which could result in construction lasting up to 5 years. Therefore, the modeling assumed a 5-year construction timeframe. Assumptions about fish passage for modeling during this time were considered separately from fish passage during operation. During construction, the temporary diversion tunnel would be used for downstream passage of juveniles and a temporary trap and transport facility would be used for adult upstream passage. Additional details and research are summarized in the Fish Passage Survival Tables included in Attachment H.

3.3.2.1.1 Survival through the Diversion Tunnel

Downstream fish passage of juveniles past the proposed project area during construction would be through a diversion tunnel. The tunnel is anticipated to be a 20-foot by 20-foot, horseshoe-shaped, concrete-lined tunnel that would be drilled and blasted through rock. It is expected to be approximately 1,630 feet long at a slope of about 1%.

Fish passage flows are required by Washington state and federal agencies to be between the 95% and 5% exceedance of mean daily flows (16 cfs to 2,200 cfs) for the river (NMFS 2011; WDFW 2013, 2019). At these flows, the anticipated flow velocity within a smooth, hydraulically efficient tunnel would be expected to range from 4 feet per second (fps) to 25 fps, respectively. Downstream juvenile passage guidelines require flows between 6 and 12 fps, with higher velocities requiring special design considerations (NMFS 2011). Downstream fish passage through the diversion tunnel appears feasible, although significant modifications to the tunnel design may be required to ensure flow velocities within the 95% to 5% exceedance of mean daily flows does not exceed fish passage guidance while still accommodating the range of river flows required for flood retention facility construction. The FPTS agreed in 2016 that the final design flows for the conduits through the flood retention facility may exceed the 2 fps criteria required by NMFS as long as they mimicked the flow characteristics of the natural channel in this reach. If these design criteria were applied to the diversion tunnel, a maximum flow velocity of about 6 fps would be acceptable. A flow velocity of 6 fps corresponds to a river flow of about 50 cfs. Diversion tunnel design modifications that could be required to meet flow conditions of the natural river channel are detailed in *Chehalis River Basin Flood Control Combined Dam and Fish Passage Supplemental Design Report: FRE Dam Alternative* (HDR 2018b).

Subsequent consultation with NMFS during the proposed project salmonid modeling decision process indicated good performance of diversion tunnels has been observed on the Columbia River (Attachment C; June 24, 2019 meeting). A 12,000-foot bypass tunnel at Bonneville Dam, designed for up to 8 fps water velocity, had sub-yearling Chinook salmon survival rates of 87% to 95% and yearling Chinook salmon survival rates of 95% to 97% (Ferguson et al. 2007).

Based on previous work and current guidance from NMFS, the same Performance, Survival, and Total Survival values proposed by the FPTS for the project conduits in the *Combined Dam and Fish Passage Conceptual Design Report* (HDR 2017) for the FRO facility were used for fish passage survival through the diversion tunnel. Diversion tunnel passage values are summarized in Table 3-5 and detailed in Attachment H.

Table 3-5
Fish Passage Performance and Survival Values for EDT Modeling During Construction

TARGET SPECIES	PERFORMANCE[1]	SURVIVAL	TOTAL SURVIVAL[1]
ADULT UPSTREAM VIA TEMPORARY TRAP AND TRANSPORT			
Spring-run Chinook Salmon	79%	98%	63%
Fall-run Chinook Salmon	74%	98%	66%
Coho Salmon	42%	98%	41%
Steelhead	47%	98%	45%
JUVENILE DOWNSTREAM VIA DIVERSION TUNNEL			
Spring-run Chinook Salmon	100%	85%	85%
Fall-run Chinook Salmon	100%	85%	85%
Coho Salmon	100%	85%	85%
Steelhead	100%	95%	95%

Note:

1. Performance and Total Survival values for upstream adult passage via temporary trap and transport are adjusted for picket weir capture efficiency and delayed mortality as described in Section 3.3.2.1.2. Detailed calculations are provided in Attachment H.

3.3.2.1.2 *Survival through the Temporary Trap and Transport Facility*

Temporary trap and transport (T&T) facilities are commonly used to provide fish passage for projects that require extensive in-water work for a long duration, such as what would be required for the construction of the flood retention facility. The temporary T&T facility would be installed and begin operation prior to any other in-water work. The facility would be located far enough downstream of the diversion tunnel outlet that river flow approaching the facility would be as calm and uniform as practicable. A temporary T&T facility would likely consist of a temporary barrier such as a picket weir with a fish ladder on the left bank that leads to holding ponds or holding tanks at the top of the bank where fish could be easily accessed by transport trucks. A pump system would be used to provide auxiliary water to the fish ladder and holding tanks. Final details of the temporary T&T design and operation have not yet been provided by the applicant. The temporary T&T facility would provide upstream passage for the same species as the permanent CHTR facility to a point above the construction coffer dam. It is assumed that fish moving downstream through the diversion tunnel would be able to safely pass through the T&T facility and no further modifications to survival rates were made for downstream travel.

The temporary facility would operate 24 hours a day, 7 days a week for the full period of construction, until normal operation of the proposed project begins. Once normal operation begins, the temporary facilities in the river would be removed and the bank facilities would be abandoned or removed.

Fish passage values developed by the FPTS for the permanent conduits and CHTR facility were used as a starting point for deriving values for the T&T facility. After a review of the literature and coordination with a member of the FPTS (Attachment C, June 21, 2019 meeting), two elements of fish passage related to temporary T&T were accounted for: 1) seasonal variation in picket weir capture efficiency; and 2) delayed mortality associated with trapping, handling, and water temperature. Delayed mortality values varied by season and species. Rationale for the adjustment to Total Survival relative to the permanent passage facilities for each species under consideration are described as follows (detailed Fish Passage Survival Tables are included in Attachment H):

- **Picket Weir Capture Efficiency.** The temporary T&T will have reduced performance relative to the permanent CHTR based on seasonal variation in picket weir capture efficiency. Capture efficiency values in the literature vary from 15% to 100%. Picket weirs are more likely to fail during the winter from weather and flow events that allow fish to pass over, under, or around the structure (Schroeder 1996; Wilson et al. 2018). Based on run timing, coho salmon and winter steelhead capture efficiencies were set at 45% and 50%, respectively, because they are migrating during the winter when water levels and flows are higher (Ronne et al. 2018). Spring-run and fall-run Chinook salmon migrate when flows are lower and are expected to have higher capture efficiency at the picket weir (Ronne et al. 2018). Based on migration timing and general trends in the literature, spring-run and fall-run Chinook salmon capture efficiencies were set at 85% and 80%, respectively (Schroeder 1996; Engle et al. 2010; Null and Niemela 2011; Larson et al. 2014). In all cases, it was assumed that the 2011 NMFS *Anadromous Salmonid Passage Facility Design Guidelines* for picket barrier, fish ladder design, and monitoring would be followed during design and construction.
- **Delayed Mortality.** The temporary T&T facility represents a likely increase in delayed mortality for summer migrating species relative to the most likely summer passage conditions (conduits) during permanent operations (Ronne et al. 2018). Regionally, mean weekly pre-spawn survival probabilities of spring-run Chinook salmon after trap and transport release ranged from 80% to 100% (Keefer et al. 2010). Keefer et al. (2010) found that pre-spawn mortality after trap and transport on the Willamette River was strongly temperature dependent. A mid-range value of 90% for delayed survival was chosen because pre-spawn mortality cannot be entirely attributed to T&T. The value was then adjusted upward to 95% to account for cooler water temperatures and shorter transport distance at the Chehalis River proposed project site. A 65% weekly delayed survival value corresponds to an approximate monthly value of 81% (95%) for spring-run Chinook salmon. Expected cooler water temperatures during peak run migration were used to adjust delayed survival values upward for fall-run Chinook salmon (91%), coho salmon (99%), and steelhead (99%).

3.3.2.2 Operations

Fish passage survival during flood retention facility operation is discussed in this section. When the facility is not retaining floodwaters, upstream and downstream passage would be through the facilities' conduits. During a major or greater flood, when the facility is retaining water, upstream fish passage of adults would occur via a CHTR facility and downstream fish passage would not occur until the flood retention event is over. Fish passage survival values for each operational condition are summarized below. Additional details and research are summarized in the Fish Passage Survival Tables included in Attachment H.

3.3.2.2.1 Survival through the Conduits

The primary means of upstream and downstream passage at the flood retention facility would be through a series of five conduits that extend through the base of the flood retention facility and provide an open-channel flow condition for river flows less than 8,000 cfs. These are similar operational conditions as the FRO facility. Therefore, the *Combined Dam and Fish Passage Conceptual Design Report* (HDR 2017) fish passage values developed by the FPTS for the FRO facility conduits will be used in the EDT model (Table 3-6; Attachment H).

3.3.2.2.2 Survival Through the Collection, Handling, Transport, and Release Facility

When water is impounded behind the flood retention facility during floods the conduit gates are closed and fish passage is provided via a CHTR facility. The CHTR facility is intended to provide fish passage to upstream-moving adult salmon, steelhead, resident fish, and lamprey as well as juvenile salmon and steelhead. The facility is designed to safely collect these species and life stages and transport them upstream of the flood retention facility using specialized vehicles. When flood control scenarios require its operation, it would be a staffed facility that is operated 24 hours a day until flood operations cease and passage through the conduits resumes. The design and operation of the CHTR facility is described in detail in the *Chehalis Basin Strategy Fish Passage: CHTR Preliminary Design Report* (HDR 2018a).

Previous fish passage values were developed for passage through the CHTR facility by the Chehalis Basin FPTS. However, the FPTS values do not consider delayed mortality of fish that can occur as a result of certain types of trapping and handling, particularly during warm water conditions. This is an ongoing area of research. Where available, data from recent publications were used to adjust the FPTS total survival values for species and life histories at greatest risk of delayed mortality.

Delayed mortality is of concern when a fish that is seemingly healthy upon release dies before it is able to reproduce. Temperature is a major factor influencing delayed mortality. Passage through a CHTR facility is documented to be stressful to fish when water is warm and transport times are longer (Keefer et al. 2010; Lusardi and Moyle 2017). Adult spring-run and fall-run Chinook salmon are most likely to experience warm-water conditions, but less likely to require passage through the CHTR facility because conduit gates are likely to be open during summer and fall when these species are migrating through the area. Adult winter steelhead and coho salmon migrate when waters are cold, making conditions less stressful, but fish are more likely to experience passage via the CHTR facility during winter flood retention events. To account for the proportion of adult salmonids that would experience additional stress related to passage through the CHTR, a 1% delayed mortality rate was applied to the survival numbers previously developed by the FPTS (Table 3-6; Attachment H).

Table 3-6
Fish Passage Performance and Survival Values for EDT Modeling of Flood Retention Operations

TARGET SPECIES	PERFORMANCE	SURVIVAL	TOTAL SURVIVAL[1]
ADULT UPSTREAM VIA CONDUITS			
Spring-run Chinook Salmon	95%	99%	94%
Fall-run Chinook Salmon	95%	99%	94%
Coho Salmon	95%	99%	94%
Winter Steelhead	97%	99%	96%
ADULT UPSTREAM VIA COLLECTION, HANDLING, TRANSPORT, AND RELEASE FACILITY			
Spring-run Chinook Salmon	93%	98%	90%
Fall-run Chinook Salmon	93%	98%	90%
Coho Salmon	93%	98%	90%
Winter Steelhead	93%	98%	90%
JUVENILE DOWNSTREAM VIA CONDUITS			
Spring-run Chinook Salmon	100%	85%	85%
Fall-run Chinook Salmon	100%	85%	85%
Coho Salmon	100%	85%	85%
Winter Steelhead	100%	95%	95%

Note:
1. Total Survival for adult upstream passage via CHTR accounts for 1% delayed mortality, as described in Section 3.3.2.2.2. Detailed calculations are provided in Attachment H.

3.4 Alternative 2: Flood Retention Only (FRO) Facility and Airport Levee Improvements

Alternative 2 is the same as Alternative 1, except that the FRO facility would be built on a smaller foundation. Unlike the FRE facility, the foundation would not be designed to allow for future expansion of flood storage capacity. By comparison, the footprint for the FRO facility would be about 20 feet smaller on the downstream (south) side of the bridge. Construction of Alternative 2 would involve the same construction methods, in-water work activities, and fish passage elements as Alternative 1, except the duration of construction and the amount of materials required to build the flood retention facility would be less. It is assumed that the flood retention facility construction period for Alternative 2 would be about 9 months less than Alternative 1. Because construction and operation of the FRO facility are similar to the FRE facility, the modeling assumptions and decisions for Alternative 2 were the same as for Alternative 1.

4 SALMONID IMPACT MODEL RESULTS AND CONCLUSIONS

Salmonid impact modeling results and conclusions are provided in the EDT modeling report in Attachment A and the integrated EDT-LCMs modeling report in Attachment B.

5 SALMONID IMPACT MODEL VALIDATION AND UNCERTAINTY

Model validation and uncertainty information is provided in the EDT modeling report in Attachment A and the integrated EDT-LCMs modeling report in Attachment B.

6 PHYSICAL HABITAT SIMULATION MODELING

PHABSIM modeling was used to evaluate spawning and rearing habitat of Pacific lamprey (*Entosphenus tridentatus*), speckled dace (*Rhinichthys osculus*), largescale sucker (*Catostomus macrocheilus*), mountain whitefish (*Prosopium williamsoni*), largemouth bass (*Micropterus salmoides*; a key non-native predator), and smallmouth bass (*Micropterus dolomieu*). The model was used to evaluate how spawning and rearing habitat changed due to temperature increases predicted to occur during operation with typical flow conditions. The model uses Weighted Usable Area (WUA) as the output metric, which is the usable habitat in units of square feet per 1,000 feet of river channel. The PHABSIM model was originally based on direct measurements in the Chehalis Basin in conjunction with WDFW to model relationships between flow and WUA. The PHABSIM model extends from the upper Chehalis River near the proposed flood retention facility site downstream to Porter (RM 33) (Normandeau 2012; Caldwell et al. 2004). The change in usable spawning and rearing habitat was calculated for one site upstream of the proposed flood retention facility (at RM 110.9; originally surveyed by Caldwell et al. [2004]) and various sites downstream of the flood retention facility from Pe Ell to Porter (surveyed by Normandeau [2012]).

6.1 Methods

The Chehalis PHABSIM model was used to evaluate the change in usable habitat that would occur with the FRE facility for a representative suite of fish species. The change in WUA was calculated for one site upstream of the FRE facility (at RM 110.9; originally surveyed by Caldwell et al. [2004]) and downstream of the FRE facility from Pe Ell to Porter (surveyed by Normandeau [2012]).

The PHABSIM model uses Habitat Suitability Criteria that were developed to characterize the microhabitat preferences of the six species listed above during spawning and rearing life stages in terms of water depth, water current velocity, and substrate preference. Habitat Suitability Criteria were updated with recent observations made in the Chehalis Basin to improve specificity of the criteria (Winkowski and Kendall 2018). In addition, the relationships between flow and WUA were adjusted to show the effect of temperature on different life stages of key fish species (with input from WDFW provided in Beecher 2015; Pacheco 2019; Winkowski 2019). The monthly averages of average daily flows from water years 2013 and 2014 were used to represent the baseline condition. For evaluating the effect of the FRE facility, it was assumed that 2-year flow conditions would be unaffected and water temperatures would increase due to the removal of vegetation in the temporary reservoir inundation area. The model could only be used to evaluate 2-year flow conditions and was not used to examine the changes associated with major flood conditions or greater. This is because, for the original PHABSIM modeling effort, flow and habitat variables were measured in the field within the ranges that were safe to measure (Normandeau 2012; Caldwell et al. 2004; Beecher 2015). The model was expanded to include higher flows based on these measurements, but only for flows with water elevations that remained within the banks of the river. Under the No Action Alternative, the 10-year and 100-year floods would result in flows with water levels above the banks of the river. Therefore, temperature was the only element that changed in the model as a result of the proposed action. The average monthly flows did not change.

In addition, the WUA estimated by the PHABSIM model varies with the amount of fine substrate in a given reach, and substrate composition is predicted to change just above and below the FRE facility as a result of flood retention. However, substrate was not included as a factor in this analysis because the increase in fine sediment due to the FRE facility would not be large enough to affect the entire reach evaluated by PHABSIM (Watershed Geodynamics 2019).

Water quality modeling performed by PSU in 2017 (Van Glubt 2017) indicated that the effects of the loss of shading in the temporary reservoir area would cause increased water temperatures upstream and downstream of the FRE facility to RM 100. However, temperature increases used in PHABSIM are lower in magnitude than maximum temperature changes reported in the *Chehalis River Basin Flood Damage Reduction Project NEPA EIS Water Quality and Quantity Discipline Report* (Corps 2020b) because they are averaged monthly over the entire surveyed and modeled reach. The exception was the upper Chehalis River Basin reach since it was originally surveyed separately and at RM 110.9 only (Caldwell et al. 2004). Therefore, for the upper Chehalis River Basin, temperatures were only averaged for the river mile reach immediately surrounding the survey site, and do not include temperatures for the entire temporary reservoir footprint.

Water temperatures within the upper Chehalis River Basin reach (i.e., the reach surrounding RM 110.9) are expected to increase by up to 0.31°C between May and October (Table 6-1) during 2-year flow conditions during operation of the FRE facility. Water temperatures are expected to increase by up to 0.51°C from Pe Ell to the Elk Creek confluence. Reaches downstream of Elk Creek show minimal change in temperature. Therefore, only changes to WUA for the Upper Chehalis and Pe Ell to Elk Creek reaches are presented as results. This impact is associated with ongoing removal of riparian trees for vegetation management, resulting in less shading of the river within the temporary reservoir footprint.

Table 6-1
Chehalis River Instream Temperature Modeling Results Used in Physical Habitat Simulation

Reach	Monthly Temperature Changes (°C)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Chehalis	0.03	0.05	0.09	0.15	0.23	0.28	0.31	0.27	0.27	0.14	0.05	0.01
Pe Ell to Elk Creek	0.04	0.06	0.10	0.18	0.28	0.38	0.51	0.46	0.33	0.13	0.06	0.03
Elk Creek to South Fork Chehalis	0.02	0.02	0.04	0.10	0.14	0.16	0.15	0.09	0.07	0.07	0.03	0.01
South Fork Chehalis to Newaukum River	0.01	0.02	0.04	0.07	0.07	0.06	0.06	0.05	0.04	0.04	0.02	0.01
Newaukum River to Skookumchuck River	0.01	0.01	0.02	0.03	0.03	0.04	0.03	0.02	0.02	0.02	0.01	0.00
Skookumchuck River to Porter	0.00	0.00	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00

No change from existing conditions < > Increasing in temperature (°C)

Note:
Mainstem water temperature data are from the PSU CE-QUAL-W2 model inputs to EDT.

6.2 Results

Tables of results of the PHABSIM modeling for the Upper Chehalis and Pe Ell to Elk Creek reaches are provided for all months in Appendix I, Tables I-1 and I-2. Table I-1 gives the changes in WUA for native Pacific lamprey, speckled dace, largescale sucker, and mountain whitefish. Table I-2 gives the changes to WUA for non-native smallmouth and largemouth bass. The interpretation and discussion of these results are provided in Section 6.4.3.2 of the *Aquatic Species and Habitat Discipline Report* (Corps 2020a), to which this document is appended.

7 INFORMATION SOURCES

Campbell, L., A. Claiborne, S. Ashcraft, M. Zimmerman, and C. Holt, 2017. *Investigating Juvenile Life History and Maternal Run Timing of Chehalis River Spring and Fall Chinook Salmon Using Otolith Chemistry*. FPT 17-15. Olympia, Washington: Washington Department of Fish and Wildlife.

Ecology (Washington Department of Ecology), 2017. *Chehalis Basin Strategy Final Programmatic EIS*. June 2017. Accessed at: http://chehalisbasinstrategy.com/programmatic-eis/.

Elliot, B., T. Tschetter, and L. Karpack, 2019. Memorandum regarding: Chehalis River Existing Conditions RiverFlow2D Model Development and Calibration. February 28, 2019.

ICF (ICF International, Inc.), 2019. *Procedure for Rating Water Temperature in the Chehalis ASRP EDT model*. March 21, 2019.

Karpack, L., and C. Butler, 2019. Memorandum regarding: Chehalis River Basin Hydrologic Modeling. February 28, 2019.

Lestelle, L., M. Zimmerman, C. McConnaha, and J. Ferguson, 2019. Memorandum regarding: Spawning Distribution of Chehalis Spring-Run Chinook Salmon and Application to Modeling. April 8, 2019. Liedtke, T.L., M.S. Zimmerman, R.G. Tomka, C. Holt, and L. Jennings, 2016. *Behavior and movements of adult spring Chinook salmon (Oncorhynchus tshawytscha) in the Chehalis River Basin, southwestern Washington, 2015*. U.S. Geological Survey Open-File Report 2016-1158. Accessed at: http://dx.doi.org/10.3133/ofr20161158.

Ronne, L., 2019. Memorandum regarding: Contribution of Steelhead, Coho and Chinook from upper Chehalis basin above the proposed dam site to the Grays Harbor populations. January 22, 2019. Olympia, Washington: Washington Department of Fish and Wildlife.

Winkowski, J.J., E.J. Walther, and M.S. Zimmerman, 2018a. *Summer riverscape patterns of fish, habitat, and temperature across the Chehalis River basin*. FPT 18-01. Olympia, Washington: Washington Department of Fish and Wildlife.

Winkowski, J.J., E.J. Walther, and M.S. Zimmerman, 2018b. *Summer Distribution and Movements of Juvenile Salmonids in the South Fork Newaukum River, 2016*. FPT 18-05. Olympia, Washington: Washington Department of Fish and Wildlife.

Winkowski, J., and M.S. Zimmerman, 2019. *Chehalis River Smolt Production, 2018*. FPA 19-01. Olympia, Washington: Washington Department of Fish and Wildlife.

8 REFERENCES

Anchor QEA (Anchor QEA, LLC), 2019. Memorandum to: Chehalis River Basin Flood Damage Reduction Project NEPA EIS Team. Regarding: Chehalis NEPA EIS Alternatives and Assumptions. June 24, 2019.

Beecher, H. (Washington Department of Fish and Wildlife), 2015. Email to: Robert Montgomery (Anchor QEA). Regarding: Weighted Usable Area for species. November 5, 2015.

Caldwell, B. and J. Pacheco (Ecology), H. Beecher, T. Hegy, and R. Vadas (WDFW), 2004. *Chehalis River Basin WRIAs 22 and 23 Fish Habitat Analysis Using the Instream Flow Incremental Methodology.* March 2004. Technical Report 04-11-006.

Corps (U.S. Army Corps of Engineers), 2020a. *Chehalis River Basin Flood Damage Reduction Project NEPA EIS Discipline Report for Aquatic Habitats and Species*. September 2020.

Corps, 2020b. *Chehalis River Basin Flood Damage Reduction Project NEPA EIS Discipline Report for Water Quality and Quantity*. September 2020.

Engle, R.O., W.R. Brigon, and J. Salicky, 2010. *Evaluation of a Resistance Board Weir in the White Salmon River for Capture of Lower Columbia River Fall Chinook Salmon (*Oncorhynchus tshawytscha*) for Transport during the Year of Condit Dam Removal*. Vancouver, Washington: U.S. Fish and Wildlife Service, Columbia River Fisheries Office.

Ferguson, J.W., B.P. Sandford, R.E. Reagan, L.G. Gilbreath, E.B. Meyer, R.D. Ledgerwood, and N.S. Adams, 2007. "Bypass system modification at Bonneville Dam on the Columbia River improved the survival of juvenile salmon." *Transactions of the American Fisheries Society* 136(6):1487–1510.

HDR (HDR Engineering, Inc.), 2017. *Chehalis Basin Strategy Combined Dam and Fish Passage Conceptual Design Report*. Prepared for the State of Washington Recreation and Conservation Office and Chehalis Basin Work Group. June 2017.

HDR, 2018a. *Chehalis Basin Strategy Fish Passage: CHTR Preliminary Design Report*. February 2018.

HDR, 2018b. *Chehalis River Basin Flood Control Combined Dam and Fish Passage Supplemental Design Report: FRE Dam Alternative*. September 2018.

ICF (ICF International, Inc.), 2017. *Chehalis Basin Strategy Analysis of Salmonid Habitat Potential to Support the Chehalis Basin Programmatic Environmental Impact Statement*. July 2017.

Keefer, M.L., G.A. Taylor, D.F. Garletts, G.A. Gauthier, T.M. Pierce, and C.C. Caudill, 2010. "Prespawn mortality in adult spring Chinook salmon outplanted above barrier dams." *Ecology of Freshwater Fish* 19(3):361–372.

Larson, E.I., K.A. Meyer, and B. High, 2014. "Incidence of spinal injuries in migratory Yellowstone cutthroat trout captured at electric and waterfall-velocity weirs." F*isheries Management and Ecology* 21(6):509–514.

Lusardi, R.A., and P.B. Moyle, 2017. "Two-way trap and haul as a conservation strategy for anadromous salmonids." *Fisheries* 42(9):478–487.

NMFS (National Marine Fisheries Service), 2011. *Anadromous Salmonid Passage Facility Design*. Portland, Oregon: National Marine Fisheries Service, Northwest Region.

Normandeau, 2012. *Chehalis River Fish Study. PHABSIM Instream Flow Study.* Appendix D. April 2012.

Null, R., and K. Niemela, 2011. *Monitoring and evaluation of the modified fish ladder and barrier weir at the Coleman National Fish Hatchery*. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office. March 2011.

Pacheco, J. (Washington State Department of Ecology) 2019. Email to: Larissa Rohrbach (Anchor QEA), John Ferguson (Anchor QEA), and Marie Winkowski (WDFW). Regarding: Chehalis 2012 Instream Flow Study. June 18, 2019.

Ronne, L., N. Vanbuskirk, C. Holt, and M. Zimmerman, 2018. *Spawner Abundance and Distribution of Salmon and Steelhead in the Upper Chehalis River, 2017-2018*. FPT 18-09. Olympia, Washington: Washington Department of Fish and Wildlife.

Schroeder, R.C., 1996. *Review of capture techniques for adult anadromous salmonids*. Portland, Oregon: Oregon Department of Fish and Wildlife, Fish Division. March 1996.

Van Glubt, S., C. Berger, and S. Wells. 2017. *Technical Memorandum: Chehalis Water Quality and Hydrodynamic Modeling: Model Setup and Preliminary Calibration and Scenario Development*. Prepared by Portland State University for the Washington Department of Ecology.

Watershed GeoDynamics, 2019a. *Geomorphology and Sediment Transport*. Chehalis River Basin Flood Damage Reduction Proposed Project. Prepared for the Washington Department of Ecology and U.S. Army Corps of Engineers. May 2019.

WDFW (Washington Department of Fish and Wildlife), 2013. *Water Crossing Design Guidelines Manual*. Olympia, Washington: Washington Department of Fish and Wildlife.

WDFW, 2019. *Fish Passage Inventory, Assessment, and Prioritization Manual*. Olympia, Washington: Washington Department of Fish and Wildlife.

Wilson, J., B. Glaser, D. Rawding, and T. Buehrens, 2018. *Monitoring of Grays River Fall Chinook Salmon using an Instream Weir, 2008-2010*. Ridgefield, Washington: Washington Department of Fish and Wildlife. November 2018.

Winkowski, Marie (Washington Department of Fish and Wildlife), 2019. Email to: Larissa Rohrbach (Anchor QEA). Regarding: Dataset. July 22, 2019.

Winkowski, M., and N. Kendall, 2018. *Validation of Habitat Preferences for Select Native Freshwater Fishes in the Chehalis River, Washington State*. Olympia, Washington: Washington Department of Fish and Wildlife.

Attachment A
EDT Modeling Report

Evaluation of the Impact of the Flood Retention Expandable (FRE)/ Flood Retention Only (FRO) Facility on Chehalis Basin Salmonid Habitat using Ecosystem Diagnosis and Treatment (EDT) – NEPA

February 2020

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1 INTRODUCTION

The Chehalis Basin is the largest river basin entirely within Washington state. It supports a unique ecosystem including numerous anadromous salmonid species, additional native fish, amphibians, and other wildlife. Native salmonids in the basin include coho salmon (*Oncorhynchus kisutch*), Chinook salmon (fall- and spring-run; *O. tshawytscha*), steelhead (*O. mykiss*), and chum salmon (*O. keta*). All of these species, except chum salmon, spawn or rear in geographic areas that have the potential to be impacted by the proposed Flood Retention Expandable (FRE) facility.

The Ecosystem Diagnosis and Treatment (EDT) model was customized specifically for the Chehalis Basin and estimated the impacts of habitat alteration on salmon and steelhead species on a reach scale relative to existing conditions at a specific point in time (McConnaha et al. 2017). ICF International, Inc. (ICF) has used the Chehalis EDT model to analyze the potential effect of the proposed flood control structure in the Chehalis River on the four anadromous salmonid species. The analysis builds on much of the data and modeling conducted for the Chehalis Basin Strategy (http://chehalisbasinstrategy.com/eis/eis-resources/) and development of the Aquatic Species Restoration Plan (ASRP; Aquatic Species Restoration Plan Steering Committee 2019). This report summarizes the results and conclusions of ICF's analysis.

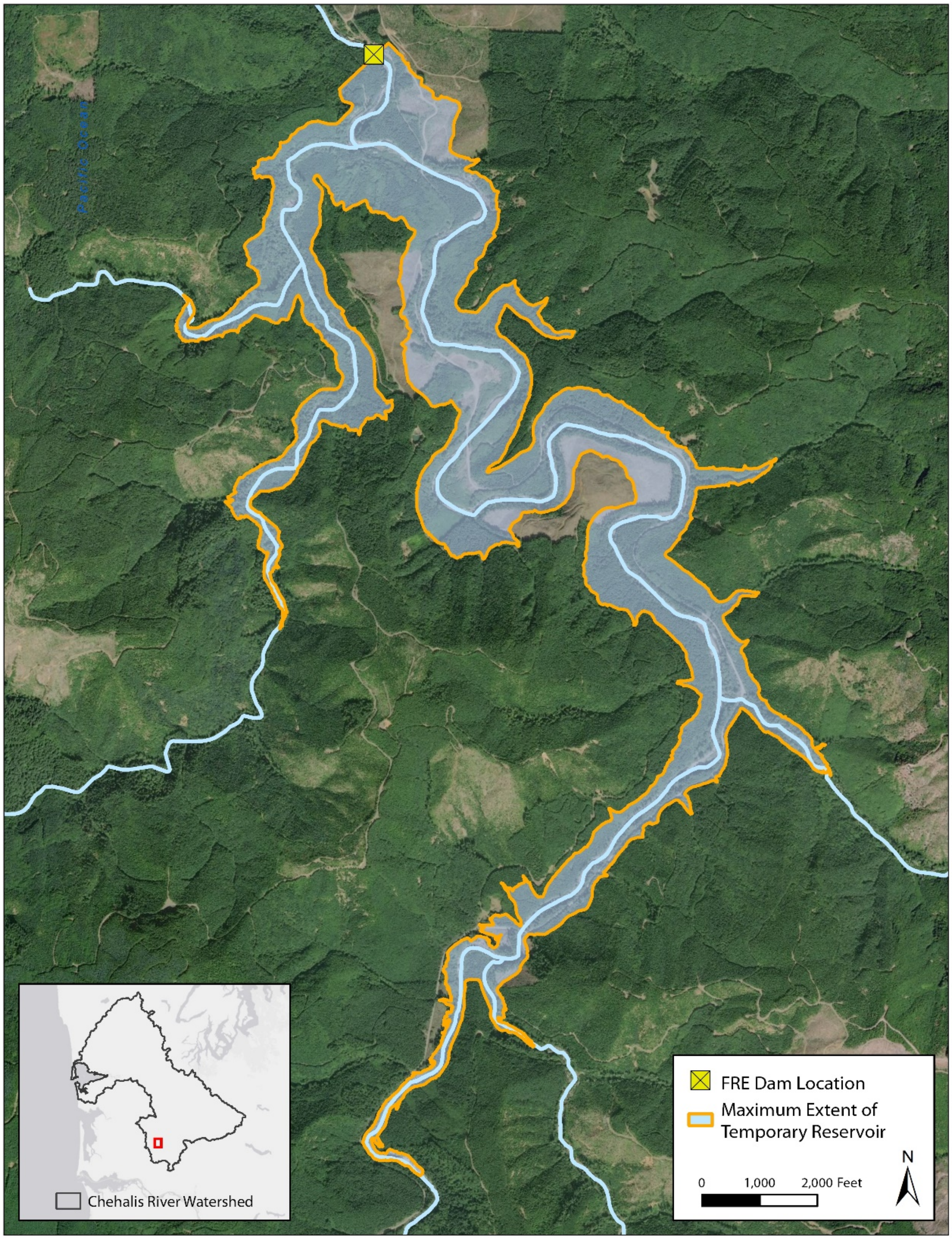
Habitat potential under current and future conditions was evaluated using the Chehalis EDT model (Blair et al. 2009; McConnaha et al. 2017). Habitat potential is a measure of the ability of the habitat, through its physical and biological characteristics, to potentially support the species being modeled. Habitat potential can be looked at through the lens of habitat quantity (capacity), habitat quality (productivity), or equilibrium abundance, which is calculated based on productivity and capacity and so summarizes both. Diversity is also an indicator of habitat potential, in terms of the breadth of spawning areas and life histories for a species that could be supported by the habitat.

In this case, habitat was evaluated with and without the FRE facility; under different time periods (current—2020s, mid-century—2040, and late-century—2080); under different flow scenarios representative of 2-, 10- and 100-year floods; and under a construction period. Evaluation of the impact of the FRE facility was based primarily on the estimated change in equilibrium abundance of populations as a result of construction and operation of the facility relative to a baseline without the project (No Action Alternative). Productivity and diversity changes were also evaluated.

2 PURPOSE

The analysis was conducted to support development of the National Environmental Policy Act (NEPA) Environmental Impact Statement (EIS) for the proposed FRE facility to be located at river mile (RM) 108 on the Chehalis River just below the confluence of Crim Creek (Figure 2-1). The flood retention facility is intended to capture precipitation from peak storms in the upper Chehalis River in a temporary reservoir to control downstream flooding. Following a major flood (7-year flood or greater as measured at the Grand Mound gage), the temporary reservoir would be slowly drained back to the riverine condition. In all but the major flood conditions that trigger closure of the facility, water would flow through the facility and riverine conditions would exist above the facility within the temporary reservoir footprint.

Figure 2-1
Location of the FRE Facility and Maximum Extent of the Temporary Storage Reservoir During a Flood Capture Event



3 METHODS

3.1 EDT Model Overview

EDT is a spatially explicit deterministic model used to evaluate habitat conditions relevant to the life stages of the modeled fish species in river reaches through time (Blair et al. 2009). Overall, three basic components are used in EDT to characterize a watershed: the system geometry (river network), the habitat attributes, and the life histories of the fishes evaluated (Figure 3-1).

The life history component of the model describes and defines, per species evaluated, where the species can spawn, the timing of life stage transitions, and the rate of movement through the system per life stage (Table 3-1). For each species, hundreds to thousands of trajectories are run using the model. Each trajectory demonstrates a specific and realistic life history pattern that could be expressed by that species in the system. Each trajectory starts in one spawning location, has a certain number of days in the egg life stage, a certain number of days until emergence to fry, and specific locations and timings for movements and transitions to additional life stages until returning as a spawner. For the Chehalis EDT model, ICF ran 8,628 trajectories for fall-run Chinook salmon, 2,001 trajectories for spring-run Chinook salmon, 40,001 trajectories for coho salmon, and 20,003 trajectories for steelhead. Collectively, all the trajectories for each species evaluated (termed a 'trajectory set') encompasses a full range of viable spawning locations and specific life history patterns throughout the Chehalis Basin.

Figure 3-1
Ecosystem Diagnosis and Treatment Framework

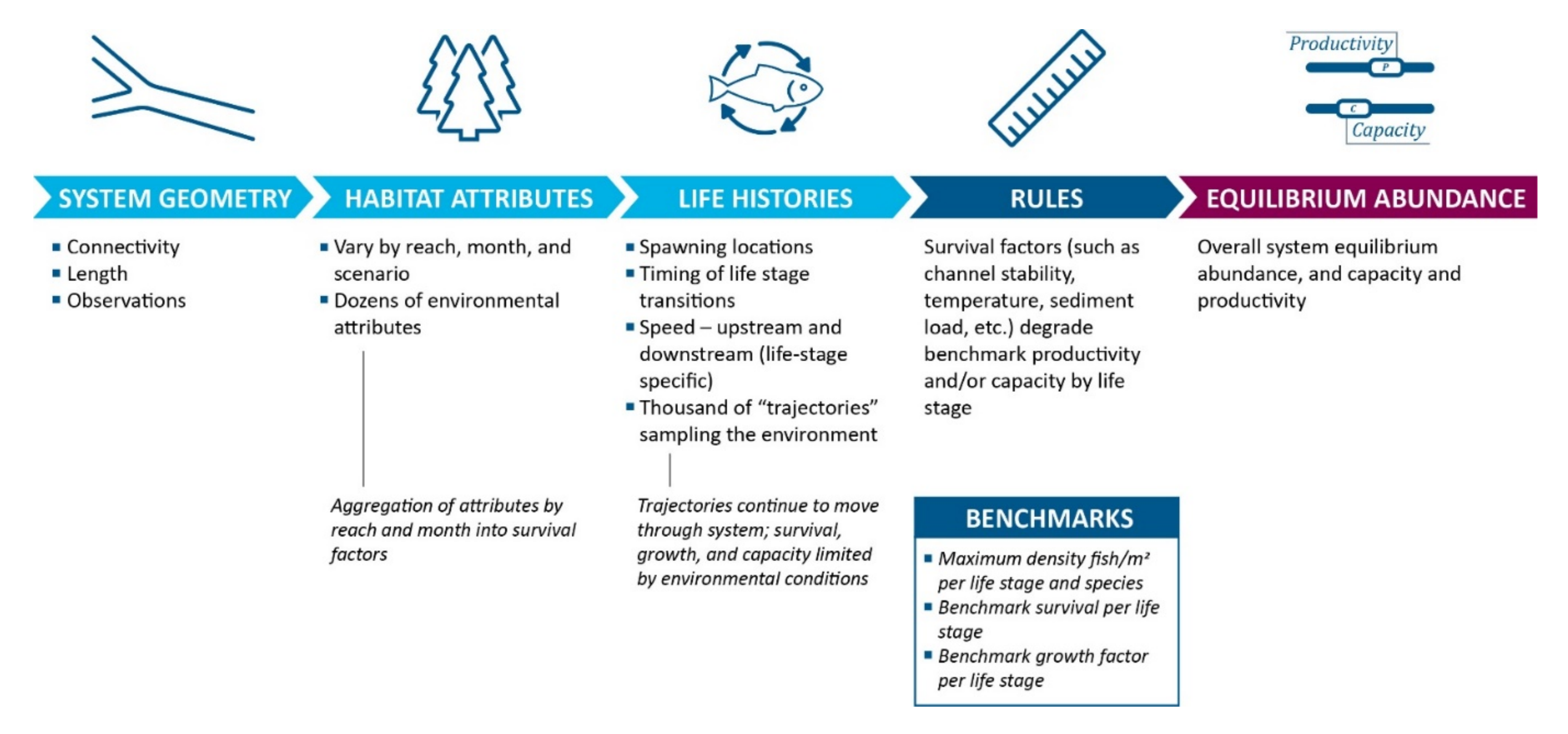
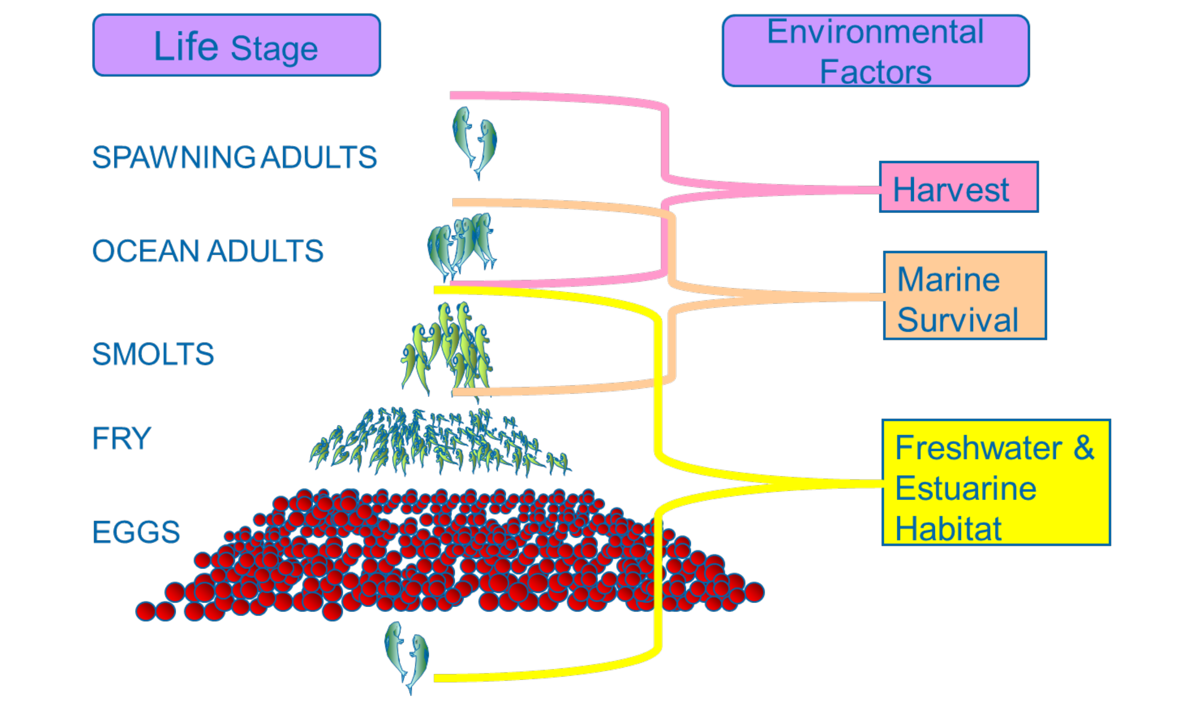


Table 3-1
Parameters Defining Life Cycle Models for EDT Populations

PARAMETER	DESCRIPTION	LIFE CYCLE APPLICATION	UNITS
Spawning Reach	Reach locations allowed for spawning trajectories start distributed among these reaches	Trajectories begin as eggs and end as spawners in these locations	EDT reach
Duration	Defines minimum and maximum amount of time trajectory may spend in a life stage	Defined specifically for each life stage	Days
Transition Time Window	Time periods during which one life stage may transition to another	Defined for spawning and for transitions between life stages (egg to fry; marine to migrant prespawner, and so on)	Dates
Speed	Speed at which life stage may move up or downstream	Defined for each life stage	kilometers per day
Location Window	Locations at which one life stage may transition to another	Defined for transitions between life stages	River kilometers (relative to mouth)

Overall, system geometries and trajectory sets remain static among scenarios. Therefore, changes in model results among scenarios are not due to differences in life history configurations or changes to stream networks, but to the habitat modeled. Habitat attributes vary among scenarios, and the interaction of the components of the model for different scenarios is what drives differences in population performance. Overall, the life history trajectories for species are affected in their productivity and capacity by life stage due to habitat conditions (e.g., temperatures that are too high, too much fine sediment, not enough benthic invertebrates) as compared to benchmark values of productivity and capacity (Figure 3-2). Survival values in Grays Harbor and the Pacific Ocean are entered as fixed survival rates to complete the species life history. Marine survival rates in EDT have been set to produce numbers that correspond with actual observations of Chehalis River run sizes.

Figure 3-2
Example of Life History Stages Modeled in EDT and Environmental Factors Affecting Their Performance



Ultimately, the EDT model results in population level estimates of capacity, productivity, diversity, and equilibrium abundance by scenario.

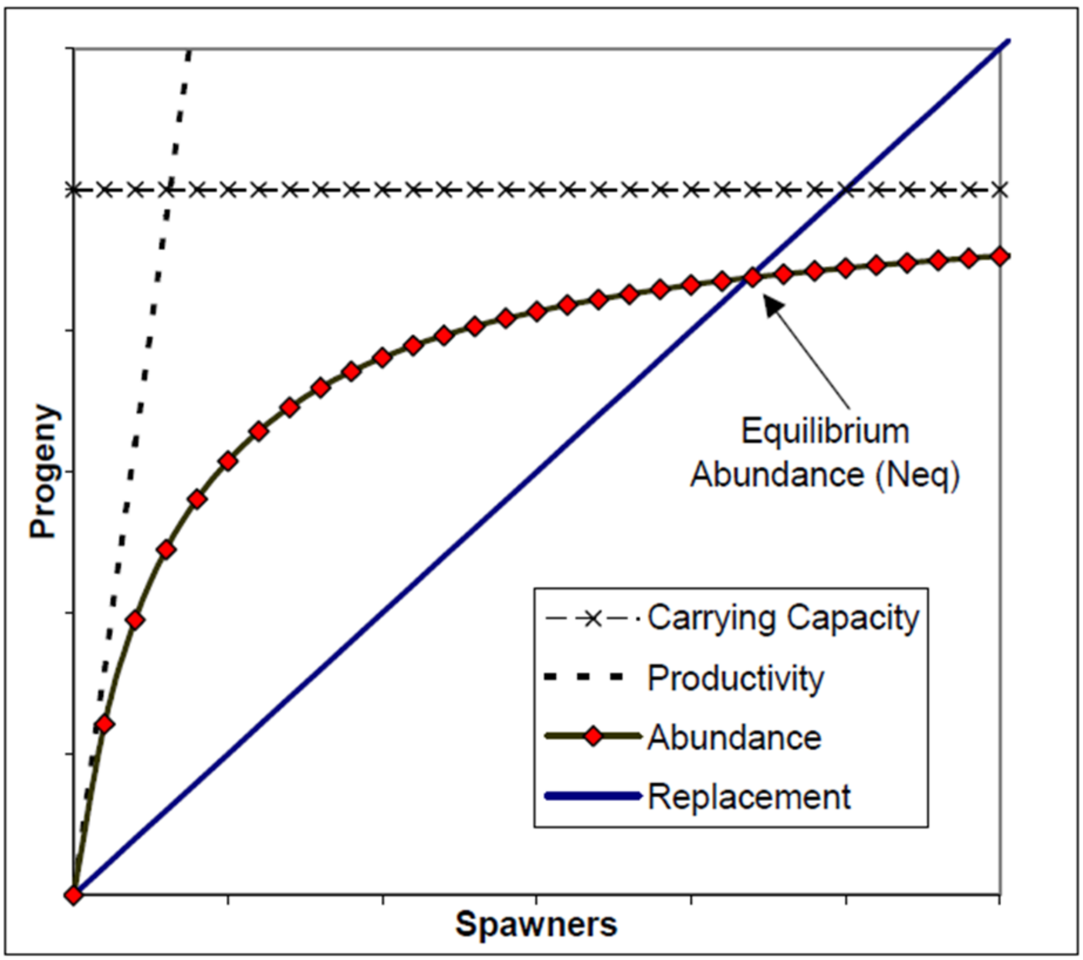
Capacity in EDT describes how large a population can grow given the quantity and quality of habitat (Figure 3-3). Capacity in EDT is the asymptotic limit to abundance reflecting habitat area, habitat type (e.g., pools, riffles), food, and productivity.

Productivity in EDT is density-independent survival (intrinsic productivity discussed in McElhany et al. 2000). Productivity under a given set of conditions is the slope of the abundance line of a Beverton-Holt production function graph at its origin (Figure 3-3). Productivity reflects the quality of habitat in reaches and across months throughout the model, according to the life stages of the fish species being evaluated. Productivity is a function of habitat attributes such as temperature, large wood, and water quality that affect survival of life stages. Within the Beverton-Holt formulation, calculation of equilibrium abundance requires a productivity of at least 1 (spawners = progeny). Life history trajectories with productivities less than 1 are considered non-sustainable and do not enter into the calculation of abundance.

Equilibrium abundance (Neq) is calculated based on productivities and capacities, and the Neq is the point where the abundance curve crosses the spawner-progeny replacement line (Figure 4; Lestelle et al. 2004). The estimate of potential fish performance in EDT reflects habitat conditions from spawning grounds all the way downstream, and back up to spawning grounds as returning adults, spanning the entire life history of the species.

One additional parameter calculated in EDT is diversity. Diversity in EDT is the proportion of sustainable life history trajectories that are used to calculate equilibrium abundance. EDT diversity relates to the breadth of suitable habitat within the spatial unit and the variation in modeled life histories within the population. A lower diversity indicates that the calculated abundance relies on an increasingly narrow range of suitable habitat and life histories within the population. Populations in EDT with higher diversity are assumed to have greater resiliency to environmental perturbations compared to those with lower diversity.

Figure 3-3
Example Beverton-Holt Production Function (from Lestelle et al. 2004)



EDT is a habitat-based model that is used to evaluate habitat potential for a modeled species by looking at habitat quality (capacity), habitat quality (productivity), and/or equilibrium abundance.

Diversity is also an indicator of habitat potential measured as the breadth of spawning areas and life histories for a species that could be supported by the habitat.

3.2 General Model Information

3.2.1 Species Modeled

The four modeled species included coho salmon, steelhead, and Chinook salmon (spring-run and fall-run). These species differ in their distribution across the Chehalis Basin, life history patterns, and relative abundance. These differences affected the estimated impact of the FRE facility on each species.

3.2.1.1 Coho Salmon

Coho salmon are the most abundant and widely distributed of the four species in the Chehalis Basin. They were assumed to potentially spawn in all modeled stream reaches including smaller stream reaches in the upper Chehalis River as well as the mainstem Chehalis River (Ashcraft et al. 2017). Coho spawn in late fall and winter with juveniles emerging the following spring. They rear in freshwater for 1 year and emigrate to the ocean in their second spring. Juvenile life history of coho salmon in the model included a portion that rear in the vicinity of their natal spawning reach and another portion that distribute downstream. Coho salmon spend 2 years in the ocean and return to spawn as 3-year-old adults.

3.2.1.2 Steelhead

Chehalis River steelhead are winter run and are modeled in EDT to spawn in February to March with juveniles emerging in early summer (Ashcraft et al. 2017). Spawning occurs in most areas of the Chehalis Basin, especially in smaller upper basin stream reaches. The analysis assumed that steelhead spend 1 to 2 years in freshwater as juveniles prior to emigration and 1 to 3 years in the ocean.

3.2.1.3 Spring-Run Chinook Salmon

Spring-run Chinook salmon are the least abundant of the four species and have the most restricted distribution in the Chehalis Basin. Spring-run Chinook salmon are modeled in EDT to spawn in late August to mid-October. Based on their distribution, they are modeled to spawn in the upper Chehalis River above and below Crim Creek, in the South Fork Chehalis River, the Newaukum River, and the Skookumchuck River with most of the production occurring in the latter two sub-basins. Spring-run Chinook salmon in the Chehalis River system are found in the mainstem reaches of the tributaries and Chehalis River and do not appear to migrate into the upper headwater streams. Above Crim Creek in the upper Chehalis Basin, spring-run Chinook salmon were assumed to be confined to the mainstem river below the East Fork and West Fork Chehalis confluence (Ashcraft et al. 2017). Adult spring-run Chinook salmon enter the Chehalis River in the spring, then move up into the mainstem river and tributaries where they hold during summer prior to spawning. Juveniles emerge in early spring and emigrate prior to summer in their first spring (referred to as an ocean-type life history).

3.2.1.4 Fall-Run Chinook Salmon

Fall-run Chinook salmon also have an ocean-type life history similar to spring-run Chinook salmon but do not enter the Chehalis River until late summer and fall and so do not have the over-summer holding life stage of spring-run Chinook salmon. They are more widely distributed across the basin and occupy both mainstem reaches as well as smaller headwater streams (Ashcraft et al. 2017).

3.2.2 Flow and Flood Conditions

ICF evaluated the No Action Alternative and FRE facility scenarios under alternative 2, 10, and 100 year flow conditions occurring in the historical records. The goal of the modeling was to contrast habitat conditions when the FRE facility was in the open and closed positions under different flood conditions. Flood year conditions in the model, regardless of whether the FRE facility was modeled, differed for the following factors:

- Monthly average flow
- Monthly average channel width
- Bed scour

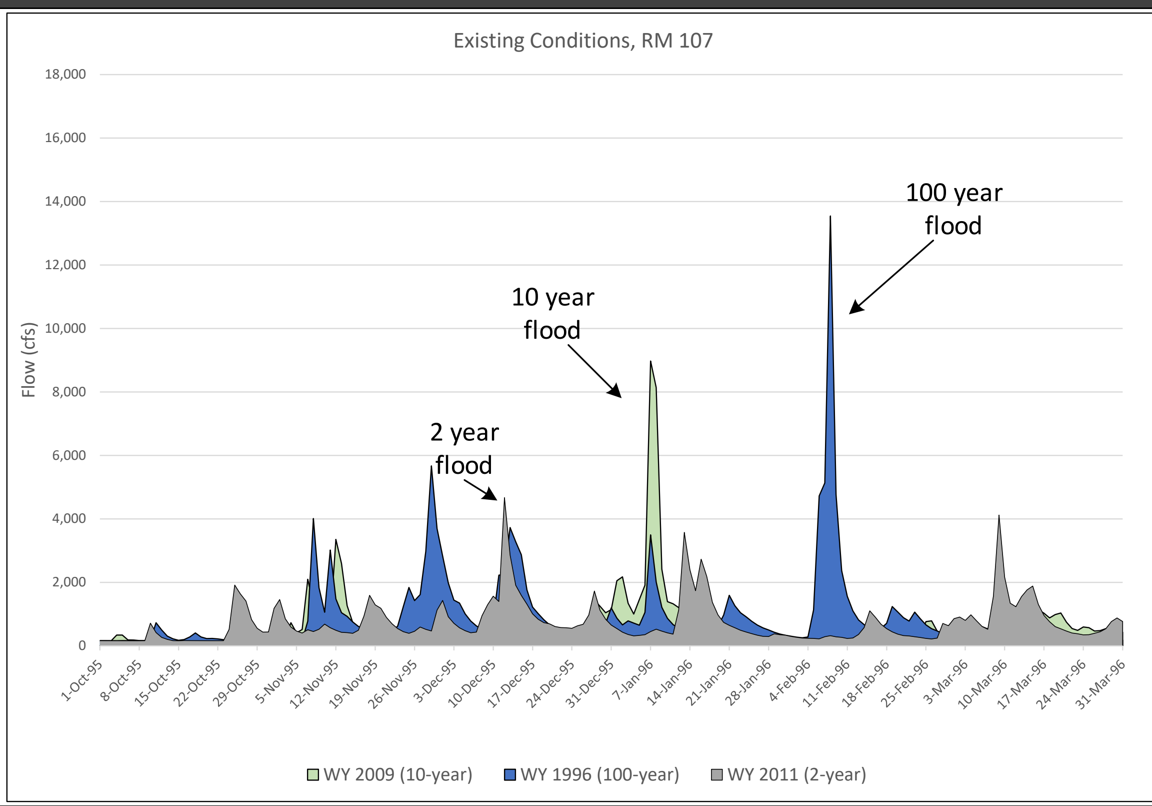
Average flow and channel width also varied by whether the FRE facility was modeled within a modeled flow year. A HEC-RAS model was used to estimate the flow and channel width in the mainstem Chehalis River (the FRE facility location down to approximately RM 22) in 3 water years selected from the hydrologic record with and without the FRE facility (Hill 2019) shown in Figure 3-4. The varying flow conditions characterized by the HEC-RAS analysis only applied to the mainstem river; no change between flood years was assumed in the tributary reaches. A 2-year flood recurrence interval characterized by water year (WY) 2011 was considered the “normal” or prevailing condition under which the FRE facility was not closed in winter. Under 10-year (WY 2009) and 100-year (WY 1996) flood conditions, the FRE facility was closed and a temporary reservoir was created behind the FRE facility.

The 2-, 10- and 100-year floods were brief episodic events within their respective flow years (WYs), and the 3 flood flow years do not represent a progression of increasing average flows. For example, average monthly flow in the year used to represent the 10-year flood (WY 2009) was less than the average monthly flow in the year used to represent the 2-year flood (WY 2011). The water years were chosen to represent specific floods that would highlight operation of the FRE facility and not vary system-wide flow conditions. EDT models flow and the resulting channel width as a monthly average and is not responsive to brief, episodic events such as a flood lasting a few days except insofar as it affects the monthly average flow and channel width.

A further consideration for using the actual flow conditions from specific years in the model is that each year has a unique pattern of flow and channel width that affects model performance. For example, it can be seen in Figure 3-4 that the 100-year flood in 1996 occurred in mid-February, the 10-year flood in 2009 occurred in early January, and the 2-year flood in 2011 occurred in mid-December. The unique flow conditions of each year create pulses of flow and increased channel width during different months that have varying effects on different life stages.

The model assumed that bed scour would increase in the 10- and 100-year floods relative to the 2-year "normal condition" in the mainstem Chehalis River reaches above Elk Creek. River gradient increases appreciably above Elk Creek and the river above that point is an area of currently high scour and unstable substrate (Watershed GeoDynamics 2017). No quantitative method was available to determine the expected increase in scour at the specific floods that occurred in WY 2009 (10-year flood) and WY 1996 (100-year flood). To capture this assumption, ICF increased the 2-year flood scour ratings in this area in the EDT model by 33% in the 10-year flood and by 50% in the 100-year flood (McConnaha and Ferguson 2019). The analysis did not assume that bed scour increased in the higher flood years below Elk Creek because of the very low gradient of the mainstem river.

Figure 3-4
Daily Average Flow in the Three Flood Conditions Modeled by HEC-RAS at RM 107 near Pe Ell



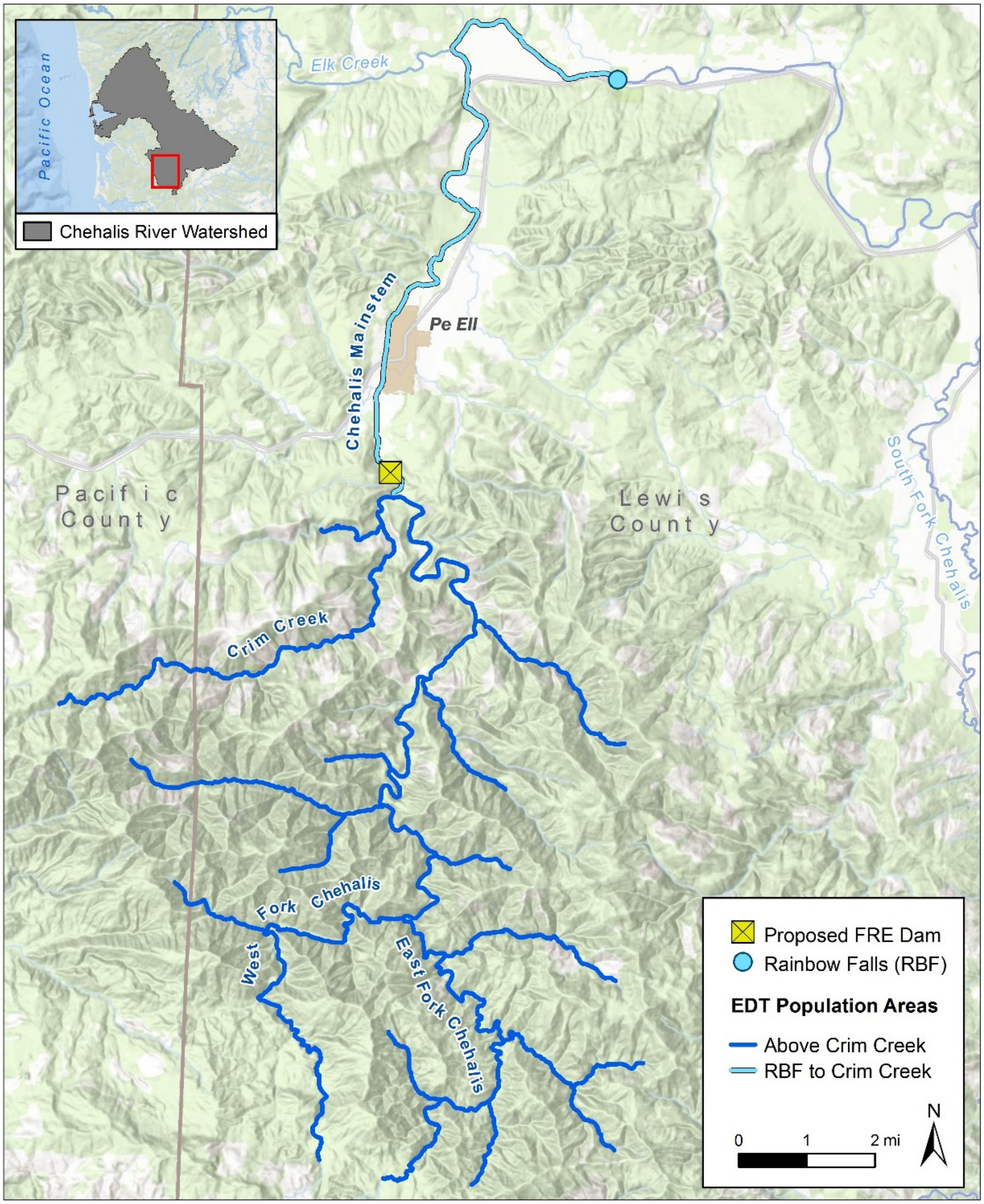
3.2.3 Water Temperature

Water temperature data used in the EDT model were the data used previously for the ASRP/PEIS EDT model. Overall, the data were derived from two modeling sources. In the mainstem Chehalis River, water temperature was estimated by Portland State University (PSU) using the CE-QUAL-W2 model (Van Glubt et al. 2017). The PSU model estimated water temperature from the confluence of the East and West forks of the Chehalis River down to Porter Creek (approximately RM 33) under Current (WY 2013 and 2014) conditions. PSU also modeled scenarios associated with temperature in the mainstem Chehalis River with the FRE facility and temporary reservoir. Current temperature in the tributaries within the project area was estimated by the Washington Department of Fish and Wildlife (WDFW) Thermalscape model (Winkowski 2019). Temperature did not change among the three flood year conditions.

3.2.4 Spatial Extent of the Analysis

The Chehalis EDT model encompasses the entire Chehalis Basin including the mainstem river tributaries at a reach scale. This basin scale includes the Chehalis River and tributaries above and below the proposed flood retention facility site down to Grays Harbor, and tributaries that flow directly into Grays Harbor, but does not include Grays Harbor. The NEPA analysis of the FRE facility focused on a project area consisting of two EDT populations located above Rainbow Falls (RBF). Within the project area ICF defined two EDT populations separated by the location of the FRE facility: Above Crim Creek and RBF to Crim Creek (Figure 3-5). The Above Crim Creek population included the mainstem Chehalis River and all EDT tributaries. The RBF to Crim Creek population included only the mainstem Chehalis River from RBF to Crim Creek.

Figure 3-5
Chehalis EDT Model NEPA Project Area



3.2.5 Modeled Scenarios

Nineteen scenarios were modeled in EDT to evaluate the FRE facility and temporary reservoir (Table 3-2). Modeled performance of the four species with the FRE facility was compared to a No Action Alternative NEPA baseline (Table 3-2).

3.3 Input Parameters and Assumptions

3.3.1 No Action Alternative

The No Action Alternative NEPA baseline for the analysis reflected assumptions about how conditions within the project area might change in the future regardless of the FRE facility. Under the No Action Alternative, no flood retention facility or airport levee improvements would be constructed and local flood damage reduction efforts would likely continue based on local planning and regulatory actions. The No Action Alternative included projects and programs that have been planned and designed to address flood damage and are underway, and flood damage reduction programs and projects that have been constructed or are funded and permitted. The analysis incorporated the following elements in the No Action Alternative NEPA baseline that resulted in a varying baseline into the future regarding production of the modeled species:

- Maturation of riparian forests within managed forest areas of the Chehalis Basin
- Increase in human population and development within the Chehalis Basin
- Early action restoration in five sub-basins (Section 3.3.1.3)
- Removal of fish passage barriers including injunction culverts

No Action Alternative NEPA baseline conditions were assessed at three points in time: current (2020s), mid-century (2040), and late-century (2080).

Table 3-2

Scenarios Modeled in EDT to Characterize the FRE Facility

		NO ACTION ALTERNATIVE			FRE FACILITY			
FLOOD RECURRENCE	MODELED FLOW YEAR	CURRENT[1]	MID-CENTURY	LATE-CENTURY	CONSTRUCTION	POST-CONSTRUCTION	MID-CENTURY	LATE-CENTURY
2-year	2011	2020s	2040	2080	2025	2030	2040	2080
10-year	2009	2020s	2040	2080		2030	2040	2080
100-year	1996	2020s	2040	2080		2030	2040	2080

Note:

1. Average of current conditions modeled for pre-construction period.

3.3.1.1 Tree Growth in Managed Forests

About 65% of the Chehalis Basin lies within forest areas managed for commercial harvest including areas within U.S. Forest Service and Washington Department of Natural Resources ownership. The Above Crim Creek area is almost entirely within commercially managed forest. Consistent with assumptions used in the ASRP, ICF assumed that trees within managed forest areas would continue to grow and that riparian forests would be protected from harvest in the future under requirements of the Washington Forest Practices Act (Title 222 WAC).

To incorporate the effect of tree growth within managed forests, the analysis relied on a set of hypotheses developed by an expert panel convened under the Chehalis Flood Control project. This panel associated various restoration actions, including protection of riparian forests, to attributes in the EDT model as well as the degree of control that the action would likely have on the attributes. Based on those hypotheses, the team assumed that maturation of riparian forests within managed forest areas consistent with the Washington Forest Practices Act would affect in-stream conditions in mid- and late-century by moderating water temperature through increased shade, increasing the supply of large wood in the streams, and decreasing bed scour due to the increase in large wood.

3.3.1.2 Increase in Human Population and Development Outside Managed Forests

Over the remainder of the 21st century, human population in the Chehalis Basin is expected to increase. Consistent with assumptions used in the ASRP, the analysis assumed that development would negatively affect aquatic habitat but only in areas outside managed forests. ICF assumed that development would negatively affect all reaches outside managed forest including the RBF to Crim Creek area that is within the FRE facility project area. The effect of increased development was incorporated into the EDT model using a set of associative hypotheses for the effect of urbanization on EDT attributes developed by the ASRP Scientific Review Team. These hypotheses resulted in degradation of large wood, riparian function, flow, temperature, and pollution as a result of urbanization. Similar to the ASRP model, a higher intensity of degradation was also applied in areas identified as urban growth areas such as the Chehalis-Centralia area.

3.3.1.3 Early Action Restoration

As part of the Chehalis Basin Strategy, the Chehalis Basin Board has approved five restoration projects in the Chehalis Basin as "early actions" pending prioritization of restoration under the ASRP. Early action projects are slated to restore habitat in the following streams:

- Wynoochee River
- East Fork Satsop River
- Skookumchuck River
- South Fork Newaukum River
- Stillman Creek (South Fork Chehalis River)

Because these projects are expected to be permitted and implemented, the ASRP Steering Committee directed that they be included in the ASRP baseline and they were also included in the NEPA baseline. Based on project descriptions and discussions with proponents, ICF assumed that these projects would include actions to improve riparian condition, increase wood loading, and reconnect off-channel habitat.

3.3.1.4 Culvert Removals

The Washington State Treaty Tribes sued the State of Washington under Phase 2 of the Boldt decision[1] regarding the effect of culverts throughout the state on passage of anadromous fish and the effect on tribal fishing rights. The tribes won that case and an injunction was issued by the Court directing that the State remove or fix all culverts under state highways. As a result, the Washington State Department of Transportation developed a list of affected culverts in the Chehalis Basin that included 24 culverts in the Chehalis EDT model network (Mobbs 2019). As part of the ASRP baseline, the analysis assumed that half of those culverts would be removed by mid-century and the remainder by late-century. These assumptions have also been included in the NEPA EDT model.

3.3.2 Alternative 1: Flood Retention Expandable (FRE) Facility

Alternative 1 would include construction of an FRE facility that would temporarily retain up to 65,000 acre-feet of water during a major (10-year) or greater flood. Parameters and assumptions for the analysis of the FRE facility were developed collectively with the U.S. Army Corps of Engineers, Anchor QEA, ICF, and the National Oceanic and Atmospheric Administration (NOAA). General conditions assumed for the modeled scenarios are summarized below. Both quantitative models (flow and temperature) and qualitative hypotheses were used to parameterize the scenarios. For parameters that could not be estimated through quantitative methods, hypotheses were developed by the parties based on specific assumptions, expert knowledge, and the general body of scientific literature. Passage values under construction and FRE facility scenarios are included in Exhibit 1.

3.3.2.1 FRE Facility Construction Period

Construction of the FRE facility and preparation of the upstream reservoir area is expected to take approximately 5 years. During that period, returning adult fish attempting to pass the facility site would be trapped and transported upstream. Assumptions about fish passage for modeling during this time were considered separately from fish passage during operation. During construction, the temporary diversion tunnel would be used for downstream passage of juveniles and adult steelhead, and a temporary trap and haul facility would be used for adult upstream passage. For the construction period the analysis assumed the 2-year flood flow (WY 2011).

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[1] On February 12, 1974, Federal Judge George Boldt (1903-1984) issued a ruling that reaffirmed the rights of Washington's Indian tribes to fish in accustomed places. The "Boldt Decision" allocates 50% of the annual catch to treaty tribes.

3.3.2.2 FRE Facility Gates Closed, Temporary Reservoir Created

After construction, when a major storm is predicted (greater than 38,000 cubic feet per second [cfs] at Grand Mound), outflow gates on the FRE facility would be closed to impound the flood flow from the upper Chehalis Basin. These conditions used the 10-year (WY 2009) and 100-year (WY 1996) flood flows. With FRE facility closure, the riverine conditions above the facility would change to those of a flooded reservoir (Figure 1). The two flood year conditions differed largely in the size of the temporary reservoir, which was about 518 acres for the 10-year flood and 709 acres for the 100-year flood. Formation of the temporary reservoir was assumed to occur sometime between September and February, which would coincide with spawning of the modeled species or incubation of eggs deposited in redds.

The analysis assumed that under conditions in which a temporary reservoir is created by closure of the FRE facility, all salmon production within the temporary reservoir footprint would be eliminated (i.e., spawning eliminated and eggs killed). However, habitat above the temporary reservoir footprint would be unchanged; production of the modeled species could continue in streams above the temporary reservoir footprint, and adult and juvenile life stages could freely pass through the reservoir. The FRE facility is assumed to include features and operations designed to allow passage of adults and juveniles at the facility during a closure; however, some degradation of survival was assumed to occur at the facility during a closure event. Additionally, within the temporary reservoir area, bed scour, large woody material, embeddedness, fine sediment, riparian condition, and benthic invertebrates were all hypothesized to be impacted. Downstream, large woody material was expected to be reduced, but bed scour was expected to lessen due to attenuation of the flood by the proposed structure.

3.3.2.3 FRE Facility Gates Open, No Temporary Reservoir

In most years, the outflow gates on the FRE facility would be open during winter, allowing water to flow through the facility. This condition was characterized by the 2-year flood flow (WY 2011). ICF assumed that during winter, habitat in the mainstem Chehalis River and tributaries above the facility would be altered due to actions to maintain the temporary reservoir footprint and the legacy of closure events. Winter riverine habitat within the temporary reservoir footprint would be degraded for riparian function (reduced due to riparian clearing) and benthic invertebrates (less allochthonous input). Passage survival rates for adult and juvenile fish at the facility reflected fish passage values developed for conduits.

3.3.2.4 Summer Conditions

During summer, the FRE facility gates would be open and riverine conditions would be present above the facility. Riparian condition and benthic invertebrates were hypothesized to be impacted within the temporary reservoir footprint area at all times due to maintenance of the reservoir. In addition, following 10- and 100-year floods, bed scour was predicted to increase, large woody material to decrease, embeddedness to increase, and fine sediment to increase in the impoundment area. Downstream, large woody material was predicted to decrease.

3.3.2.5 Integration of EDT Results for NOAA Lifecycle Model

For integration of EDT results into the NOAA lifecycle model (LCM), productivity and capacity of spring-run Chinook salmon, fall-run Chinook salmon, coho salmon, and steelhead by sub-basin were broken down into final values (spawning to spawning), juvenile values, and prespawner capacity.

Specifically, the final productivity and capacity values from spawning to spawning were provided. Juvenile productivity and juvenile capacity were provided as the cumulative productivity and capacity values from spawning to departure from the Chehalis River at the Wishkah River confluence.

Prespawner survival was calculated as the density-independent survival of returning adults from when they enter the Chehalis River at the Wishkah River confluence to spawning. Prespawner capacity was calculated as the capacity parameter representing capacity constraints from when adults enter the Chehalis River at the Wishkah River confluence to spawning. Prespawner survival and prespawner capacity are not standard EDT outputs but can be readily calculated in the Moussalli-Hilborn framework (Moussalli and Hilborn 1986) as described below.

Juvenile-to-Adult Productivity and Juvenile-to-Adult Capacity (calculated for LCM) represent, respectively, the cumulative productivity and capacity from spawning up until returning adults re-enter the Chehalis River:

If $p_1 =$ Juvenile-to-Adult Productivity,
$c_1 =$ Juvenile-to-Adult Capacity,
$p_2 =$ Prespawner Survival, and
$c_2 =$ Prespawner Capacity, then by Moussalli-Hilborn equation 4 the stock-recruit (S-R) relationship for the sub-basin is as follows:

$$R = \frac{p_1 p_2 S}{1 + \left(\frac{p_1}{c_1} + \frac{p_1 p_2}{c_2}\right) S}.$$

By Moussalli-Hilborn equation 6, the spawner-to-spawner productivity P is as follows:

$$P = p_1 p_2.$$

EDT outputs P and p_1 in its standard outputs, so p_2 is therefore given by the following equation:

$$p_2 = \frac{P}{p_1}.$$

The following Moussalli-Hilborn equation 7 is equivalent to the recurrence relation for cumulative capacity C:

$$C_i = \frac{1}{\frac{1}{p_i C_{i-1}} + \frac{1}{c_i}}.$$

EDT outputs C_2 and C_1 in its standard outputs, so c_2 is therefore given by the equation ($i = 2$) as follows:

$$c_2 = \frac{1}{\frac{1}{C_2} - \frac{1}{p_2 C_1}}$$

4 RESULTS

Results are described for current (2020s) and late-century (2080) analyses here to simplify the descriptive output. Results are described for 1) the No Action Alternative condition for current and then late-century, then 2) for the construction period, and finally 3) for the FRE facility scenarios in late-century. Late-century FRE facility scenarios are compared to both the late-century No Action Alternative conditions as well as current conditions. Mid-century results can be found in Exhibit 2.

4.1 Species Performance Under No Action Alternative NEPA Baseline Conditions

4.1.1 Current Habitat Potential

4.1.1.1 Coho Salmon

Overall modeled equilibrium abundance for coho salmon in the Chehalis Basin is much higher than for the other three species (Table 4-1). About 1.2% of the current basin-wide equilibrium abundance for coho salmon occurs in the RBF to Crim Creek Sub-basin and Above Crim Creek Sub-basin, which is the area most directly affected by the FRE facility. Within this area, the RBF to Crim Creek Sub-basin below the proposed facility currently supports little coho salmon production and estimated equilibrium abundance in the area is about 11% of the estimated potential above Crim Creek.

Productivity of coho salmon in the Chehalis River above RBF is less than the productivity in the Willapa Hills Region (includes Chehalis Mainstem RBF to Crim, Upper Chehalis SB and sub-basins including EF Chehalis River, South Fork, Hope, Marcuson, Dunn, Absher, Capps, Elk Creek, Fronia, Robinson, Jones, Stowe, Rock Creek, Crim Creek, Big Creek, Roger Creek, Alder Creek, Thrash Creek, Mack Creek and WF Chehalis) or the Chehalis Basin (Table 4-1). This indicates poorer fish survival and lesser habitat quality compared to the basin as a whole. In the RBF to Crim Creek Sub-basin, productivity of coho salmon is about 1.7 adult returns/spawner (Table 4-1). Mathematically, productivity must be greater than 1.0 to calculate the abundance in Table 4-1. However, the low productivity of coho salmon in the RBF to Crim Creek Sub-basin means that sustained production of coho salmon may not occur in this area during years of poor ocean survival when productivity could drop below 1.0.

Abundance and productivity of coho salmon declined slightly between the three flood-year conditions in the sub-basins above RBF (Table 2). This reflected the assumed increase in bed scour in the river above Elk Creek at the higher flood conditions (McConnaha and Ferguson 2019). Abundance and productivity did not decline as much between the flood years at the Willapa Hills

Region and Chehalis Basin scales because bed scour was not increased below Elk Creek due to the very low gradient of the river.

Table 4-1
Estimated Habitat Potential of Coho Salmon Under Current Habitat Conditions

	CHEHALIS BASIN	WILLAPA HILLS REGION	RBF TO CRIM CREEK	ABOVE CRIM CREEK
COHO SALMON ABUNDANCE[1] UNDER CURRENT CONDITIONS				
2-year No Action Alternative	74,200	4,049	91	820
10-year No Action Alternative	73,675	4,020	82	805
100-year No Action Alternative	73,858	4,021	73	793
COHO SALMON PRODUCTIVITY[2] UNDER CURRENT CONDITIONS				
2-year No Action Alternative	4.8	3.5	1.7	2.7
10-year No Action Alternative	4.8	3.6	1.7	2.7
100-year No Action Alternative	4.8	3.6	1.6	2.6
COHO SALMON EDT DIVERSITY[3] UNDER CURRENT CONDITIONS				
2-year No Action Alternative	62.2%	25.7%	3.9%	15.0%
10-year No Action Alternative	62.2%	25.7%	1.1%	14.2%
100-year No Action Alternative	62.1%	25.0%	0.6%	13.0%

Notes:

1. Equilibrium abundance (Neq) is the point at which the abundance curve crosses the spawner-progeny replacement line, and reflects both the quantity and quality of habitat.
2. Productivity is density-independent survival, and is the slope of the abundance line of a Beverton-Holt production function. It describes the number of juveniles that survive and return as adults to spawn per original adult spawner.
3. Diversity is the proportion of sustainable life history trajectories (productivity >= 1).

4.1.1.2 Spring-Run Chinook Salmon

Spring-run Chinook salmon are known to be the least abundant of the four species in the basin and have the most restricted distribution (Table 4-2). About 9% of the modeled equilibrium abundance for spring-run Chinook salmon is above RBF (i.e., above Crim Creek and RBF to Crim Creek) and about 56% of the abundance above RBF is in the RBF to Crim Creek Sub-basin below the proposed facility (Table 4-2), making this area especially important to spring-run Chinook salmon as compared to other species.

The low abundance of spring-run Chinook salmon reflects low productivity compared to other species (Table 4-2). EDT diversity of spring-run Chinook salmon is also very low; only 5% of life history/spawning area combinations modeled result in productivity greater than 1 across the Chehalis Basin. In the project area, and especially in the RBF to Crim Creek area, EDT diversity dips as low as 1.5% under a major flood for current conditions. Spring-run Chinook salmon in the Chehalis Basin face a number of challenges that reduce survival (productivity), and thus also reduce their EDT diversity. This includes the need to survive as adults in the Chehalis River during the summer prior to spawning. In a warm system like the Chehalis River, this requires cool water refugia, which can be limiting. The low abundance and productivity of spring-run Chinook salmon, the need for summer holding habitat, and other issues related to genetics and introgression from fall-run Chinook salmon make spring-run Chinook salmon the most threatened of the four species.

Table 4-2
Estimated Habitat Potential of Spring-Run Chinook Salmon under Current Habitat Conditions

	CHEHALIS BASIN	WILLAPA HILLS REGION	CHEHALIS RBF TO CRIM CREEK	ABOVE CRIM CREEK
SPRING-RUN CHINOOK SALMON ABUNDANCE[1] UNDER CURRENT CONDITIONS				
2-year No Action Alternative	1,176	356	40	71
10-year No Action Alternative	1,143	350	35	64
100-year No Action Alternative	1,157	358	31	62
SPRING-RUN CHINOOK SALMON PRODUCTIVITY[2] UNDER CURRENT CONDITIONS				
2-year No Action Alternative	2.7	2.8	1.6	2.0
10-year No Action Alternative	2.7	2.8	1.5	1.9
100-year No Action Alternative	2.7	2.8	1.4	1.8
SPRING-RUN CHINOOK SALMON EDT DIVERSITY[3] UNDER CURRENT CONDITIONS				
2-year No Action Alternative	5.1%	6.3%	4.8%	6.2%
10-year No Action Alternative	5.1%	5.9%	4.0%	6.2%
100-year No Action Alternative	5.1%	5.8%	1.6%	5.7%

Notes:

1. Equilibrium abundance (Neq) is the point at which the abundance curve crosses the spawner-progeny replacement line, and reflects both the quantity and quality of habitat.
2. Productivity is density-independent survival, and is the slope of the abundance line of a Beverton-Holt production function. It describes the number of juveniles that survive and return as adults to spawn per original adult spawner.
3. Diversity is the proportion of sustainable life history trajectories (productivity >= 1).

4.1.1.3 Fall-Run Chinook Salmon

Although fall-run and spring-run Chinook salmon in the Chehalis Basin both have an ocean-type life history, fall-run Chinook salmon do not enter the Chehalis system until fall and lack the summer holding life stage that limits spring-run Chinook salmon. Fall-run Chinook salmon are relatively abundant throughout the Chehalis Basin but only about 1% of the equilibrium abundance for fall-run Chinook salmon estimated by EDT was above RBF (Table 4-3).

Productivity of fall-run Chinook salmon was appreciably greater than that of spring-run Chinook salmon (Table 4-3) because fall-run Chinook salmon are not exposed to high summer water temperatures like spring-run Chinook salmon. Fall-run Chinook salmon were most abundant and have the highest productivity of the four species in the RBF to Crim Creek Sub-basin below the site of the proposed facility (Table 4-3). Their diversity numbers are also high compared to other species for the same reasons.

Table 1-3
Estimated Habitat Potential of Fall-Run Chinook Salmon under Current Habitat Conditions

	CHEHALIS BASIN	WILLAPA HILLS REGION	CHEHALIS RBF TO CRIM CREEK	ABOVE CRIM CREEK
FALL-RUN CHINOOK SALMON ABUNDANCE[1] UNDER CURRENT CONDITIONS				
2-year No Action Alternative	39,415	1,198	230	198
10-year No Action Alternative	39,068	1,177	200	191
100-year No Action Alternative	39,239	1,187	180	186
FALL-RUN CHINOOK SALMON PRODUCTIVITY[2] UNDER CURRENT CONDITIONS				
2-year No Action Alternative	4.4	4.5	3.2	3.9
10-year No Action Alternative	4.4	4.4	2.7	3.6
100-year No Action Alternative	4.4	4.4	2.3	3.3
FALL-RUN CHINOOK SALMON EDT DIVERSITY[3] UNDER CURRENT CONDITIONS				
2-year No Action Alternative	81.1%	39.3%	12.7%	21.5%
10-year No Action Alternative	81.1%	38.7%	11.3%	18.5%
100-year No Action Alternative	81.1%	37.4%	11.3%	16.2%

Notes:
1. Equilibrium abundance (Neq) is the point at which the abundance curve crosses the spawner-progeny replacement line, and reflects both the quantity and quality of habitat.
2. Productivity is density-independent survival, and is the slope of the abundance line of a Beverton-Holt production function. It describes the number of juveniles that survive and return as adults to spawn per original adult spawner.
3. Diversity is the proportion of sustainable life history trajectories (productivity >= 1).

4.1.1.4 Winter Steelhead

Steelhead are distributed throughout the Chehalis River system in moderate abundance (Table 4-4). About 6% of the basin-wide steelhead equilibrium abundance was estimated to be above RBF but almost all of the current potential was in the Above Crim Creek Sub-basin; only 2% of the equilibrium abundance above RBF was in the RBF to Crim Creek Sub-basin (Table 4-4). Steelhead potential below the proposed facility site was especially low compared to the other species as a result of their life history. Winter steelhead spawn in late winter and juveniles emerge in spring and summer. The RBF to Crim Creek Sub-basin has high summer water temperature that decreased survival of fry produced in this area. This is reflected in the comparatively very low productivity and EDT diversity of steelhead in the RBF to Crim Creek Sub-basin (Table 4-4).

Table 4-4
Estimated Habitat Potential of Steelhead Under Current Habitat Conditions

	CHEHALIS BASIN	WILLAPA HILLS REGION	CHEHALIS RBF TO CRIM CREEK	ABOVE CRIM CREEK
STEELHEAD ABUNDANCE[1] (ADULT SPAWNERS) UNDER CURRENT CONDITIONS				
2-year No Action Alternative	14,527	1,655	19	817
10-year No Action Alternative	14,503	1,647	16	807
100-year No Action Alternative	14,521	1,652	15	806
STEELHEAD PRODUCTIVITY[2] (RETURNS/SPAWNER) UNDER CURRENT CONDITIONS				
2-year No Action Alternative	22.4	19.3	1.5	12.0
10-year No Action Alternative	22.4	19.3	1.4	12.0
100-year No Action Alternative	22.4	19.3	1.4	12.0
STEELHEAD EDT DIVERSITY UNDER CURRENT[3] CONDITIONS				
2-year No Action Alternative	41.1%	51.9%	7.8%	44.2%
10-year No Action Alternative	41.1%	51.6%	7.0%	43.6%
100-year No Action Alternative	41.1%	51.6%	7.0%	43.1%

Notes:
1. Equilibrium abundance (Neq) is the point at which the abundance curve crosses the spawner-progeny replacement line, and reflects both the quantity and quality of habitat.
2. Productivity is density-independent survival, and is the slope of the abundance line of a Beverton-Holt production function. It describes the number of juveniles that survive and return as adults to spawn per original adult spawner.
3. Diversity is the proportion of sustainable life history trajectories (productivity >= 1).

4.1.2 No Action Alternative in Late-Century

The results below demonstrate the predicted change in abundance for all modeled species moving from the current time period to the late-century time period, without the FRE facility. Conditions that changed from the current to late-century No Action Alternative models included the following: 1) changes in habitat due to maturation of riparian areas within managed forests; 2) changes in habitat due to land use degradation outside of managed forests; 3) changes in habitat due to implementation of early action restoration; and 4) removal of tribal injunction culverts.

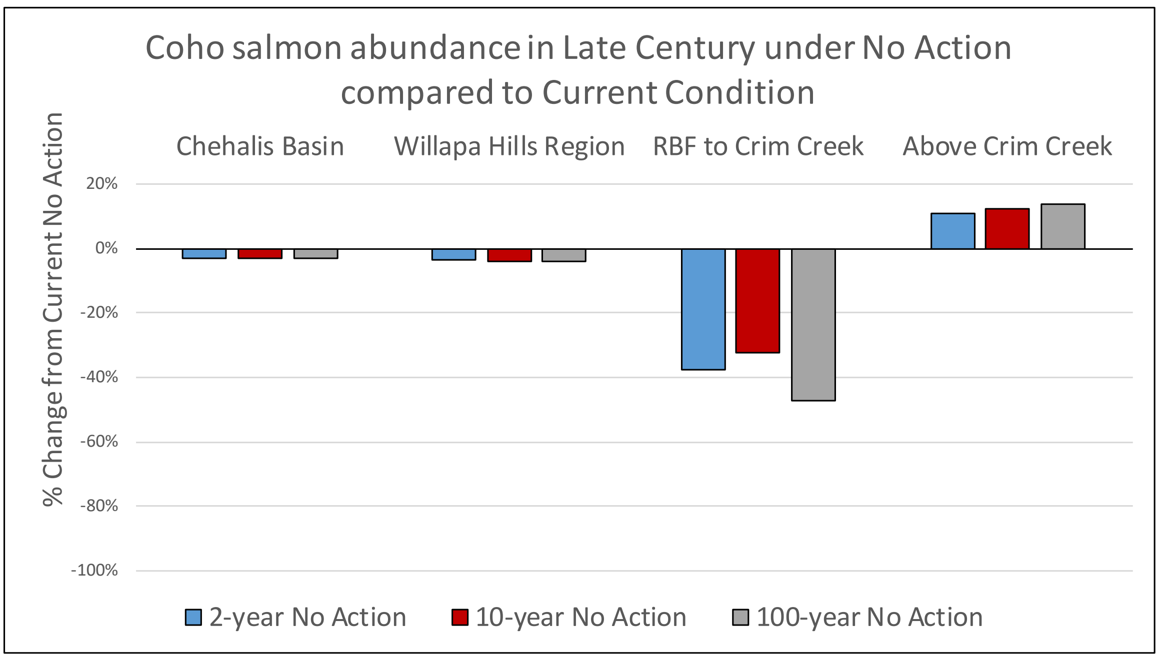
Modeled changes in abundance by late-century vary among species due to the countervailing effects of improvements (managed forests, culvert removals, restoration) and degradations (land use change). These effects vary at spatial scales that impact which species are most affected by which assumed actions. Below the facility site, land use is a mixture of managed forest, urban, and rural. The condition in the RBF to Crim Creek Sub-basin was degraded in the baseline due to assumptions regarding the effect of human population increase outside managed forest. Above

Crim Creek land use is almost entirely managed forest, and habitat conditions benefited from baseline assumptions regarding tree growth inside managed forests.

4.1.2.1 Coho Salmon

Coho salmon abundance in the No Action Alternative was estimated to decline about 3% by late-century at the basin scale. In the project area, coho salmon abundance was estimated to decline by approximately 32% to 47% in the RBF to Crim Creek area and to increase by approximately 11% to 14% above Crim Creek (Figure 4-1). Above Crim Creek late-century habitat benefited from assumed tree growth. However, in the RBF to Crim Creek Sub-basin, habitat potential declined in late-century because of the assumptions regarding human population increase.

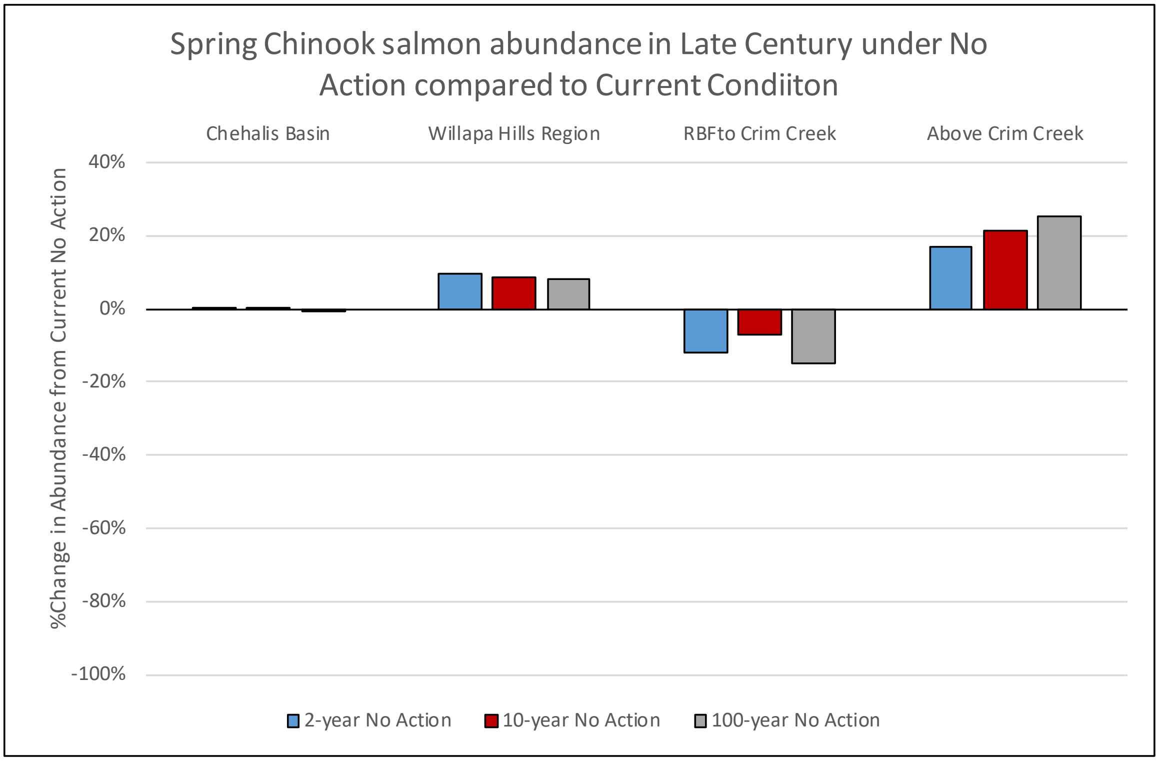
Figure 4-1
Change in Estimated Abundance of Coho Salmon in Late-Century Under No Action Alternative



4.1.2.2 Spring-Run Chinook Salmon

Impacts to spring-run Chinook salmon varied by area. At the basin-wide scale, there were no discernible changes in predicted abundance across water years (Figure 4-2). Abundance of spring-run Chinook salmon increased under all water years in the Willapa Hills Region and Above Crim Creek by late-century, while abundance was estimated to decline from RBF to Crim Creek. These varied effects are due to the implications of land use degradation versus maturation of riparian forests on spring-run Chinook salmon habitat.

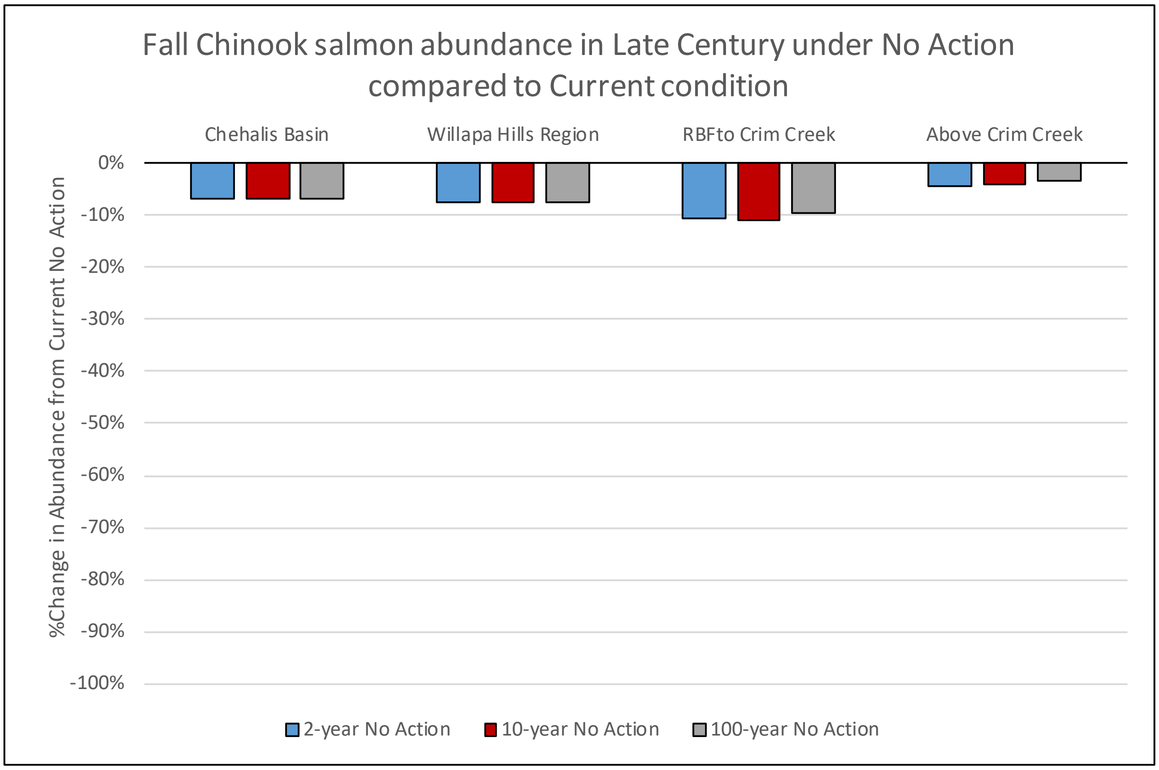
Figure 4-2
Change in Estimated Abundance of Spring-Run Chinook Salmon in Late-Century with No Action Alternative



4.1.2.3 *Fall-Run Chinook Salmon*

Fall-run Chinook salmon were predicted to decline in abundance from around 5% to 10% by late-century at all spatial scales evaluated (Figure 4-3). The differences in projected performance of the two Chinook salmon species are due to differences in their life history and exposure to adverse versus beneficial conditions. Fall-run Chinook salmon spawn in late fall and emerge in spring to emigrate in early summer. As a result, they were less affected by improvement in summer temperatures due to riparian maturation in the uppermost sub-basin.

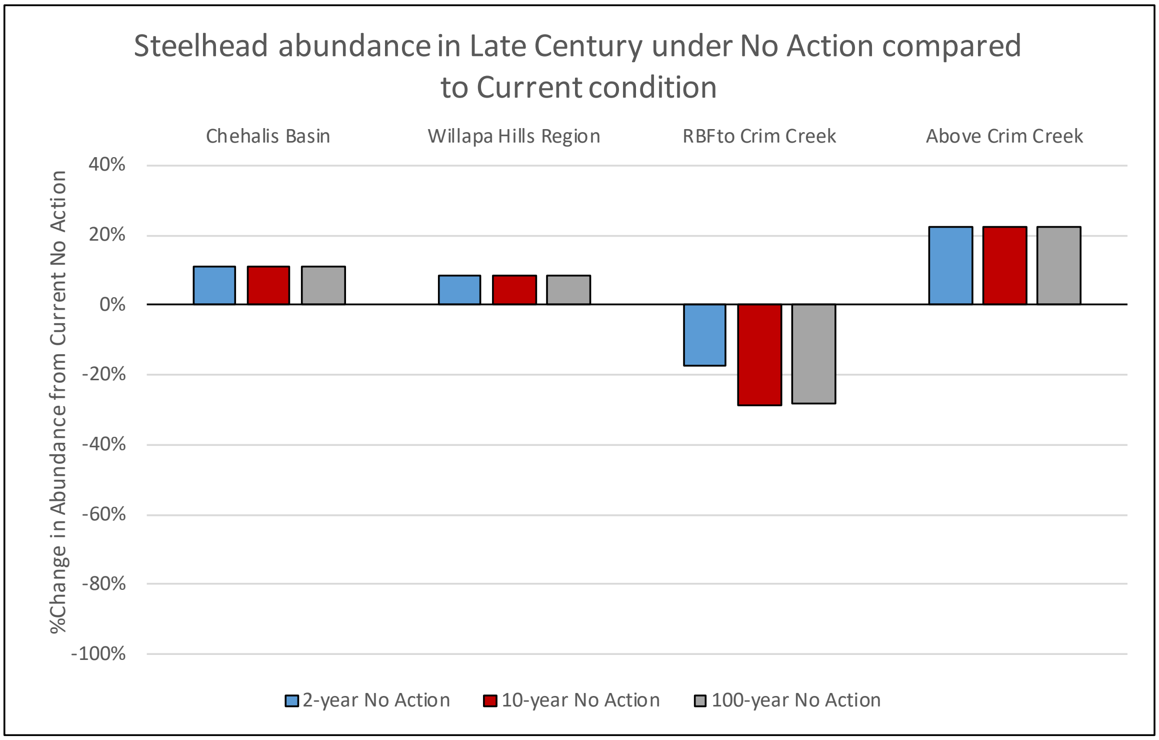
Figure 4-3
Change in Estimated Abundance of Fall-Run Chinook Salmon in Late-Century with No Action Alternative



4.1.2.4 Winter Steelhead

Steelhead were estimated to increase from 8% to 22% at all spatial scales modeled by late-century, except for the RBF to Crim Creek Sub-basin. In the RBF to Crim Creek Sub-basin, they were estimated to decline from 17% to 29% (Figure 4-4). Steelhead were estimated to increase at the basin scale because of riparian maturation in managed forests and early action restoration. Production of steelhead in the model is skewed toward the smaller headwater streams that were generally improved by maturation of riparian areas within managed forests by late-century.

Figure 4-4
Change in Estimated Abundance of Steelhead in Late-Century with No Action Alternative



4.2 Habitat Potential with the FRE Facility

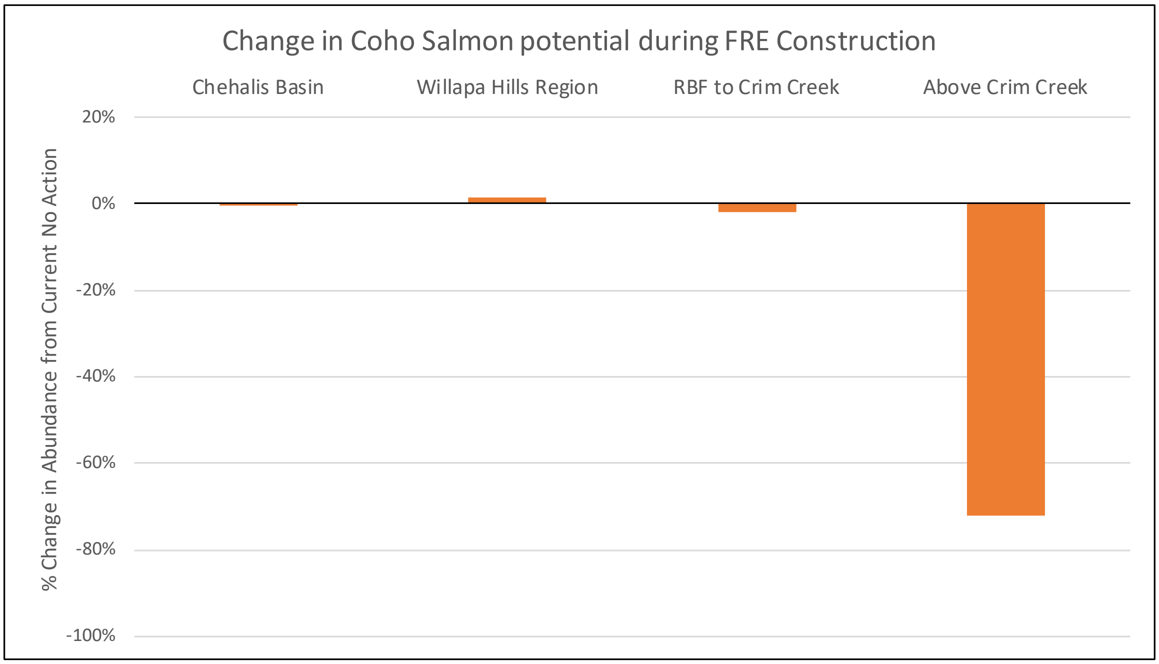
4.2.1 Construction Period

Construction of the FRE facility and temporary reservoir is projected to occur over a 5-year period (Table 3-2). Measures would be taken to move adult returning fish above the construction site and allow juveniles to pass downstream. However, it was assumed that adult fish passage survival would be appreciably lower during the construction period compared to survival after completion of the facility and fish passage facilities (Exhibit 1).

4.2.1.1 Coho Salmon

The greatest impact of construction was seen in the Above Crim Creek Sub-basin, where fish were affected by the clearing of the forest in the temporary reservoir footprint and especially by the assumed low passage survival rate (41%) at the facility site during construction. Coho salmon habitat potential in the Above Crim Creek Sub-basin declined by 72% during construction compared to the potential under the current condition (Figure 4-5). Habitat potential for coho salmon declined by about 2% below the facility site (RBF to Crim Creek) during construction due to increased water temperature.

Figure 4-5
Change in Coho Salmon Abundance During the FRE Facility Construction Period

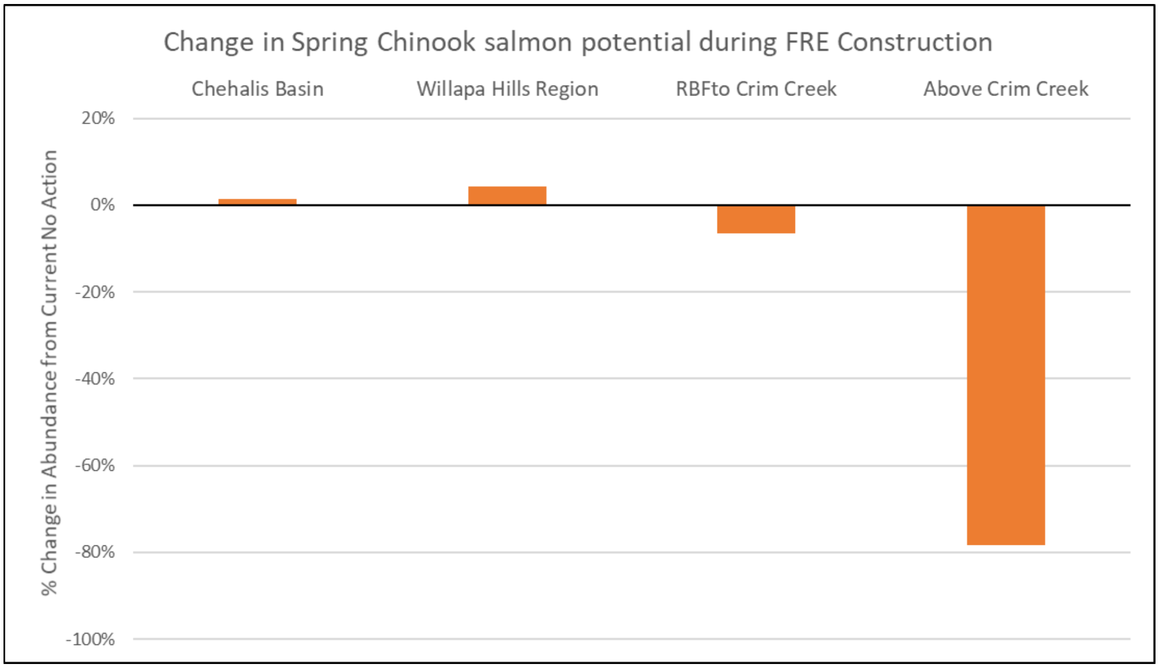


4.2.1.2 Spring-Run Chinook Salmon

While the assumed passage survival for spring-run Chinook salmon (63%) was appreciably higher than for coho salmon, equilibrium abundance for spring-run Chinook salmon in the Above Crim Creek Sub-basin declined by a similar amount during construction (Figure 4-6). In this case, the decline in spring-run Chinook salmon potential above the construction site was due to the degradation of habitat conditions within the temporary reservoir footprint, which encompassed nearly all modeled production of spring-run Chinook salmon above the facility site. The assumed habitat degradation above the facility site included an increase in summer water temperature that decreased survival of spring-run Chinook salmon during the adult holding period. A small increase in equilibrium abundance was seen in the Willapa Hills Region overall; due to changes in the flow regime and widths (an increase in capacity) with a post-contruction flow (Figure 4-6).

Current habitat potential for spring-run Chinook salmon below the facility site is very low (Table 4-2). Potential was reduced about 7% in the RBF to Crim Creek Sub-basin by the increased water temperature associated with land clearing above the facility.

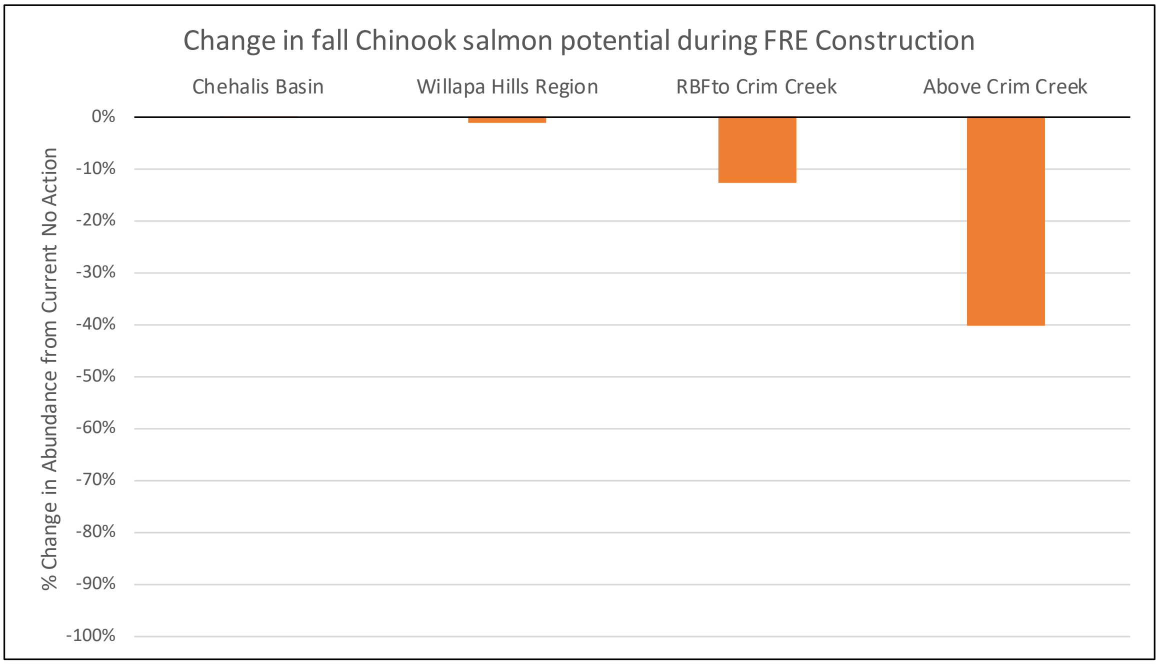
Figure 4-6
Change in Spring-Run Chinook Salmon Habitat Potential During the FRE Facility Construction Period



4.2.1.3 Fall-Run Chinook Salmon

Equilibrium abundance in the Above Crim Sub-basin for fall-run Chinook salmon declined by about 40% during the construction period, while abundance in the RBF to Crim Creek Sub-basin declined about 13% (Figure 4-7). Passage survival of fall-run Chinook salmon during construction (66%) was assumed to be similar to that of spring-run Chinook salmon and relatively high compared to the assumptions for coho salmon and steelhead. Much, but not all, of the fall-run Chinook salmon spawning above the facility site was assumed to be within the temporary reservoir footprint and affected by the degraded habitat during construction. However, because production outside the temporary reservoir footprint was unaffected during construction and because they lack the summer adult holding life stage of spring-run Chinook salmon, habitat potential of fall-run Chinook salmon was less affected by the habitat degradation associated with construction above the facility.

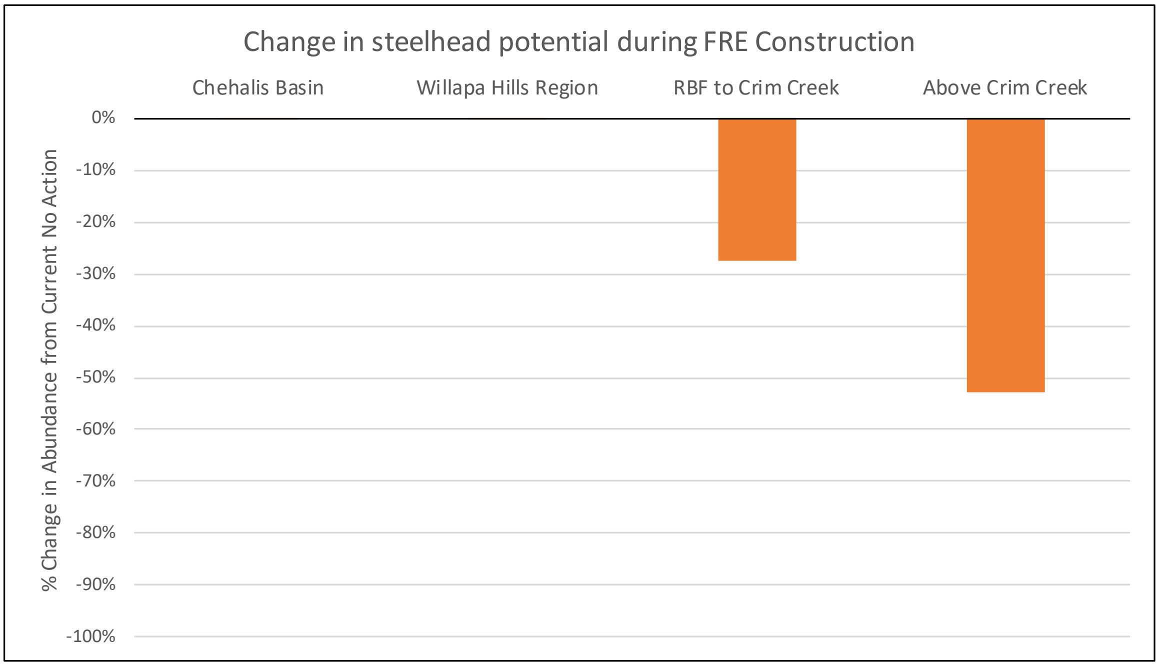
Figure 4-7
Change in Fall-Run Chinook Salmon Equilibrium Abundance During the FRE Facility Construction Period



4.2.1.4 Winter Steelhead

Equilibrium abundance for steelhead Above Crim Creek was decreased during construction by about 53% compared to potential under the current condition (Figure 4-8). Assumed passage survival for steelhead during construction (45%) was slightly better than for coho salmon, accounting for the lesser impact of construction. Equilibrium abundance for steelhead below the facility site was very low and reduced further by about 27% due to the increase in water temperature.

Figure 4-8
Change in Steelhead Equilibrium Abundance During the FRE Facility Construction Period



4.2.2 FRE Facility in Late-Century Compared to No Action Alternative in Late-Century

At a basin-wide scale, late-century changes in equilibrium abundance for the four modeled species were minimal when comparing late-century FRE facility results with late-century No Action Alternative results (from a 0% change to an average 1.06% change across water years). Figures 4-9 and 4-10 address how the FRE facility changed the estimated equilibrium abundance for the four species in late-century relative to the late-century No Action Alternative in the project area.

Figure 4-9
RBF to Crim Creek: Change in Equilibrium Abundance for Coho Salmon, Spring-Run Chinook Salmon, Fall-Run Chinook Salmon, and Steelhead with FRE Facility Implementation in Late-Century

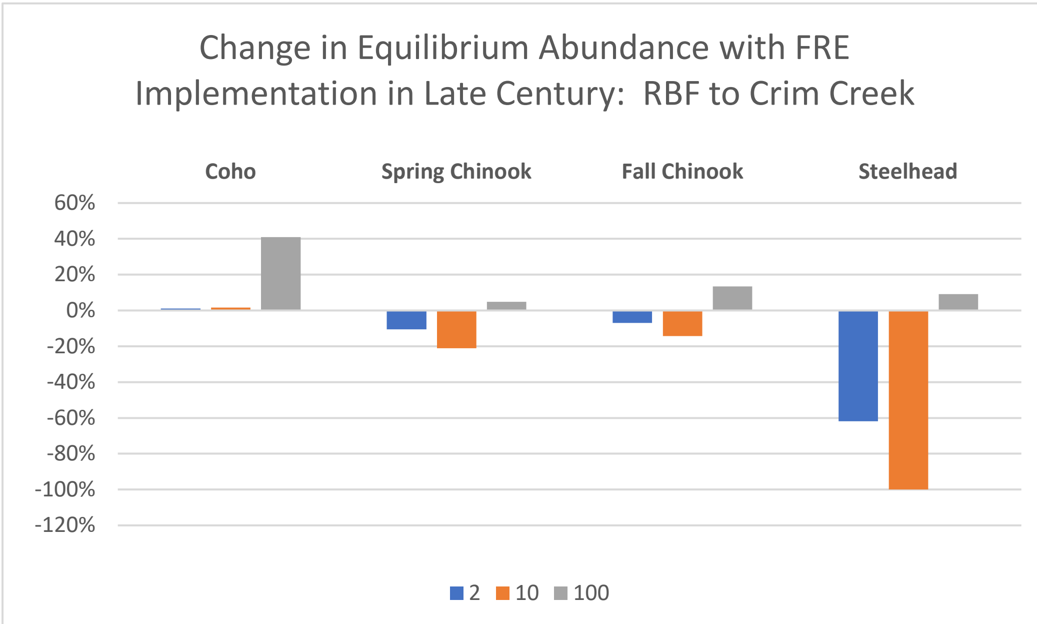
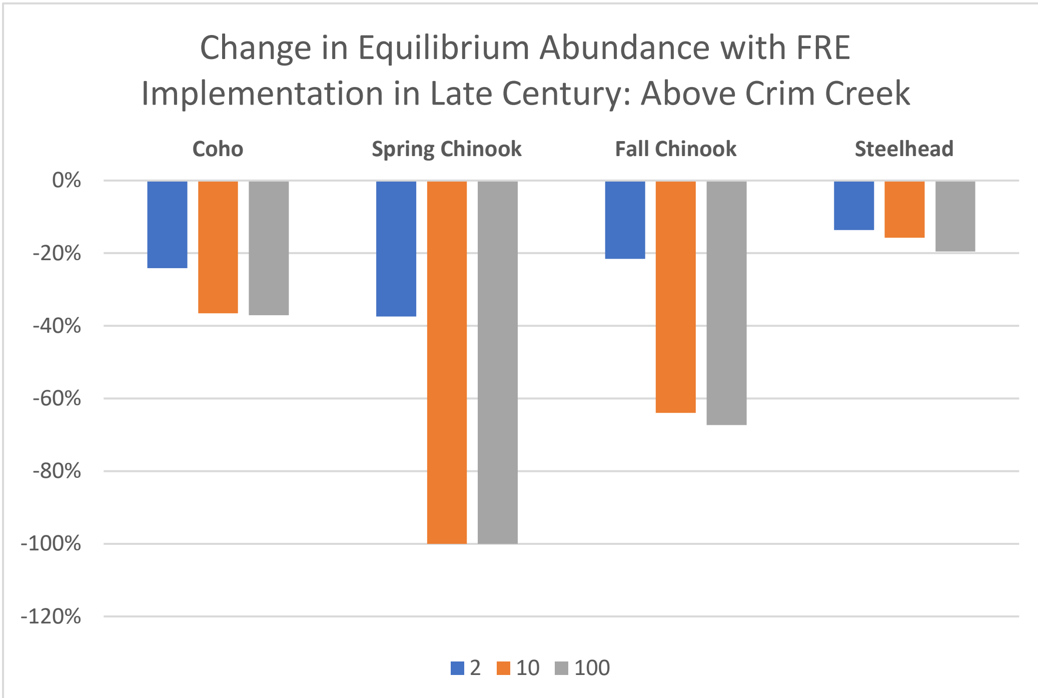


Figure 4-10
Above Crim Creek: Change in Equilibrium Abundance for Coho Salmon, Spring-Run Chinook Salmon, Fall-Run Chinook Salmon, and Steelhead with FRE Facility Implementation in Late-Century



From RBF to Crim Creek, the effect of FRE facility implementation in late-century on equilibrium abundance varied depending on the species and water year modeled. Interestingly, all species increased with the FRE facility under a 100-year flood condition. This result was due to the reduced bed scour modeled downstream of the structure (assumed due to flood attenuation). Most species declined in the 10-year scenario (less reduction in scour; effects of FRE facility temperatures and other habitat degradation downstream of the proposed structure; Figure 4-9).

Above Crim Creek, all species declined in equilibrium abundance in late-century with implementation of the FRE facility as compared to the No Action Alternative. This decline generally increased across water years (from current to mid- to late-century). This is due to the habitat degradation modeled in the temporary reservoir footprint both during and outside of the 10-year and 100-year flood conditions due to management of land in the project area footprint (Figure 4-10).

4.2.2.1 FRE Facility in Late-Century Compared to Current Conditions

Figures 4-11 through 4-14 examine the impacts of the late-century FRE facility as compared to current No Action Alternative. Coho salmon are predicted to decline by up to 37% in late-century with the FRE facility as compared to current No Action Alternative conditions at all spatial scales evaluated (Figure 4-11). However, without the FRE facility, the abundance was predicted to also decline at all spatial scales evaluated except for Above Crim Creek in late-century (Figure 4-1). The one sub-basin that was expected to improve in late-century (Above Crim Creek) due to riparian maturation in managed forests is expected to decline if the FRE facility is implemented due to habitat degradation in the project area.

Spring-run Chinook salmon are predicted to decline in the project area in late-century compared to the current abundance with FRE facility implementation (Figure 4-12), and are predicted to be completely eliminated Above Crim Creek under flood year conditions. This is because all spawning for spring-run Chinook salmon above Crim Creek was assumed to occur in the mainstem Chehalis River within the footprint of the 10-year flood reservoir. Without the FRE facility, spring-run Chinook salmon were predicted to increase Above Crim Creek in late-century due to baseline changes (Figure 4-2).

Much of the fall-run Chinook salmon spawning above Crim Creek (66%) was assumed to occur within the temporary reservoir footprint. However, a portion of fall-run Chinook salmon spawning was above the temporary reservoir footprint, resulting in some production during FRE facility closure events (Figure 4-13). Fall-run Chinook salmon were predicted to decline in abundance under almost all water year conditions and at most spatial scales by late-century with FRE facility implementation (Figure 4-13). By late-century without FRE facility implementation, fall-run Chinook salmon were estimated to decline in abundance at all spatial scales modeled and under all water year conditions (Figure 4-3). The increase from RBF to Crim Creek predicted with the FRE facility under 100-year flood conditions (Figure 4-13) is due to decreased bed scour from assumed flood attenuation at the proposed structure.

Steelhead salmon are predicted to increase in abundance at a basin-wide scale in late-century with FRE facility implementation (Figure 4-14). This result is primarily due to spawning conditions in upper watershed managed forest reaches that are predicted to improve by late-century. Steelhead only have 30% of their Above Crim Creek spawning occurring in the temporary reservoir footprint area, and they also spawn later than many of the other modeled species, such that their spawning period avoids the predicted timing of temporary reservoir formation behind the proposed structure (i.e., after February). While predicted to increase at a basin-wide scale, steelhead are predicted to have a steep decline in abundance in the RBF to Crim Creek area due to habitat degradation from the FRE facility combined with land use degradation (Figure 4-14). Steelhead are estimated to decline at this spatial scale without the FRE facility by late-century (Figure 4-4). Above Crim Creek, the FRE facility implementation reduces the benefits steelhead would experience from riparian maturation in managed forest reaches (Figure 4-4 and Figure 4-14).

Figure 4-11
Change in Abundance of Coho Salmon in Late-Century with the FRE Facility

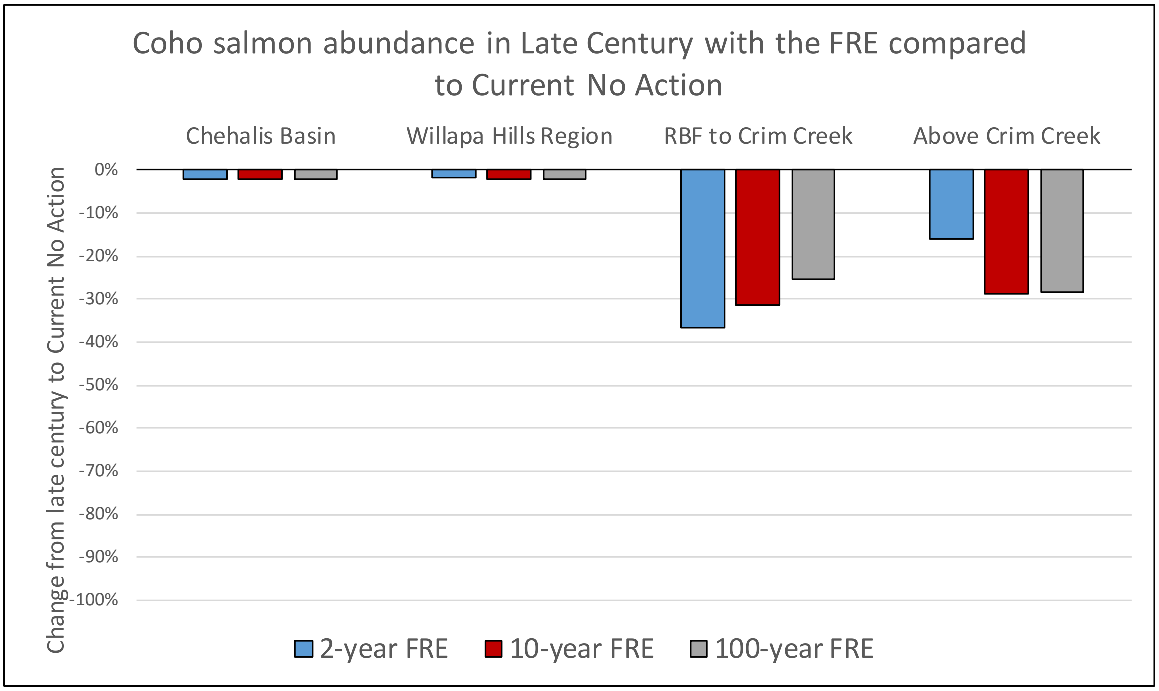


Figure 4-12
Change in Abundance of Spring-Run Chinook Salmon in Late-Century with the FRE Facility

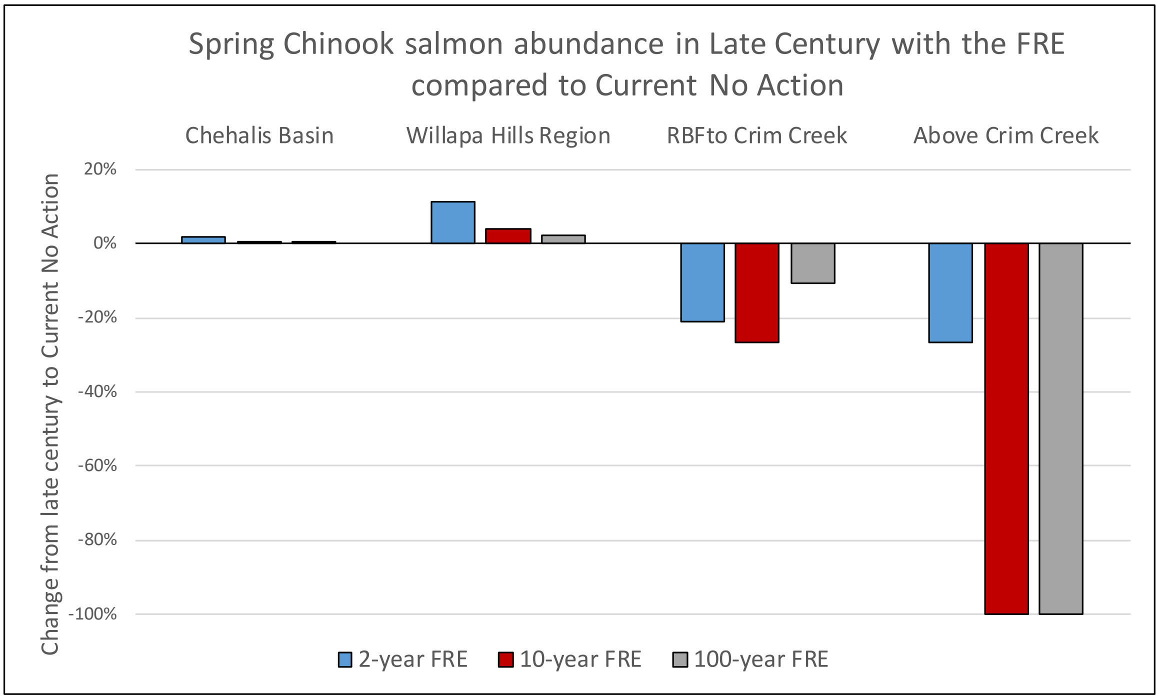


Figure 4-13
Change in Abundance of Fall-Run Chinook Salmon in Late-Century with the FRE Facility

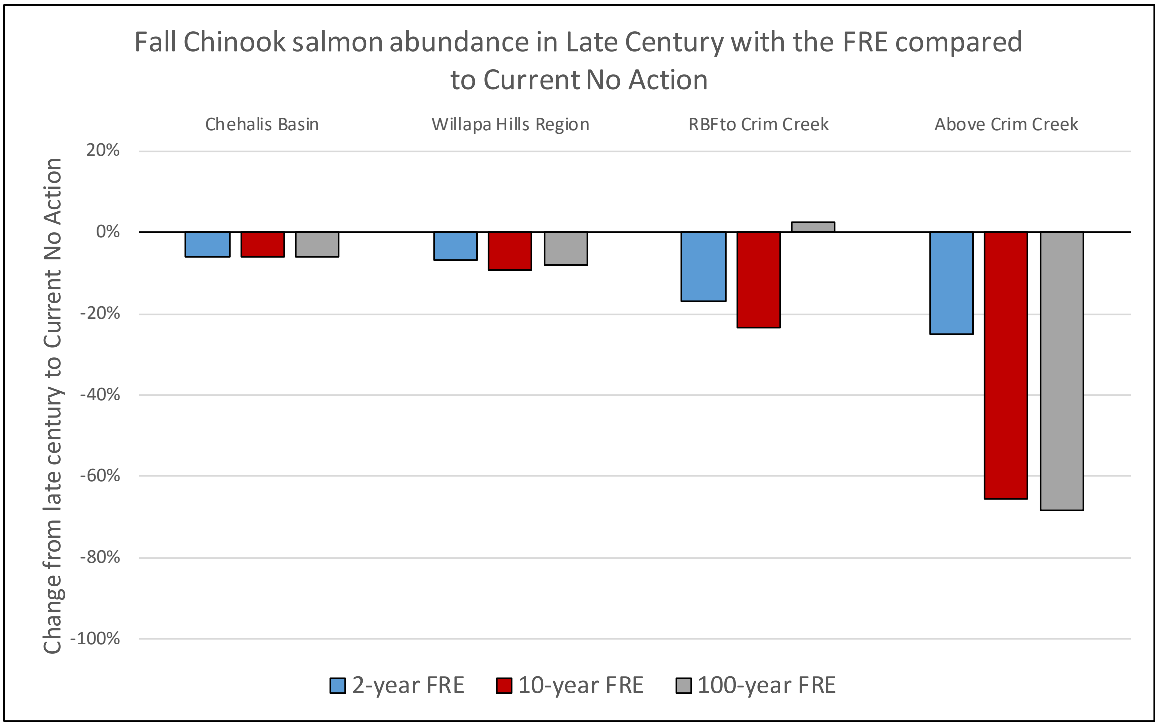


Figure 4-14
Change in Abundance of Steelhead in Late-Century with FRE Facility

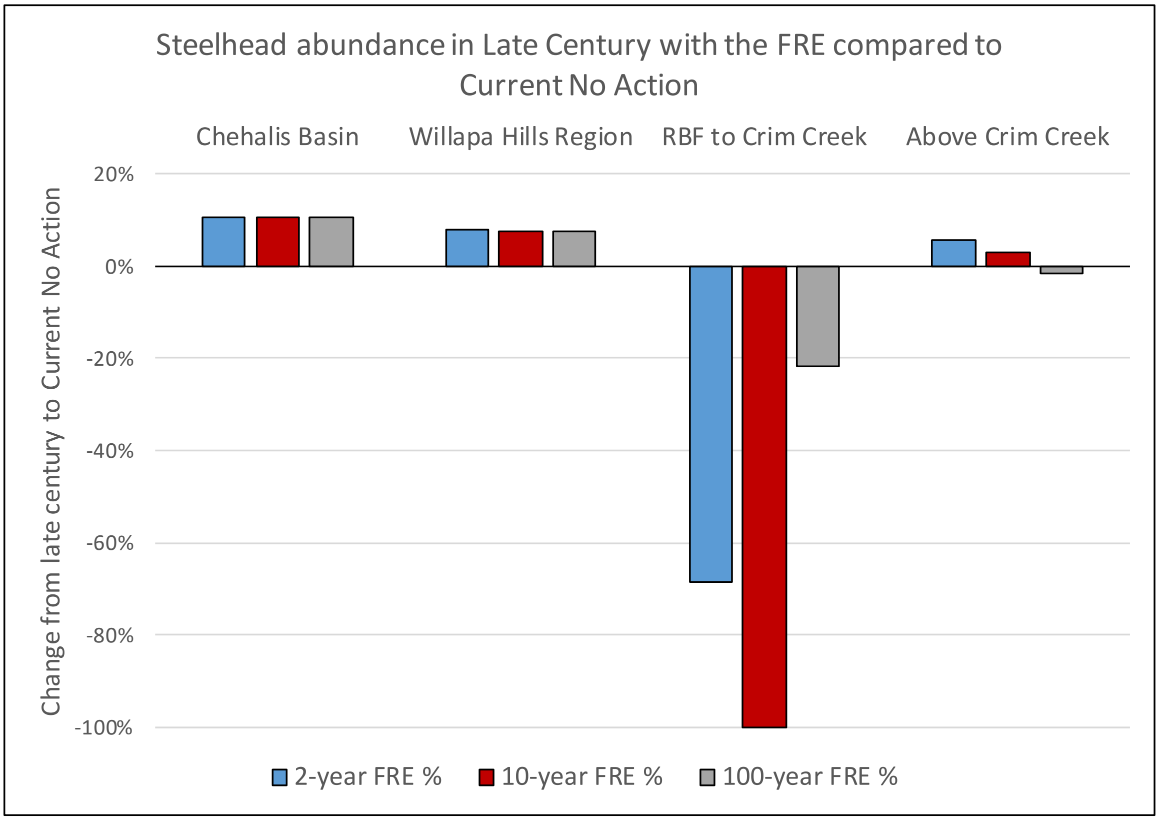
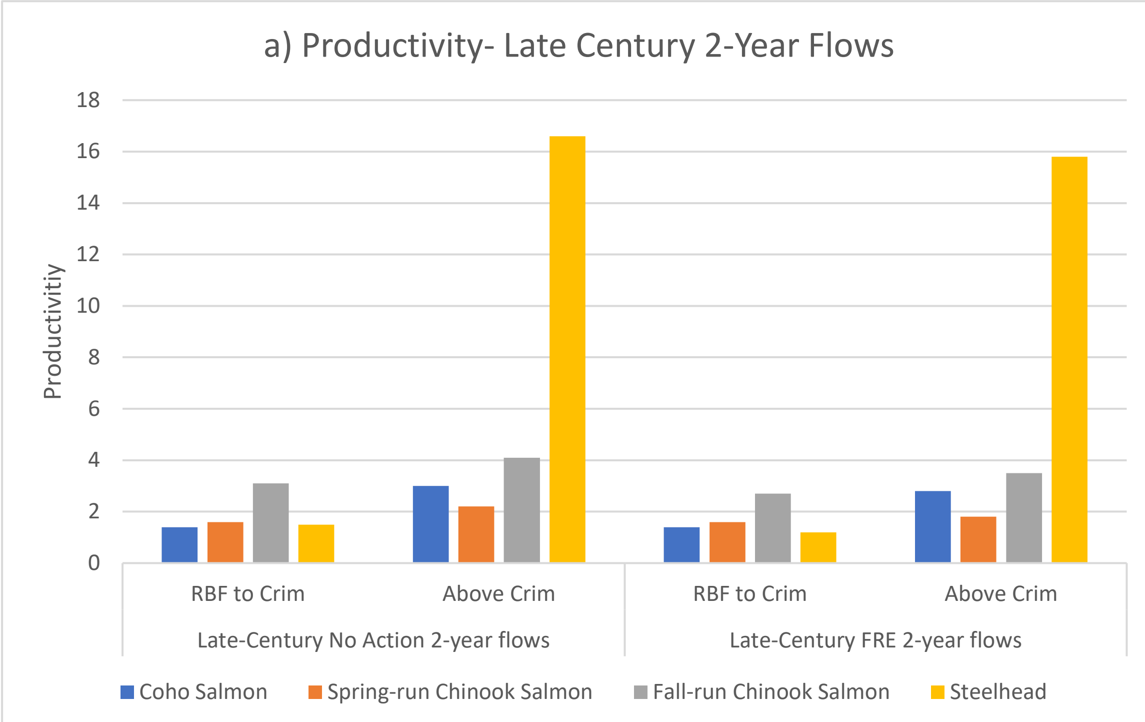


Figure 4-15 reports productivities associated with modeled species in late-century in the project areas (RBF to Crim Creek and Above Crim Creek) under No Action Alternative and FRE facility scenarios, and under 2- and 100-year flood flow years; modeled productivities for 10-year flows are reported in Exhibit 2. For all scenarios except late-century FRE 100-year flows, productivity of all species is higher in the Above Crim Sub-basin than in RBF to Crim Creek (Figure 4-15), indicative of its generally higher habitat quality. The Above Crim Creek Sub-basin is also modeled to reflect more benefits of riparian maturation in managed forests by late-century than the RBF to Crim Creek Sub-basin. Under the late-century 100-year flood flow scenario with the FRE facility, productivity is higher for Chinook salmon in the RBF to Crim Creek area than Above Crim Creek because of the high percent of spawning area for Chinook salmon above Crim Creek, and the impact of habitat degradation in the proposed project footprint.

In the RBF to Crim Creek area, the lowest productivities were most often associated with the late-century No Action Alternative 100-year flood (Figure 4-15). The productivities of No Action Alternative as compared to FRE facility are generally lower for the flood scenarios because the FRE facility was assumed to reduce bed scour due to flood attenuation. Under the 2-year flood flow scenarios, productivities remained the same with and without the FRE facility in the RBF to Crim Creek Sub-basin for coho salmon and spring-run Chinook salmon, but decreased for fall-run Chinook salmon and steelhead (Figure 4-15). This is likely due to modeled downstream temperature effects from vegetation removal in the reservoir footprint of the FRE facility.

In the Above Crim Creek Sub-basin, productivities declined for all species in late-century when comparing results of FRE facility implementation with No Action Alternative model results within the same flow year (Figure 4-15). This is because of the degradation of habitat in the footprint area of the project, as well as reduced fish passage through the FRE conduits as compared to the no-action alternative (Exhibit 1, Table 2).

Figure 4-15
Productivities for Modeled Species in Late-Century Project Areas with and Without the Modeled FRE Facility and Under 2-Year (panel a) and 100-Year (panel b) Flood Flow Conditions



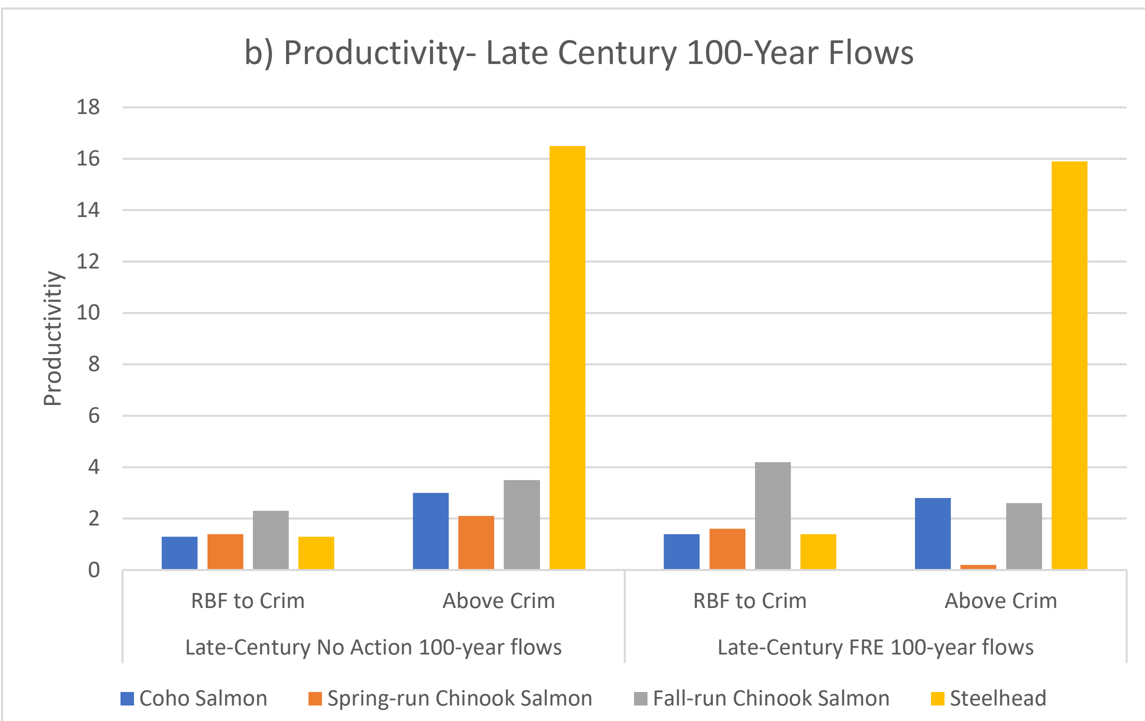
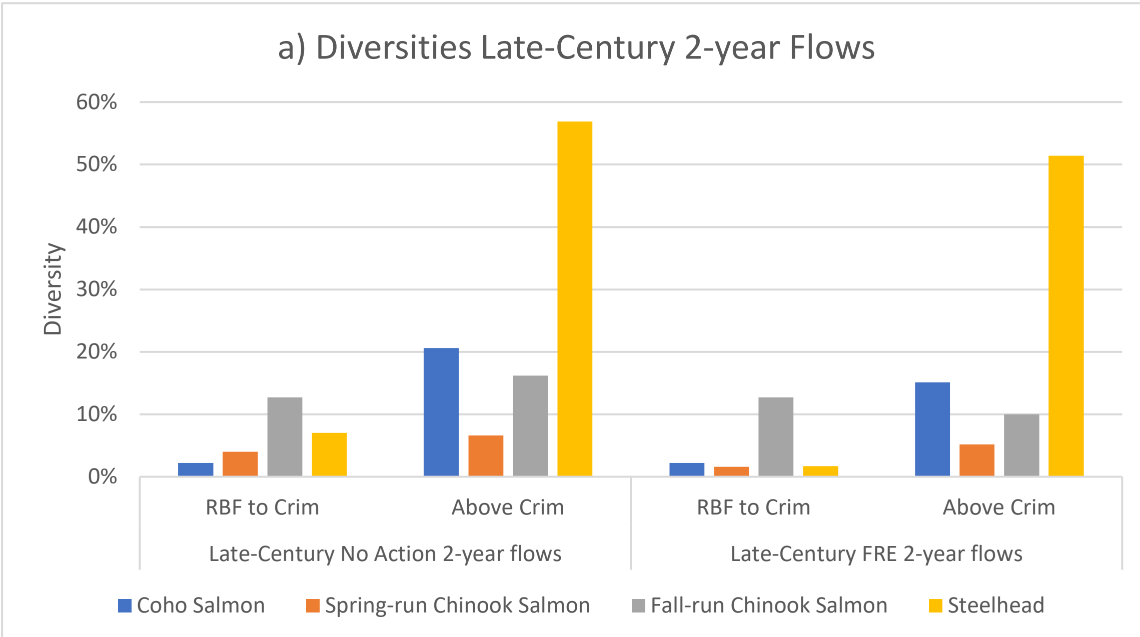
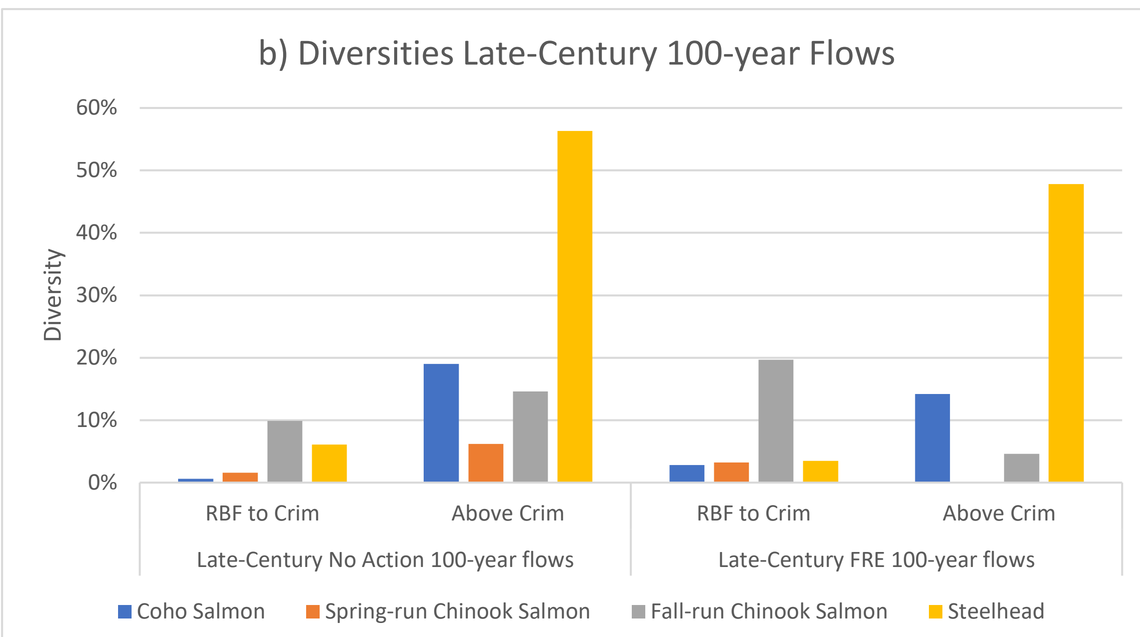


Figure 4-16 reports EDT diversities associated with modeled species in late-century in the project areas (RBF to Crim Creek and Above Crim Creek) under No Action Alternative and FRE facility scenarios, and under 2- and 100-year flood flows. Under a 2-year flow scenario, all species in the project areas have lower EDT diversity for the FRE facility scenario compared to a No Action Alternative scenario in late-century. The changes in habitat both upstream and downstream of the proposed structure limit the life history and spawning location combinations of species that are successful, overall reducing spatial diversity of suitable habitat for all species under average flow conditions.

The 100-year flood flow scenario demonstrates a more complicated pattern in EDT diversity responses across species modeled in the project area. Almost all species are predicted to increase in EDT diversity from RBF to Crim Creek Sub-basin when the FRE facility is implemented in a 100-year flood year in late-century. This is most likely due to the reduced bed scour modeled in late-century in this area due to flood attenuation by the proposed project. However, steelhead abundance declines under this scenario with the FRE facility, likely due to degradation of other habitat elements (e.g., a reduced riparian buffer along the river, reduced large wood). In the Above Crim Creek Sub-basin, all species are predicted to decline in EDT diversity in late-century in 100-year flood years when the FRE facility is implemented. This can be attributed to habitat degradation in the project area footprint as well as reduced fish passage with an implemented FRE (as compared to no FRE). Fall-run Chinook salmon diversity is reduced to approximately one-third of the successful life history and spawning area combinations they would have above Crim Creek with implementation of the FRE facility, and spring-run Chinook salmon populations completely fail (Figure 4-16).

Figure 4-16
Diversities for Modeled Species in Late-Century Project Areas with and Without the Modeled FRE Facility and Under 2-Year (panel a) and 100-Year (panel b) Flood Flow Conditions





5 MODEL UNCERTAINTY AND VALIDATION

The EDT model is calibrated to each species-watershed at a few levels. These include: 1) ensuring that current conditions and historic conditions in the model are characterized as accurately as possible with the most up-to-date information, 2) reviewing spawning locations and life history data for fish species in the basin and updating the model with the most recent information, and 3) calibrating ocean survival for species that results in realistic current population size estimates (this adjusts the results of the model to current conditions, which can then be realistically compared to alternate scenarios).

Updating current conditions in the model is a data-intensive process, which involves communicating with local watershed groups, agencies, and experts to ensure that recent monitoring data (for example, large wood or temperature modeling) are incorporated and reviewed against previous characterization in the model. This process also involves using modeled data, for example, data from a spatial stream network model, where empirical data are not available continuously or for all reaches within a basin. Updating current conditions in the model can also involve predictive hypotheses, whereby actions that have occurred (restoration actions, new development) since the last time the model was run are translated into updates about the habitat in the model. Likewise, updates to fish species life histories include reviewing recent information on salmonid species in the basin, communicating with local experts, and updating modeled life histories. Modes of data derivation and certainty are described in metadata for scenarios in the EDT model.

Updates to ocean survival occur by adjusting marine survival rates to those that produce a reasonable predicted equilibrium abundance size under current conditions as compared to those observed. Once this calibration is complete, the modeled evaluation of habitat conditions under alternate scenarios can be considered accurate as relative to current conditions. For any species, ocean survivals in EDT are characterized to be the same across all model runs within a watershed. However, because the trajectories express a variety of life histories and the population performance output is weighted by trajectory success, smolt-to-adult returns (SARs) as reported by EDT can vary somewhat from scenario to scenario even with the same ocean survival values. Average SARs across all scenarios and sub-basins for species modeled in NEPA (as measured from the Wishkah confluence) were 14% for coho salmon, 3% for fall-run Chinook salmon, 3% for spring-run Chinook salmon, and 29% for winter steelhead.

Table 5-1 demonstrates how the Chehalis EDT NEPA No Action Alternative current condition results compare to run sizes estimated by WDFW from 2009 to 2018 (Scharpf 2019).

Table 5-1
Basin-Wide Equilibrium Abundance Predicted by EDT Compared to WDFW Estimates

SPECIES	CHEHALIS EDT NEPA NO ACTION CURRENT CONDITIONS PREDICTED EQUILIBRIUM ABUNDANCE	ESTIMATED MIN/ AVERAGE/ MAXIMUM RUN SIZE (WDFW) 2009-2018
Coho Salmon	74,200	28,545/ 71,787/ 128,525
Spring-run Chinook Salmon	1,176	528/ 1,749/ 3,495
Fall-run Chinook Salmon	39,415	8,264/ 13,782/ 21,474
Steelhead	14,527	5,622/ 8,657/ 12,352

Coho salmon abundance as predicted by EDT falls near the current estimated average run size. Spring-run Chinook salmon abundance falls slightly lower than current average estimated run size. Predicted abundances for both fall-run Chinook salmon and steelhead are above the current estimated maximum run size. This reflects a high smolt to adult return (SAR) value and perhaps the juvenile age composition assumed in this analysis. The implications are that all scenarios modeled for fall-run Chinook salmon and steelhead may be predicted to be higher than would actually occur under these scenarios at a basin-wide scale. However, relative to each other the scenarios provide realistic and useful results. Recent information provided by WDFW indicates that steelhead in the Chehalis Basin may predominantly spend 1 and 2 years in freshwater, while this analysis assumed they spend predominantly 2 and 3 years in freshwater. This information is still under review and it is not yet determined whether the model will be updated.

While there is uncertainty in the parameters used to define the changing No Action Alternative NEPA baseline over time, the impact analysis reported here is best understood as a relative comparison of No Action versus FRE scenario. Uncertainty in the modeled baselines includes maturation of riparian areas in managed forests as well as land use degradation and early action restoration projects in five sub-basins. However, climate change modeling was not included in this EDT model. Climate change is expected to cause warmer temperatures especially in summer months in many areas of the Chehalis Basin, as well as shift the precipitation and flow regime toward flashier winters, early springs, and drier summers (Mauger et al. 2016). Including climate change predictions in the mid- and late-century scenarios would dramatically alter species responses across the basin and might change conclusions about effects of the proposed project on the four modeled salmonid species. There is also inherent uncertainty in the details of how land use degradation and riparian maturation in managed forests may affect Chehalis Basin habitat, given that management regimes and land use practices and laws may change in the future.

6 CONCLUSIONS

The Chehalis Basin ecosystem is integrally important in the Pacific Northwest as the largest river basin entirely in Washington state, supporting a multitude of native aquatic and riparian species. The purpose of this analysis was to examine potential effects of a proposed flood control structure on anadromous salmonid habitat in the Chehalis Basin, to support a NEPA EIS process. While this analysis was focused on potential effects on habitat for salmonids, it can also be used to consider potential effects on several species that are directly or indirectly affected by success of salmonid populations or similar healthy aquatic habitat. Species that directly depend on salmonids for their development (e.g., freshwater mussels) or as a food source (e.g., bears, orcas, eagles) are directly impacted by improvement or degradation of salmon populations. Additional species are affected due to shifts in food chains and shifts in environmental nutrients provided by salmon carcasses (marine-derived nutrients). This report discusses the predicted impacts of the proposed structure on four native salmonids, with the caveat that implications for additional species should be considered.

The four species/runs of salmonids evaluated in terms of habitat change are coho salmon, spring-run Chinook salmon, fall-run Chinook salmon, and steelhead. These four species have spawning areas in the Chehalis Basin that are both within and outside of the proposed project area. Of the four species, spring-run Chinook salmon and steelhead have the highest percentage of potential spawning habitat within the project area (about 10% of potential spawning habitat for spring-run Chinook salmon and about 6% of potential spawning habitat for steelhead).

The construction period, while only 5 years, could have a long-lasting impact on the modeled species due to its low passage survival rates and degraded habitat. Indeed, all species were predicted to decline by large percentages above the proposed structure during the construction period. In the project area Above Crim Creek, coho salmon abundance is predicted to decline 72%, spring-run Chinook salmon abundance to decline almost 80%, fall-run Chinook salmon abundance to decline 40%, and steelhead abundance to decline 53% during the construction period. The limitations placed on species during the construction period, and the reduction in spatial diversity of successful spawning areas and life histories, could create a bottleneck, especially on the most sensitive species such as spring-run Chinook salmon.

Effects of the proposed project on salmonid habitat by late-century were modeled in comparison to a baseline condition without the project. The NEPA baseline assumed that current climate conditions would prevail through late-century and that tree growth in managed forest areas above the facility (Above Crim Creek) would improve conditions by late-century relative to the current condition. The baseline also assumed that an increase in human population in the Chehalis Basin would degrade conditions outside managed forest including the area below the facility within the project area (RBF to Crim Creek). The FRE facility was evaluated for late-century in the context of these varied conditions within the project area both with and without the proposed flood control structure. In the NEPA baseline, by late-century, predictions of abundance changes varied among species due to the countervailing effects of habitat improvements (riparian maturation in managed forests, early action restoration, culvert removals) versus habitat degradations (land use impacts). Without the proposed structure, by late-century (and according the NEPA No Action Alternative baseline), the abundance of three of the four evaluated species was predicted to increase in the project area Above Crim Creek. Abundances of most species were already predicted to be low in the lower RBF to Crim Creek portion of the project area due to comparatively less suitable habitat, and abundances were generally negatively impacted by late-century due to impacts of land use degradation.

In late-century with the proposed FRE structure, all species under all modeled water years were predicted to decline in abundance in the project area Above Crim Creek. Spring-run Chinook salmon were completely wiped out in this portion of the project area during 10- and 100-year flood flow years. For all modeled species, habitat potential in the Above Crim Creek Sub-basin was significantly reduced by implementation of the proposed FRE structure. By late-century, the Above Crim Creek Sub-basin was predicted to improve in habitat conditions because of riparian maturation for three of the four modeled species, and this benefit would be lost by FRE facility implementation. For the one species not predicted to increase in this area in late-century (fall-run Chinook salmon), the decline in abundance is predicted to be greater with FRE facility implementation than without in late-century. EDT diversity of all species was indicated to decline in the project area in late-century with FRE facility implementation under average flow conditions, reducing the potential life history configurations and successful spawning areas for all species.

Variable effects were seen in the RBF to Crim Creek portion of the project area with implementation of the FRE facility, primarily due to the modeled reduction in bed scour in flood years due to flood flow attenuation at the proposed structure. However, this area was not predicted to be important in sustaining spawning runs of most species, especially as compared to the Above Crim Creek Sub-basin.

Overall, the EDT model predicts that the FRE structure would have significant negative impacts on all four modeled species in the upper watershed (Above Crim Creek), and especially on spring-run Chinook salmon. While at a basin-wide scale impacts are predicted to be minimal for most modeled species, it should be considered that the upper watershed Above Crim Creek is currently beneficial salmonid habitat that can provide a buffer against future potential degradation, including climate change effects that were not included in this NEPA analysis, in the watershed.

7 REFERENCES

Aquatic Species Restoration Plan Steering Committee. 2019. *Chehalis Basin Strategy Aquatic Species Restoration Plan. Phase I: November 2019.* Publication No. 19-06-009.

Ashcraft, S., C. Holt, M. Scharpf, M. Zimmerman, and N. Vanbuskirk. 2017. *Spawner Abundance and Distribution of Salmon and Steelhead in the Upper Chehalis River, 2013-2017*. Olympia, WA: Washington Department of Fish and Wildlife.

Blair, G. R., L. C. Lestelle, and L. E. Mobrand, 2009. The Ecosystem Diagnosis and Treatment Model: A Tool for Assessing Salmonid Performance Potential Based on Habitat Conditions. E.E. Knudsen, editor, *Pacific Salmon Environment and Life History Models.* Bethesda, MD: American Fisheries Society; pp. 289–309.

Hill, Adam (Anchor QEA, LLC), 2019. Email to: Chip McConnaha (ICF). Regarding: Updated Chehalis River HEC-RAS Results. April 1, 2019.

Lestelle, L.C., L.E. Mobrand, and W.E. McConnaha, 2004. *Information Structure of Ecosystem Diagnosis and Treatment (EDT) and Habitat Rating Rules for Chinook Salmon, Coho Salmon, and Steelhead Trout.* Mobrand Biometrics, Inc.

Mauger, G. S., S. Lee, C. Bandaragoda, Y. Serra, and J. Won, 2016. *Effect of Climate Change on the Hydrology of the Chehalis Basin.* Seattle: University of Washington, Climate Impacts Group.

McConnaha, Chip (ICF), and John Ferguson (Anchor QEA, LLC), 2019. Personal communication. Regarding: Parameterizing Bed Scour in the Chehalis EDT Model. September 9, 2019.

McConnaha, W., J. Walker, K. Dickman, and M. Yelin, 2017. *Analysis of Salmonid Habitat in the Chehalis Basin Using EDT.* Volume 1: Methods. Seattle, Washington: Anchor QEA.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt, 2000. *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units.* U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-42.

Mobbs, Mark (Quinault Indian Nation), 2019. Personal Communication with Willis McConnaha (ICF). January 23, 2019.

Moussalli, E., and R. Hilborn, 1986. "Optimal stock size and harvest rate in multistage life history models." *Canadian Journal of Fisheries and Aquatic Sciences* 43(1): 135-141.

Scharpf, Mike (Washington Department of Fish and Wildlife), 2019. Personal communication with Chip McConnaha (ICF). Regarding: Spreadsheet of Chehalis Basin Recent Salmonid Returns. August 8, 2019.

Van Glubt, S., C. Berger, and S. Wells, 2017. *Technical Memorandum: Chehalis Water Quality and Hydrodynamic Modeling: Model Setup and Preliminary Calibration and Scenario Development.* Portland State University and Washington Department of Ecology.

Watershed GeoDynamics, 2017. *Chehalis Basin Strategy: Geomorphology, Sediment Transport and Large Woody Debris Report.* Seattle, Washington: Anchor QEA.

Winkowski, J., 2019. *Development and Methods of the Chehalis Thermalscape Model*.

Exhibit 1
Adult and Juvenile Fish Passage Assumptions at the FRE Facility

Table 1

Proposed Project Environmental Impact Statement Juvenile Downstream Migrant Survival Estimates

SPECIES	CONSTRUCTION	OPERATIONS – NON FLOOD RETENTION
Spring-run Chinook Salmon	0.85	0.85
Fall-run Chinook Salmon	0.85	0.85
Coho Salmon	0.85	0.85
Steelhead	0.95	0.95

Table 2

Estimated Adult Salmonid Passage Effectiveness during FRE Facility Operations (2030-2080)

SPECIES/RUN	NON-FLOOD RETENTION[1]	FLOOD RETENTION[2]
Spring-run Chinook Salmon	0.94	0.90
Fall-run Chinook Salmon	0.94	0.90
Coho Salmon	0.94	0.90
Steelhead	0.96	0.90

Table 3

Estimated Adult Salmonid Passage Effectiveness during FRE Facility Construction (2025 to 2030)

SPECIES/RUN	TRAPPING EFFICIENCY (INCLUDING EFFECTS OF FISH MOVING DOWNSTREAM FROM WEIR)	HANDLING AND TRANSPORT TRUCK LOADING SURVIVAL	TRANSPORT, RELEASE, AND DELAYED MORTALITY	CUMULATIVE FISH PASSAGE EFFECTIVENESS (SURVIVAL)
Spring-run Chinook Salmon	0.85	0.98	0.81	0.63
Fall-run Chinook Salmon	0.80	0.98	0.90	0.66
Coho Salmon	0.45	0.98	0.99	0.41
Steelhead	0.50	0.98	0.99	0.45

Exhibit 2
EDT Results for the NEPA FRE
Facility Analysis

NEPA FRE Analysis Results for Coho: 09.02.19 fine sediment correction

No Action

No Action Current	Current Conditions			
Current Conditions	Chehalis Basin	Willapa Hills Region	RBF to Crim Creek	Above Crim Creek
2-year No Action	74,200	4,049	91	820
10-year No Action	73,675	4,020	82	805
100-year No Action	73,858	4,021	73	793

No Action Mid-Centur	Mid-Century			
Mid-Century Conditions	Chehalis Basin	Willapa Hills Region	RBFto Crim Creek	Above Crim Creek
2-year No Action	76,553	4,082	83	845
10-year No Action	77,746	4,245	82	901
100-year No Action	77,930	4,244	72	894

No Action Late-Centu	Late Century			
Late-Century Conditions	Chehalis Basin	Willapa Hills Region	RBF to Crim Creek	Above Crim Creek
2-year No Action	71,957	3,902	57	908
10-year No Action	71,476	3,868	55	905
100-year No Action	71,625	3,863	38	903

CONSRUCTION

Construction

Construction Period	Chehalis Basin	Willapa Hills Region	RBF to Crim Creek	Above Crim Creek
Construction	74,157	4,104	89	228
Compared to Current No Action	0%	1%	-2%	-72%

FRE

Current-- FRE

Current Conditions	Chehalis Basin	Willapa Hills Region	RBF to Crim Creek	Above Crim Creek
2-year FRE	74,175	4,075	89	570
10-year FRE	73,606	4,016	81	447
100-year FRE	73,731	4,018	82	440

Mid-Century-- FRE

Current Conditions	Chehalis Basin	Willapa Hills Region	RBF to Crim Creek	Above Crim Creek
2-year FRE	78,263	4,299	89	654
10-year FRE	77,682	4,242	81	515
100-year FRE	77,805	4,243	81	503

Late-Century-- FRE

Current Conditions	Chehalis Basin	Willapa Hills Region	RBF to Crim Creek	Above Crim Creek
2-year FRE	72,746	3,988	57	690
10-year FRE	72,232	3,938	56	574
100-year FRE	72,356	3,945	54	568

NEPA FRE Analysis Results for Spring Chinook: 09.02.19

No Action

No Action Current	Current Conditions			
Current Conditions	Chehalis Basin	Willapa Hills Region	RBFto Crim Creek	Above Crim Creek
2-year No Action	1,176	356	40	71
10-year No Action	1,143	350	35	64
100-year No Action	1,157	358	31	62

No Action Mid-Century	Mid-Century			
Current Conditions	Chehalis Basin	Willapa Hills Region	RBFto Crim Creek	Above Crim Creek
2-year No Action	1,248	384	40	77
10-year No Action	1,236	379	35	71
100-year No Action	1,250	387	31	69

No Action Late-Century	Late Century			
Current Conditions	Chehalis Basin	Willapa Hills Region	RBFto Crim Creek	Above Crim Creek
2-year No Action	1,180	391	35	83
10-year No Action	1,143	380	33	78
100-year No Action	1,155	387	27	78

CONSRUCTION

Construction

Construction	Chehalis Basin	Willapa Hills Region	RBFto Crim Creek	Above Crim Creek
Construction-2 year flood	1,191	371	37	15
Compared to Current No Action	1%	4%	-7%	-78%

FRE

Current-- FRE

Current Conditions	Chehalis Basin	Willapa Hills Region	RBFto Crim Creek	Above Crim Creek
2-year FRE	1,177	358	37	42
10-year FRE	1,122	327	31	0
100-year FRE	1,131	330	29	0

Mid-Century-- FRE

Current Conditions	Chehalis Basin	Willapa Hills Region	RBFto Crim Creek	Above Crim Creek
2-year FRE	1,273	389	36	46
10-year FRE	1,215	355	30	0
100-year FRE	1,223	359	28	0

Late-Century-- FRE

Current Conditions	Chehalis Basin	Willapa Hills Region	RBFto Crim Creek	Above Crim Creek
2-year FRE	1,197	396	32	52
10-year FRE	1,146	364	26	0
100-year FRE	1,159	366	28	0

NEPA FRE Analysis Results for Fall Chinook: 09.0219

No Action

No Action Current	Current Conditions			
Current Conditions	Chehalis Basin	Willapa Hills Region	RBFto Crim Creek	Above Crim Creek
2-year No Action	39,415	1,198	230	198
10-year No Action	39,068	1,177	200	191
100-year No Action	39,239	1,187	180	186

No Action Mid-Century	Mid-Century			
Current Conditions	Chehalis Basin	Willapa Hills Region	RBFto Crim Creek	Above Crim Creek
2-year No Action	38,707	1,183	228	195
10-year No Action	38,870	1,159	195	188
100-year No Action	39,034	1,168	176	183

No Action Late-Centur	Late Century			
Current Conditions	Chehalis Basin	Willapa Hills Region	RBFto Crim Creek	Above Crim Creek
2-year No Action	36,783	1,110	206	189
10-year No Action	36,474	1,090	178	183
100-year No Action	36,618	1,099	163	180

CONSRUCTION

Construction				
Construction	Chehalis Basin	Willapa Hills Region	RBFto Crim Creek	Above Crim Creek
Construction	39,399	1,185	201	118
Compared to Current No Action	0%	-1%	-13%	-40%

FRE

Current-- FRE				
Current Conditions	Chehalis Basin	Willapa Hills Region	RBFto Crim Creek	Above Crim Creek
2-year FRE	39,406	1,192	212	154
10-year FRE	39,022	1,142	173	69
100-year FRE	39,244	1,190	168	152

Mid-Century-- FRE				
Current Conditions	Chehalis Basin	Willapa Hills Region	RBFto Crim Creek	Above Crim Creek
2-year FRE	39,200	1,173	206	151
10-year FRE	38,824	1,124	166	67
100-year FRE	38,959	1,138	174	59

Late-Century-- FRE				
Current Conditions	Chehalis Basin	Willapa Hills Region	RBFto Crim Creek	Above Crim Creek
2-year FRE	37,105	1,115	192	148
10-year FRE	36,761	1,067	153	66
100-year FRE	36,921	1,092	184	59

NEPA FRE Analysis Results for Steelhead: 09.02.19

No Action

No Action Current	Current Conditions			
Current Conditions	Chehalis Basin	Willapa Hills Region	RBFto Crim Creek	Above Crim Creek
2-year No Action	14,527	1,655	19	817
10-year No Action	14,503	1,647	16	807
100-year No Action	14,521	1,652	15	806

No Action Mid-Centu	Mid-Century			
Current Conditions	Chehalis Basin	Willapa Hills Region	RBFto Crim Creek	Above Crim Creek
2-year No Action	15,521	1,740	19	890
10-year No Action	15,497	1,731	16	879
100-year No Action	15,516	1,737	15	878

No Action Late-Centur	Late Century			
Current Conditions	Chehalis Basin	Willapa Hills Region	RBFto Crim Creek	Above Crim Creek
2-year No Action	16,099	1,792	15	998
10-year No Action	16,077	1,783	11	988
100-year No Action	16,094	1,789	11	987

CONSRUCTION

Construction				
Construction	Chehalis Basin	Willapa Hills Region	RBF to Crim Creek	Above Crim Creek
Construction	14,518	1,650	13	387
Compared to Current No Action	0%	0%	-27%	-53%

FRE

Current-- FRE				
Current Conditions	Chehalis Basin	Willapa Hills Region	RBF to Crim Creek	Above Crim Creek
2-year FRE	14,516	1,648	14	704
10-year FRE	14,485	1,632	6	680
100-year FRE	14,504	1,638	7	642

Mid-Century-- FRE				
Current Conditions	Chehalis Basin	Willapa Hills Region	RBF to Crim Creek	Above Crim Creek
2-year FRE	15,512	1,733	13	767
10-year FRE	15,479	1,716	6	725
100-year FRE	15,499	1,723	6	692

Late-Century-- FRE				
Current Conditions	Chehalis Basin	Willapa Hills Region	RBF to Crim Creek	Above Crim Creek
2-year FRE	16,091	1,785	6	862
10-year FRE	16,062	1,771	0	833
100-year FRE	16,084	1,778	12	794

Attachment B
Integrated EDT-LCMs Modeling Report

Integrated EDT-Lifecycle Modeling of Salmonids for the Chehalis NEPA EIS

February 2020

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1 INTRODUCTION

The ability to understand salmonid responses to habitat changes through time can be addressed using population dynamics models. The following report outlines the methods, results, and assumptions for an integrated modeling approach that combined a lifecycle model (LCM) with an equilibrium-state habitat model. The approach described below reflects the decision of the National Environmental Policy Act (NEPA) analysis team to use EDT modeling to estimate annual salmonid freshwater habitat conditions and impacts from proposed flood control actions, and for the integrated EDT-LCM to use the EDT modeling results in a time-oriented population dynamics model to estimate changes through time. The EDT modeling reflected the steady-state equilibrium response to the sets of environmental conditions that vary with flood magnitude, and the integrated EDT-LCM illustrated the dynamic population response to changes in environmental conditions using stochastic year-to-year variation in flood magnitudes based on their recurrence intervals.

2 PURPOSE

NOAA developed LCMs for four species of salmonids in the Chehalis Basin to simulate effects from alternatives evaluated in the Chehalis NEPA environmental impact statement (EIS). The purpose of the integrated EDT-LCMs was to examine time trends in spawner abundance using the EDT-generated estimates of equilibrium conditions for the 'No Action' and 'Flood Retention Expandable (FRE)/Flood Retention Only (FRO)' alternatives under several flood conditions, and to estimate population responses to a 2-year consecutive recurring flood condition (i.e., 10-year flood followed by a 100-year flood).

3 METHODS

3.1 LCM Model Overview

The LCMs developed and used to integrate with EDT outputs were a matrix-type model similar to that described by Zabel et al. (2006). On an annual time step, fish were moved through an abundance array consisting of each age (0, 1, 2, …) for each EDT subpopulation. The transitional rules that moved fish through the abundance array consisted of applying two types of functions: density-dependent and density-independent. In the case of a density-dependent life stage, where there was an assumption that habitat capacity could limit the amount of fish in that life stage, a Beverton-Holt production function was applied as follows:

$$N_{stage+1} = \frac{p \cdot N_{stage}}{1 + \left(\frac{p}{c}\right) \cdot N_{stage}} \quad ,$$

where $N_{stage+1}$ is the number of fish in the ending life stage, p is the productivity of the transition, c is the capacity of $N_{stage+1}$, and N_{stage} is the number of fish of the starting life stage. In the case of a density-independent life stage, under an assumption that there was no habitat capacity limitation on that life stage, to arrive at the number of fish at the ending life stage ($N_{stage+1}$) the starting life stage (N_{stage}) was multiplied by the productivity for the life stage transition (p).

The analysis team applied the density-dependent function in the adult spawner to juvenile stages and all juvenile freshwater stages. The density-independent function was applied for all marine life stages and for the returning adult through prespawning life stages. The productivities (p) and capacities (c) in the above functions were provided in outputs from EDT modeling of the 'No Action' and 'FRE/FRO' scenarios. EDT information provided for integration included a smolt-to-adult return (SAR) marine stage, which was partitioned into a smolt-to-ocean (bay) rearing stage, annual ocean stages, and propensities for ocean stages to mature and return to spawn. The ocean productivities came from the parameters used in the Chehalis Basin Aquatic Species Restoration Plan (ASRP) lifecycle modeling, and bay productivities were estimated after calculation of the other constituent parts of the EDT SAR. When the partitioned SAR used in the integrated EDT-LCM SAR was combined, it matched the EDT-provided SAR value.

The integrated EDT-LCM is a forward-simulation model that used the functions above to move fish from one life stage step to the next (Table 1). All EDT output stages included density-dependent p and c parameters. In the cases where density-independent productivities were calculated, the equilibrium abundance of the ending stage $N_{stage+1}$ was divided by the abundance of starting stage N_{stage} (Table 1). The integrated EDT-LCM included parameters from the EDT outputs for each life stage, aggregated to the EDT subpopulation spatial level. Parameters for each life stage and EDT subpopulation were the life stage-specific productivities and capacities, and in the case of steelhead there were parameters governing the proportions of smolts of each age class migrating to sea.

Table 1
Descriptions of Functions and Parameters Used in the Integrated EDT-LCM by Life Stage Transition Type

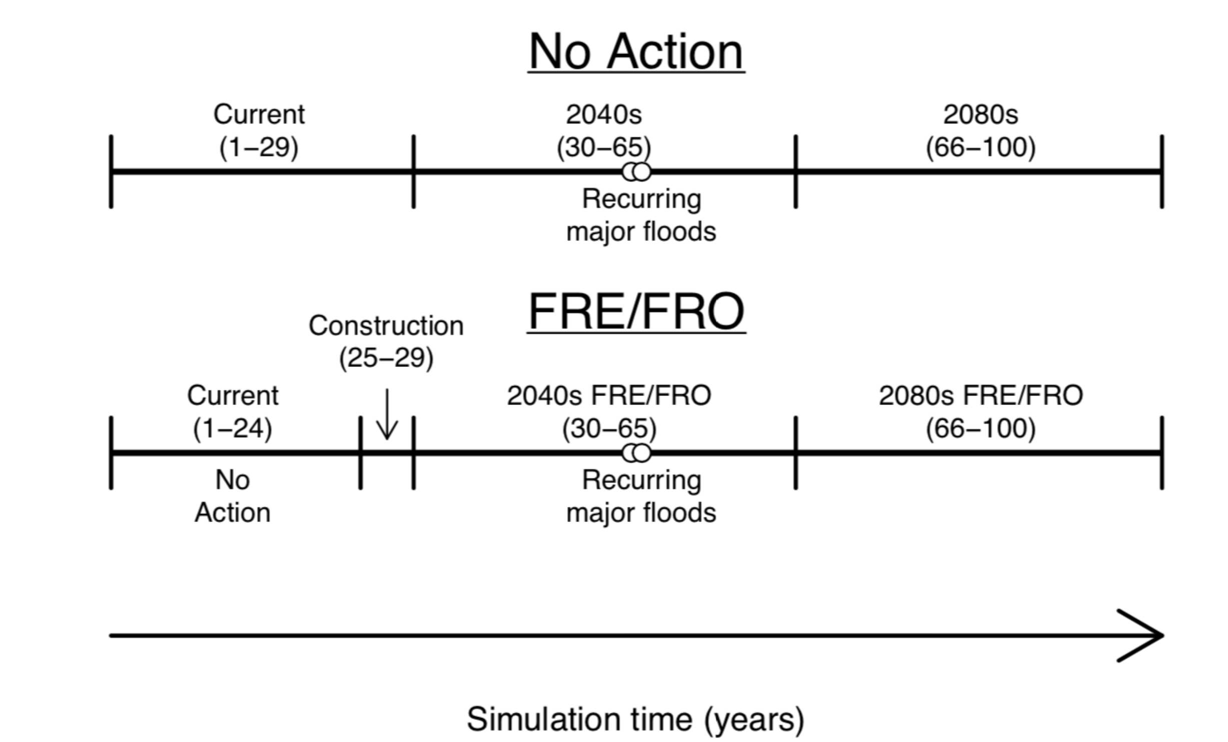
LIFE STAGE	SPRING-RUN CHINOOK SALMON	FALL-RUN CHINOOK SALMON	COHO SALMON	WINTER STEELHEAD
Total returns to spawners	DI: Equilibrium Abundance / Juvenile-to-Adult Abundance	DI: Equilibrium Abundance / Juvenile-to-Adult Abundance	DI: Equilibrium Abundance / Juvenile-to-Adult Abundance	DI: Equilibrium Abundance / Juvenile-to-Adult Abundance
Spawners to freshwater rearing stage 1	DD: p, c	DD: p, c	DD: p, c	DD: p, c
Freshwater rearing stage 1 to 2	---	---	---	DD: p, c
Freshwater rearing stage 2 to 3	---	---	---	DD: p, c
Age of smolts	---	---	---	DI: median of proportions from EDT
Bay survival	DI: partitioned from SAR (Juvenile-to-Adult Abundance / Juvenile Abundance)	DI: partitioned from SAR (Juvenile-to-Adult Abundance / Juvenile Abundance)	DI: partitioned from SAR (Juvenile-to-Adult Abundance / Juvenile Abundance)	DI: partitioned from SAR (Juvenile-to-Adult Abundance / Juvenile Abundance)
Ocean survival	DI: partitioned from SAR (Juvenile-to-Adult Abundance / Juvenile Abundance)	DI: partitioned from SAR (Juvenile-to-Adult Abundance / Juvenile Abundance)	DI: partitioned from SAR (Juvenile-to-Adult Abundance / Juvenile Abundance)	DI: partitioned from SAR (Juvenile-to-Adult Abundance / Juvenile Abundance)
Ocean maturation	DI: partitioned from SAR (Juvenile-to-Adult Abundance / Juvenile Abundance)	DI: partitioned from SAR (Juvenile-to-Adult Abundance / Juvenile Abundance)	DI: partitioned from SAR (Juvenile-to-Adult Abundance / Juvenile Abundance)	DI: partitioned from SAR (Juvenile-to-Adult Abundance / Juvenile Abundance)

Notes:
c: capacity
DD: density-dependent
DI: density-independent
p: productivity

3.2 Integration of EDT and LCM

The analysis team used parameters generated from EDT modeling for each scenario and flood condition to populate the integrated EDT-LCM. Two main scenarios were run through the integrated EDT-LCM: 'No Action' and an 'FRE/FRO' proposed scenario (Figure 1). Each scenario was composed of both an Action ('No Action', 'FRE/FRO') and a future condition ('Current', mid-century ['2040s'], and late century ['2080s']).

Figure 1
Scenarios for the Integrated EDT-LCM NEPA Analysis



In each of the scenarios, EDT-estimated current, mid-century (2040s), and late-century (2080s) habitat conditions, and freshwater capacities and productivities generated by those conditions were used to parameterize the integrated EDT-LCM. The number of annual steps included 29 years of current conditions in the No Action scenario (or 24 years of current conditions and 5 years of construction in the FRE/FRO scenario) followed by 36 years representing the 2040s and 35 years representing the 2080s. At each simulation step, 2-, 10-, or 100-year flood conditions were applied according to their probabilities of recurrence. An additional condition included a recurring consecutive flood that consisted of a 10-year flood followed by 100-year flood conditions.

Additionally, for each action-future condition combination, EDT outputs included parameters for 2-year, 10-year, and 100-year flood conditions. At each integrated EDT-LCM time step, the 2-year, 10-year, or

100-year flood condition was chosen based on its probability of recurrence. In every year of the integrated EDT-LCM model (100 years total), one of the three floods always occurred. In other words, it was assumed that the chance of any one of the three floods occurring during a 1-year period would be 100%. The chance that a less than 2-year flood occurs is not modeled, so the total number of chances each year is 61 (50+10+1 = 61). Therefore, the integrated EDT-LCM modeling overestimates the likelihood of occurrence of each flood as follows:

- 2-year flood: In the model this flood has an 82.0% chance (50/61) of occurring in each year of a 100-year run. Generally, in the Chehalis Basin flows of this size would only have an approximately 50% chance of occurring in each year.
- 10-year flood: In the model this flood has a 16.4% chance (10/61) of occurring in each year of a 100-year run. Generally, in the Chehalis Basin flows of this size would only have an approximately 10% chance of occurring in each year.
- 100-year flood: In the model this flood has a 1.6% chance (1/61) of occurring in each year of a 100-year run. Generally, in the Chehalis Basin flows of this size would only have an approximately 1% chance of occurring in each year.

Included as an additional condition, the integrated EDT-LCM model was also run with sequential recurring floods (10-year flood followed by a 100-year flood condition) at the midpoint of the simulations. Because the integrated EDT-LCM had stochastic flood conditions, the results described in the following section reflect 100 model iterations for each scenario.

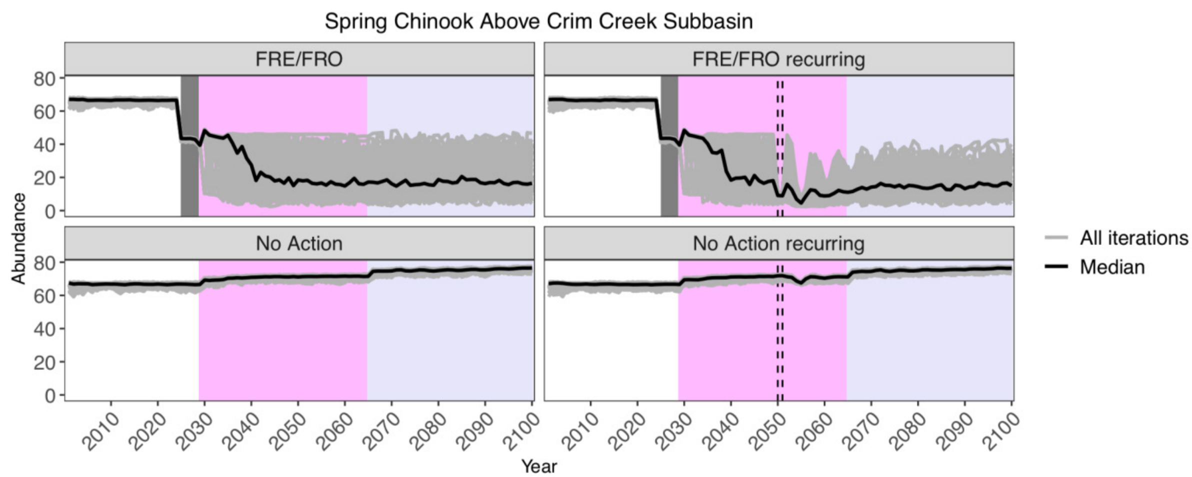
4 RESULTS

The following results show responses to the scenarios with and without a recurring sequential flood. A common feature of the integrated EDT-LCM results was a very slight response to flood conditions alone (i.e., 2-, 10-, and 100-year flood conditions) within 'Current', mid-century or late century, but flood conditions that resulted in flood control operations from the proposed project (i.e., 'FRE/FRO') had a noticeable and large impact compared to the 'No Action' scenario. Most species exhibited a substantial decline in spawner abundance as a result of imposing the conditions during the 'Construction' period. Some subpopulations were at very low abundance after the 'Construction' period and were potentially vulnerable to depensatory demographic effects and extirpation (McElhany et al. 2000).

4.1 Spring-Run Chinook Salmon

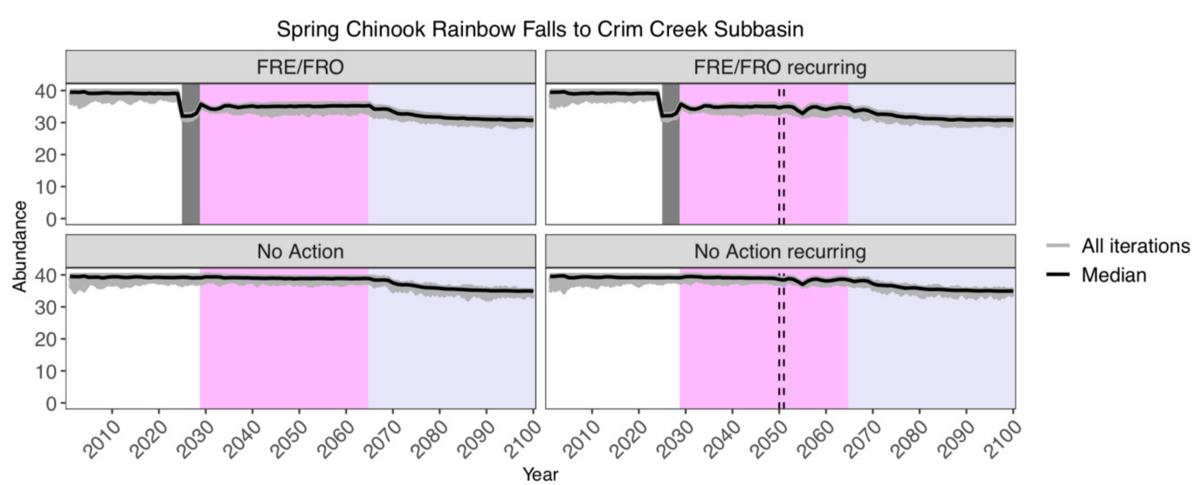
Spring-run Chinook salmon subpopulations above the proposed project site were adversely impacted by the proposed project (Figure 2; in this and subsequent figures, no color represents 'Current' period, gray represents 'Construction', pink represents the mid-century period, and lavender represents the 'late century' period). After construction, median spawner abundance dropped below 20 fish. In the 'No Action' scenario, there were very slight increases as conditions transitioned between mid-century and late century (Figure 2). Imposing a consecutive flood added some fluctuation to spawner abundance in the 'FRE/FRO' scenario, but the abundance was already extremely low. Under the 'No Action' scenario, there was a relatively small fluctuation in spawner abundance with the recurring flood condition, and spawner abundance during the late-century period equilibrated to a level equivalent to the scenario with no consecutive flood. Another characteristic of the 'No Action' scenario was that there was little variation in spawner abundance due to the 2-, 10-, and 100-year flood conditions.

Figure 2
Spring-Run Chinook Salmon Spawner Abundance of Subpopulations Above Crim Creek



Spring-run Chinook salmon below the proposed project site had a relatively smaller response as a consequence of the proposed project (Figure 3). There was a relatively small drop in spawner abundance with construction, and a small decrease through to late century. There was a relatively small response to the consecutive recurring flood, and scenarios that included it ended up in the late-century period at the same levels. Parameters from the EDT modeling had little difference between 2-, 10-, and 100-year conditions, which led to a relatively small amount of variability within the scenarios.

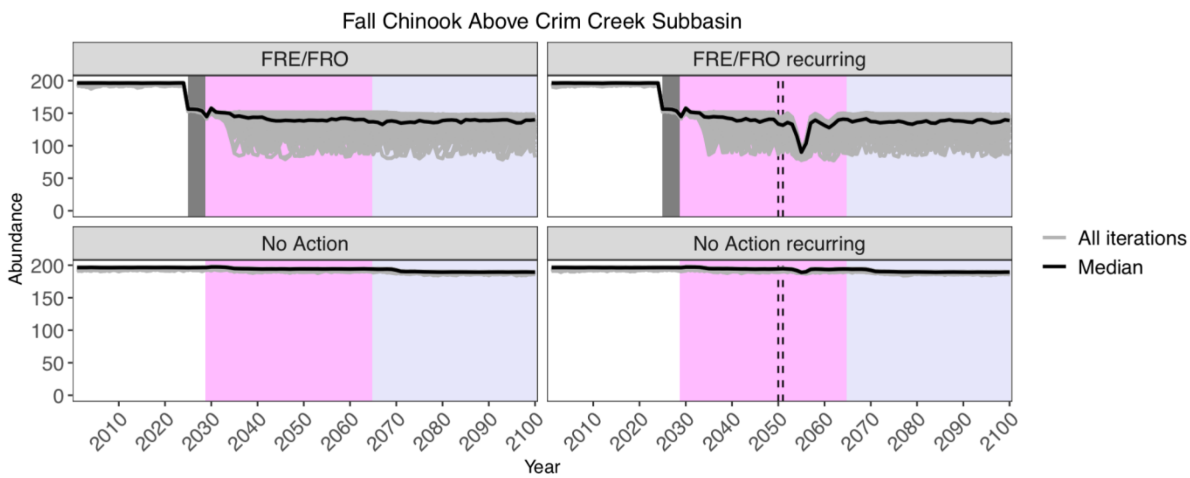
Figure 3
Spring-Run Chinook Salmon Spawner Abundance of Subpopulations Below Crim Creek to Rainbow Falls



4.2 Fall-Run Chinook Salmon

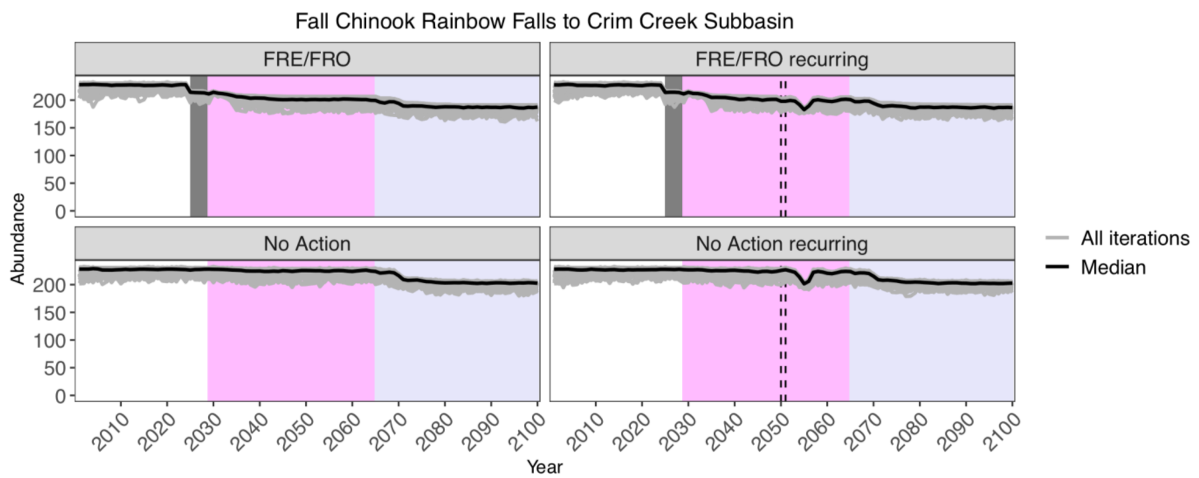
Fall-run Chinook salmon above the proposed project site were impacted by the proposed project during construction, and afterwards remained at a lower abundance through the late-century period (Figure 4). The recurring consecutive flood impacted 2 brood years in sequence. However, the spawner abundance recovered relatively rapidly and equilibrated to the spawner level in the late century equivalent to the non-recurring scenarios. The 'No Action' alternatives had very little variability because of the small changes between the 2-year, 10-year, and 100-year flood conditions EDT parameters.

Figure 4
Fall-Run Chinook Salmon Spawner Abundance of Subpopulations Above Crim Creek



Fall-run Chinook salmon subpopulations below the proposed project site (Figure 5) exhibited relatively more variability and showed similar patterns of decline as those above the project site. There was a small but visible perturbation from the consecutive recurring flood, and by late century the effect of the recurring flood was indistinguishable from the scenario that did not include it.

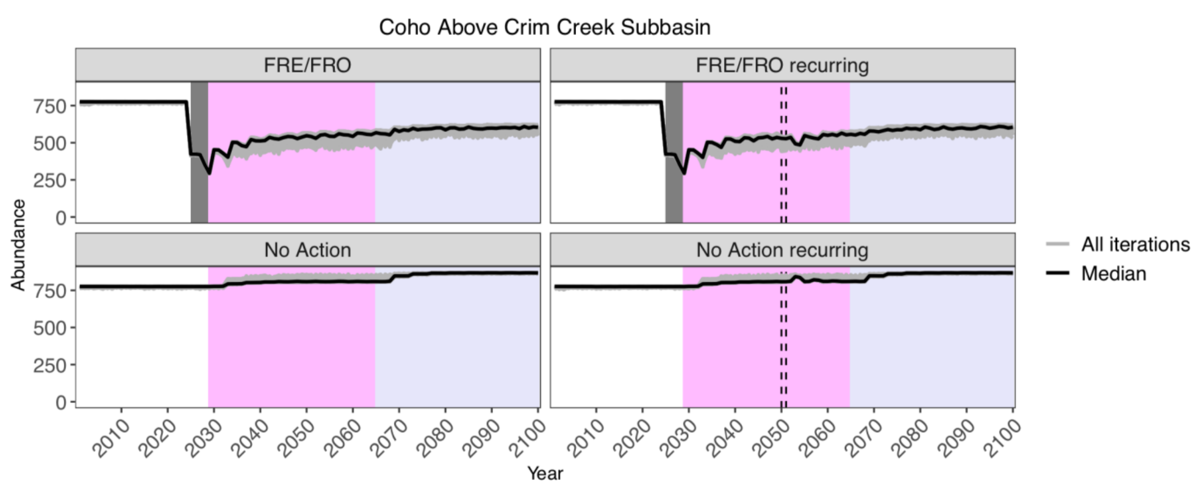
Figure 5
Fall-Run Chinook Salmon Spawner Abundance of Subpopulations Below Crim Creek to Rainbow Falls



4.3 Coho Salmon

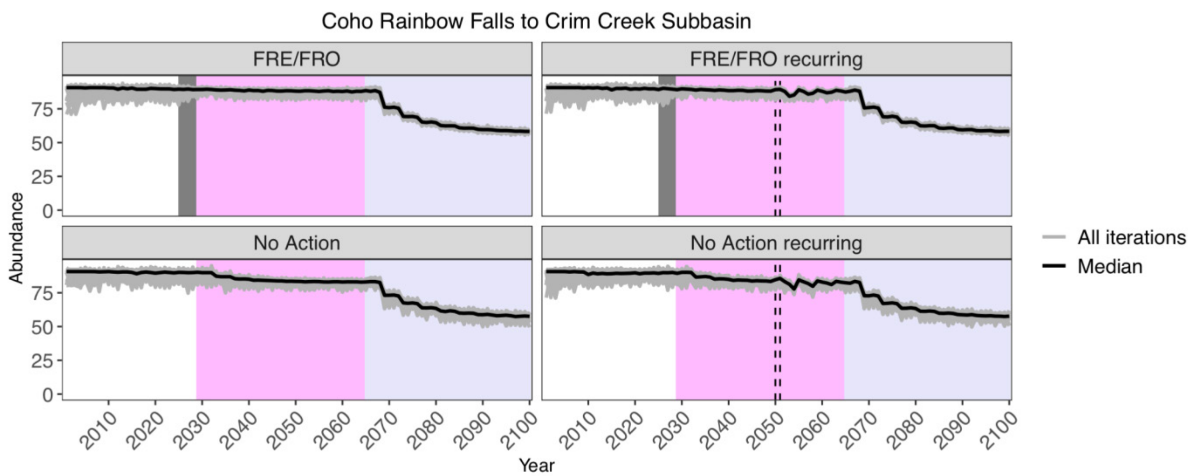
Coho salmon responses to the proposed project were relatively large (Figure 6). After construction, which decreased spawner abundance by approximately 65%, spawner abundance increased through the late-century period to approximately 70% of its preconstruction level. The effect of a consecutive recurring flood was relatively small, and not distinguishable in the late-century period with scenarios that did not include it. Under the 'No Action' scenario, spawner abundance increased slightly from the beginning to late century. Like spring-run Chinook salmon, there was relatively little difference between flood scenarios that led to very small variation in the integrated EDT-LCM results for coho salmon.

Figure 6
Coho Salmon Spawner Abundance of Subpopulations Above Crim Creek



Below the proposed project site, subpopulations appeared unaffected by construction of the proposed project, and compared to the 'No Action' scenario there was a slight increase in spawner abundance under the FRE/FRO scenario (Figure 7). Although there was some fluctuation introduced by the recurring consecutive flood condition, spawner abundances were at comparative levels to scenarios where no consecutive recurring flood was applied. In both scenarios, coho salmon abundance fell to nearly 50 spawners, which is likely approaching functional extirpation levels.

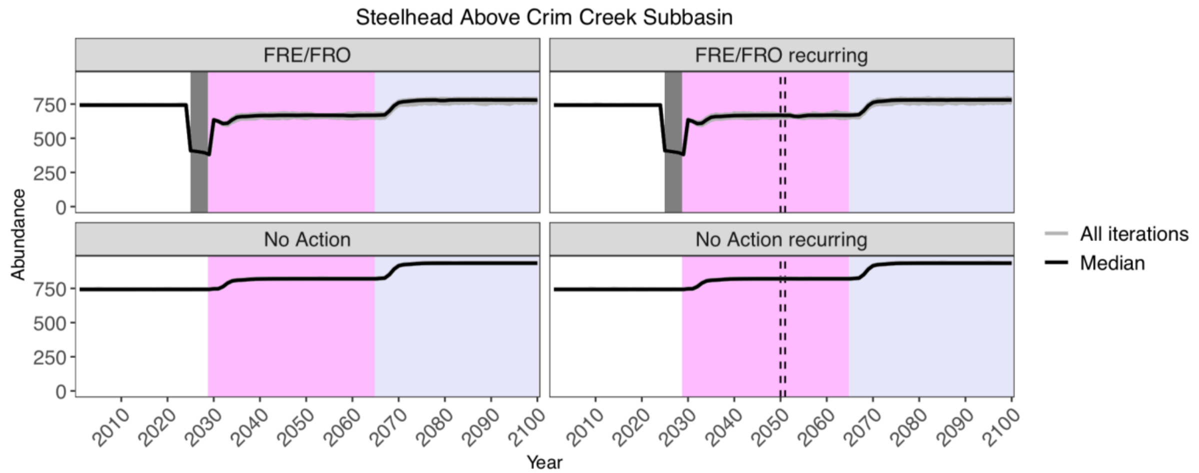
Figure 7
Coho Salmon Spawner Abundance of Subpopulations Below Crim Creek to Rainbow Falls



4.4 Winter Steelhead

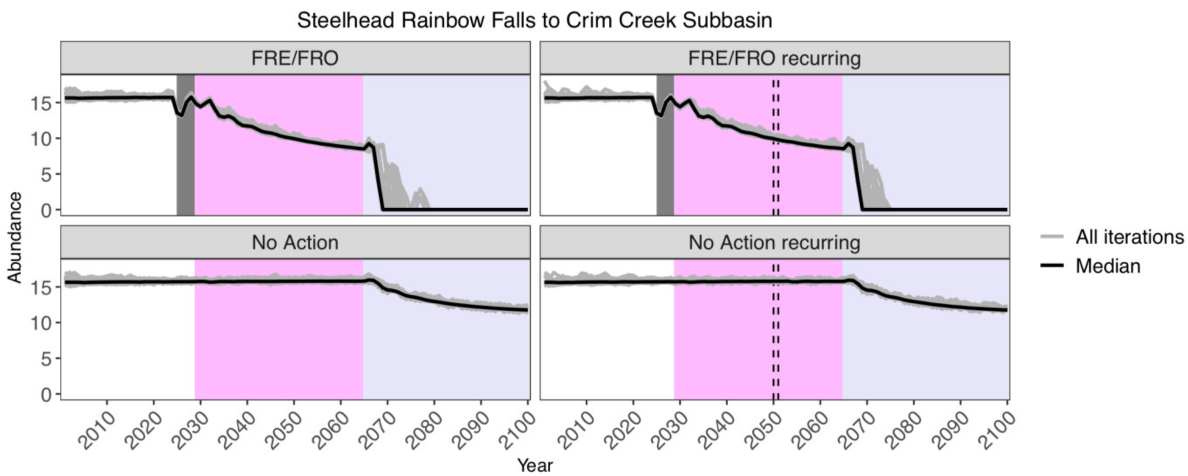
Like coho salmon, steelhead spawner abundance declined substantially in response to construction in subpopulations above the proposed project site (Figure 8). However, by the late-century period, spawner abundance reached the approximate level that occurred prior to construction. Under the 'No Action' scenario, spawner abundance appeared to increase slightly through to the late-century period. Because there was almost no difference in the steelhead parameters that defined the 2-, 10-, and 100-year flood conditions, there was very little deviance from the median results and, therefore, virtually no effect of the consecutive recurring flood scenario.

Figure 8
Results of EDT-LCM for Winter Steelhead Spawner Abundance of Subpopulations Above the Proposed Project Site



In subpopulations below the proposed site, spawner abundance was initially very low and post-construction it dropped to zero by the late-century period (Figure 9). The number of spawners in the initial period for both scenarios was very low, and at this level it is suggestive of functional extirpation for the subpopulations below the proposed project site. Under the 'No Action' scenario, spawner abundance remained steady through the mid-century period and exhibited a gradual decline in the late-century period. Similar to steelhead subpopulations above the proposed site, there was very little difference in EDT steelhead parameters characterizing the different flood conditions. Therefore, there was little variation between model iterations and a minimal response to consecutive recurring flood condition.

Figure 9
Results of EDT-LCM for Winter Steelhead Spawner Abundance of Subpopulations Below the Proposed Project Site



5 MODEL UNCERTAINTY, VALIDATION, AND EDT-LCM COMPATIBILITY

The purpose of the integrated EDT-LCMs was to examine time trends using the EDT-generated estimates of equilibrium conditions in 'Current', mid-century ('2040s'), and late-century ('2080s') time periods (and 'Construction' period for the proposed project scenario). Because of the nature of the integrative approach taken for this analysis, the integrated EDT-LCMs were constrained by the EDT life-stage-specific abundances, productivities, and capacities. This integrated approach implicitly assumed that the parameters coming from the EDT outputs used in the integrated EDT-LCMs constituted as close to 'truth' as was practicable given what is known about fishes in the Chehalis Basin. Furthermore, it was assumed that all of the freshwater habitat, biological characteristics, and attributes (e.g., survival, capacities, movement) were included within the EDT output 'Subpopulation' aggregations that were used in the integrated EDT-LCMs.

The integrated EDT-LCM validation process consisted of checks that the net equilibrium abundances (NEQs) calculated from plugging the EDT output parameters for each flood scenario into a simple lifecycle sequence of equations (see Table 1) matched the EDT-produced NEQs for that scenario. When they did not match, we optimized the bay survival and maturation rates in the EDT-LCM so that the EDT-LCM spawner age structure matched observed data and NEQs were close to those of EDT. When the outputs of the EDT-LCM were equal or similar to the NEQs found in EDT outputs, we used these lifecycle sequences in the final EDT-LCM model runs evaluating stochastic variation in flood magnitudes and effects of the project through time.

The EDT outputs were provided as fixed values, so there is no parameter uncertainty included in the modeling. However, the integrated EDT-LCM modeling characterized year-to-year variability caused by the contrasts of flood conditions (2-, 10-, and 100-year floods; and sequential recurring floods), as well as differences among time periods (current, mid-century, and late century). Time period differences were a function of the spatial extent of the HEC-RAS modeling that influenced EDT habitat attributes and ultimately the EDT capacity and productivity outputs.

None of the scenarios in the NEPA EIS analyses included projected effects from climate change. Climate change would be expected to have deleterious effects on most salmonid species. Chehalis Basin ASRP salmonid modeling, as well as other salmonid modeling efforts in the Pacific Northwest generally, have estimated significant negative impacts for the species included in this analysis as a consequence of projected changes to habitat conditions resulting from forecasted climate change. For example, Chehalis River spring-run Chinook salmon adults arrive in freshwater prior to spawning and hold during the warmer summer months, and the ability of Chinook salmon to survive and successfully spawn is very sensitive to warm water temperatures during this prespawning period.

Integrating EDT and LCM models required several simplifying assumptions to ensure their compatibility, particularly for winter-run steelhead. There are inconsistencies in reports of observations of winter-run steelhead smolt age from coastal Washington streams. The EDT outputs included emigration of smolts to the ocean that were age 2 and age 3 outmigrants, which was consistent with reports from scales of fish captured in the fisheries. However, recent observations of smolt trapping in the Chehalis Basin suggest that winter-run steelhead emigrants consisted of mostly age 1 and age 2 smolts, with a very small proportion of age 3 outmigrants. Efforts by the co-managers to reconcile the inconsistency between smolt ages determined from juvenile trapping and from scales of adult returns are ongoing. For the EDT-LCM, all model runs used the ages determined from adult scales, and the effect of using the smolt trap ages is unknown.

Additionally, the proportions of smolt ages varied by subpopulation in the EDT outputs. However, as winter-run steelhead marine survival was partitioned into its constituent parts in the LCM, we held proportions of smolts at age to a fixed proportion (at the median of the subpopulations' proportions) so that there would be a common ocean maturation rate schedule for all subpopulations. This simplification would mute differences in modeled NEQ among subpopulations for a given habitat condition, but would have little effect on differences among scenarios for each subpopulation.

One biological aspect of Chehalis Basin winter-run steelhead not characterized in the EDT model was the contribution of respawning adults, or kelts. Kelts are adult spawners that, rather than die after their first spawning, migrate back to the ocean and return to spawn again in a subsequent year. They tend to be older, larger, and more fecund than first-time spawners. Inclusion of kelts would tend to increase spawner abundances slightly in all scenarios, but the effect on the differences among the modeled scenarios is unknown.

Lastly, ocean survival, as measured by adult returns/smolt (SAR), was high relative to reports of other coastal steelhead populations (e.g., Cram et al. 2018) and higher than guidance from the Washington Department of Fish and Wildlife (WDFW) for the ASRP modeling of Chehalis Basin steelhead. This pattern of higher ocean survival relative to WDFW guidance was also present for the other salmonid species. Therefore, there may be some discrepancies between the SAR value used in the EDT model and WDFW guidance for SARs.

One general limitation of the integrated approach of the EDT-LCM related to when a new modeling year began. The new year in the winter-run steelhead EDT modeling began on approximately April 1 and ran until April of the following year. This distinction of when the modeling years began is significant because of summer habitat carryover effects from the previous winter. In the integrated EDT-LCM, a single flow condition was chosen for each year, which meant that the same flow conditions prevailed from April to April. The EDT habitat conditions established for the NEPA EIS scenarios included residual habitat carryover effects into the summer months as a consequence of flows from the previous winter. Because of the annual break set in April, the same flow condition prevailed for spring to fall and following winter, with no opportunity to change flow conditions in the fall. This may have similarly impacted coho salmon

EDT-LCM results. However, because of the relatively minor differences in the EDT outputs for the 2-year, 10-year, and 100-year flood conditions, the summer carryover effects were likely very small. Spring-run or fall-run Chinook salmon would not be affected because flood conditions primarily affect incubating eggs but not the rearing or outmigration stages.

These model assumptions and limitations mean that there is uncertainty in the absolute abundance numbers produced by the integrated model, and to some extent in the modeled changes in abundance among scenarios. However, relative changes in abundance between scenarios and flood conditions are indicative of estimated impacts to salmonids, and model uncertainties should affect abundance in the same way in each scenario.

6 CONCLUSIONS

Based on the modeling, there were very large and substantial effects on spring-run Chinook and coho salmon from the proposed project on subpopulations above Crim Creek and for winter steelhead in subpopulations below Crim Creek. However, spring-run Chinook salmon and steelhead spawning abundance in those locations were already at very low abundance. Spring-run Chinook salmon currently have a very limited spatial range, and operation of the proposed project would substantially reduce the spatial structure of this species. The construction period had a substantial negative impact on spawner abundance for all species.

In circumstances where there were appreciable differences between 2-, 10-, and 100-year flood conditions, the 2-year consecutive recurring flood event (representing 2 sequential years of flood control operations for the proposed project and 2 sequential years of high flood conditions under the 'No Action') had large and noticeable impacts. However, in many instances, model results for the 10- and 100-year flood conditions, whether under the 'No Action' or proposed project, were not much different than conditions for the 2-year flood. This was as a consequence of very little or no contrast between these conditions in the EDT outputs.

None of the NEPA EIS scenarios included projected effects on salmonids from climate change, which in some circumstances would be expected to substantially alter model outcomes in the mid- and late-century periods.

7 REFERENCES

Cram, J., N. Kendall, A. Marshall, T. Buehrens, T. Seamons, B. Leland, K. Ryding, and E. Neatherlin, 2018. *Steelhead at Risk Report: Assessment of Washington's Steelhead Populations.* Washington Department of Fish and Wildlife. FPT 19-03. Accessed at: https://wdfw.wa.gov/publications/02070.

McElhany, P., M. Ruckelshaus, M. Ford, T. Wainwright, and E. Bjorkstedt, 2000. *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units.* NOAA Technical Memorandum NMFS-NWFSC-42.

Zabel, R., M.D. Scheuerell, M.M. McClure, and J.G. Williams, 2006. "The interplay between climate variability and density dependence in the population viability of Chinook salmon." *Conservation Biology* 20:190-200.

Attachment C
Salmonid Modeling Meeting Notes

CHEHALIS NEPA EIS MEETING NOTES

Group/Committee:	Salmonid Impact Modeling Team
Topic:	Discuss input parameters for EDT and NOAA Lifecycle models for NEPA EIS – Meeting #1
Date:	June 3, 2019
Time:	1:30 to 3:00pm
Location:	Webex

Attendees

Chip McConnaha (ICF, EDT Lead)
Laura McMullen (ICF, EDT Lead)
Tim Beechie (NOAA, LCM Lead) (not present today)
Jeff Jorgensen (NOAA, LCM Lead)
Greg Hoffman (Corps, Fisheries Technical Lead)
Elizabeth Greene (Anchor QEA, Fisheries Technical Lead)
Sydney Gonsalves (Anchor QEA, Fisheries Support/Note Taker)
Heather Page (Anchor QEA)
Kim Marcotte (Anchor QEA)
Marc Auten (Anchor QEA)
Greg Summers (Anchor QEA)

Action Item and Decisions Made Summary

ASSIGNED TO	ACTION ITEM
Laura	List of EDT environmental variables and previously used values

TOPIC	DECISION MADE
No Action Alternative	Five Early Action ASRP reaches will be included in modeling
Airport Levee	Impacts of raising existing levee will not be included in modeling
FRE + Airport Levee Mitigation Framework	Mitigation will not be included in modeling

Notes

The purpose of these notes is to record key points, decisions, and discussion topics. They are not intended to be transcripts.

Intro and Purpose – led by Elizabeth

Purpose: determine what input parameters to use for modeling EDT and NOAA Lifecycle models for NEPA EIS.

Goal is to start modeling in early July.

Communication reminder about SEPA firewall, but team can discuss the models and assumptions that have been made for PEIS and ASRP. There will be a future (next few weeks) meeting on SEPA coordination, but will not be within this meeting series.

Review Meeting Work Plan – led by Elizabeth

Series of weekly meetings, now on Thursday afternoons.

Today we will go through decisions that need to be made by the Corps on input parameters for the EDT and NOAA Lifecycle models.

Below is a summary of topics that will be discussed throughout the meeting series:

- Meeting 2 – general model decisions, project description/alternatives, geographic extent, species, timeframe, how other models feed into EDT, in more detail
- Meeting 3 – EDT attributes and No Action conditions
- Meeting 4 – inputs specific to FRE alternative conditions: spatial, fish passage, survival rates, reservoir degradation, levy, mitigation, integration of EDT and NOAA Lifecycle models
- Meeting 5 – placeholder in case we don't get through everything

After meetings, Corp will prepare a final document of all decisions that have been made and this will allow modeling to begin (in early July)

EDT Model Input Parameters for ASRP/PEIS – led by Chip/Laura

Laura led discussion through model input and assumption spreadsheet and identified decisions that need to be made by the Corps prior to running the models.

1. What are Alternatives (e.g., No Action, FRE) and scenarios (flood recurrence levels) to model

2. Need to decide specific timeframes to model such as current, mid-century, late-century

    a. EDT does not model on a continuous timeframe

    b. Ex. Current is 2020, mid – 2040, late – 2080. Note that these are representative years not specific years.

    c. Should there be a construction scenario? This would be represented by year 2030 or 2035.

3. Geographic extent of model—Current modeling for ASRP includes Chehalis and tributaries above and below dam down to Gray's Harbor (but not including Gray's Harbor). NHD Hydrology and SWIFD fish distribution inputs are used.

    a. There was a discussion about whether to include tributaries going into Gray's Harbor (Humptulips, etc) in the geographic extent. Leaving tributaries in the model is recommended because this information is already in the model for ASRP, was included in the PEIS EDT modeling, and is within an area of interest for the Quinault Indian Nation.

4. Species – recommended species are spring- and fall-run Chinook, Coho, and steelhead. Do not recommend including chum salmon, since they only spawn in lower tributaries and not the mainstem Chehalis River (although has been used for ASRP). Additionally, NOAA Lifecycle model does not include chum so the integration of the models would not be effective for this species.

5. EDT Output Metrics:

    a. Corps will need to decide what metrics to include in the EDT output. Equilibrium abundance, contribution to spatial structure, productivity, diversity (behavior, life hist, physical) are all possible outputs.

    b. For ASRP – abundance has been main output. Recent efforts interested in spatial structure outputs, including sub-population health. For example, what habitats can support at least 50 fish and how will that change with potential actions?

        i. Note that 50 fish is somewhat arbitrary, a rule of thumb index value for genetic analysis. At least 50 individuals are assumed to be self-sustaining, with results indicating improvement/decline relative to that number.

6. SAR- Smolt to Adult Return. Current values used for ASRP modeling are not what is provided in the decision table. This input parameter is being used as an estimate of basin-wide abundance and has to do with ocean survival. These values are only used for calibration; values do not change between scenarios.

   a. Discussion: Chip somewhat uncomfortable calling it “SAR”. Should really be called “calibration factors”. The values are fixed, not changing across scenarios, and represent relative change compared to a current condition.

7. HEC-RAS (H&H Model) –provides channel width, floodplain habitat extent, and flow attributes.

   a. The decision on what recurrence intervals to use is being made with H&H technical leads.

8. Temperature – Thermalscape (CT) model for maximum daily temp (May-Sept), PSU CE-QUAL-W2 model where available, NorWest climate, WDFW data. Please see technical memo on EDT model temperature inputs for more details.

9. Geomorphology – sediment transport modeling has not been used in ASRP modeling yet. Some qualitative results for wood, bed scour, and fine sediment have been provided by Kathy Dube, Watershed Geodynamics, and included in EDT.

   a. Decisions on sediment transport model inputs will be made in coordination with the NEPA geomorphology technical lead.

10. EDT Environmental Attributes –The suite of attributes include wood, riparian conditions, change in pools/riffles, substrate size changes. A list of all attributes and previously used model inputs will be compiled and sent around to team (Action Item: Laura).

11. No Action Alternative – represents changing baseline over time, including tree growth, culvert removal, climate change, habitat degradation (from population increase/development). Need to determine what elements should be included in the No Action Alternative.

    a. Clarification: tree growth includes entire watershed but changes in river habitat would be influenced by riparian tree growth only. Within a managed forest, the riparian areas are protected by the Forest Practices Act so can assume tree growth.

    b. Early Action Reaches – five identified for restoration under ASRP. Should they be incorporated into No Action since they are expected to be completed in the next 5 years? NEPA No Action Alternative description includes these early action reaches, in coordination with SEPA.

       i. DECISION – Yes, include early action reaches into the EDT No Action Alternative.

12. FRE – Need to decide conditions related to operation of the FRE facility.

    a. Where would model apply different changes in terms of above, in footprint, and below FRE? This input also includes fish passage survival for different species. How far up and downstream should effects of FRE extend? What subset of attributes may be particularly vulnerable to change because of FRE? The Programmatic EIS delineated between above, within, and downstream of the structure footprint. Comments on the Programmatic EIS also focused on these three areas.

13. Fish Passage at FRE – what are fish passage survival inputs under construction and operation phases? Additional meeting to take place tomorrow to delve into construction assumptions of fish passage.
14. Airport Levee – should these impacts be modeled? Because the environmental change is minimal with little to no effects to fish, it is recommended that the airport levee not be included.
    a. DECISION – will not be included
15. Modeling during construction – what assumptions would be made about fish passage or environmental impacts during construction (for years 2025-2030)? Construction could have its own set of environmental attributes or attributes could stay the same and only passage specific inputs would change.
16. FRE Reservoir Degradation – Need to determine what attributes to degrade when reservoir forms
    a. For each flood scenario, need to calculate the size of the reservoir footprint, which is based on flow inputs and months that there would be storage. Delineating the footprint for each flood scenario for different flow years has previously been done from H&H model output.
17. FRE + Airport Levee Mitigation Framework – not currently included in EDT model. No specific mitigation has been decided at this time and will not be included in Draft EIS model run.
    a. DESCICION – will not be included
18. Linking EDT to NOAA Lifecycle model – are there any additional decisions that need to be made by the Corp?
    a. Clarification from Jeff: EDT reflects an end state model. Life stage productivities and capacities from EDT feed into NOAA Lifecycle model. What flows to use for time-series need to be determined as well as proposed operations for project/no project and climate change.

Questions from Corp modelers – led by Elizabeth

Q: Is there a way to evaluate the impacts to salmonids from a flood event that occurs at fall vs spring?

A: Yes that is possible using different set of input parameters for different months.

Q: HEC-RAS modelers said seasonal effects don't really go into it? It that true?

A: Group did not understand how that can be since there are daily inputs. Clarification on modeling requests may help get a final answer on this.

Q: What about modeling periods between floods?

A: Some model runs aren't relevant/don't make sense, for example temperature during storage if it's winter. But, can look at change to habitat between flood events.

Q: Has sensitivity analysis on model been done? Are some inputs affecting results such as productivity more? Is there value to a sensitivity analysis?

A: No strict sensitivity analysis has been done. However, if we want to run through a range of input values and see resulting outputs that can be done.

Q: What are specific Quinault concerns on EDT?

A: Floodplain extent, sediment, predation have all been discussed. Nothing outstanding at this point.

Scheduling – led by Elizabeth

Current goal is starting EDT runs July 10 to Aug 6. Ideally, we would start a week earlier in July if we are able to.

QA/QC of EDT to be completed Aug 13

NOAA Lifecycle model integration would occur: Aug 14 – Sept 10, with QA/QC Sept 11 – Sept 17

Q: How will we fit in consultation with Quinault tribe?

A: Has not been formalized yet. Current plan is to move forward with what we have. Coordination on NEPA should be directly between tribe and Corp so they won't be on these calls. Team should focus on meeting our current deliverable schedule, including draft document due in late September shortly after QA/QC of NOAA Lifecycle model.

Deliverables and Deadlines

The group identified the following deliverables for which is it responsible and corresponding deadlines. Please note that the listed deadlines are currently proposed and not finalized.

DELIVERABLE	DEADLINE(S)	NOTES
EDT Modeling	July 10 – Aug 6	
EDT QA/QC	Aug 7 – Aug 13	
NOAA Lifecycle Modeling	Aug 14 – Sept 10	
NOAA Lifecycle Modeling QA/AC	Sept 11 – Sept 17	
Draft Document	Sept 17 – Nov 1	

CHEHALIS NEPA EIS MEETING NOTES

Group/Committee:	Fish Passage Survival Discussion
Topic:	Salmon passage survival values for inputs to models - Meeting #1
Date:	June 4, 2019
Time:	1:00 to 1:45 pm
Location:	Webex

Attendees

Diane Butorac (Ecology)
Greg Hoffman (Corps, Fisheries Technical Lead)
Janelle Leeson (Corps, Project Manager)
Neala Kendall (WDFW, Fisheries Biologist)
Elizabeth Greene (Anchor QEA, Fisheries Technical Lead)
Sydney Gonsalves (Anchor QEA, Fisheries Support/Note Taker)

Action Item Summary

ASSIGNED TO	ACTION ITEM
Diane/Janelle/Greg/Elizabeth	After Diane and Janelle figure out the communication plan, set up another meeting with the two teams. This may occur during the June 24th scheduled (tentatively) coordination call with SEPA/NEPA to discuss salmonid modeling input parameters.
Sydney/Elizabeth/Greg	Reach out to Ed Meyer at NMFS Portland

Notes

The purpose of these notes is to record key points, decisions, and discussion topics. They are not intended to be transcripts.

Intro and Purpose – led by Elizabeth

Purpose of the meeting is to review fish passage survival rates that were developed for the FRO and determine if the same values should be applied to FRE and discuss assumptions for applying survival rates to construction phase of the project. Passage survival is one of the inputs to the EDT and NOAA Lifecycle models and the NEPA team is currently reviewing and making decisions on EDT and NOAA

Lifecycle model input parameters. The NEPA team has reviewed previous research by Fish Passage Technical Subcommittee and recommended Chehalis Basin PEIS documents.

Review of available passage survival numbers from Tables 11-4 and 11-5 of FRO-FRFA Combined Dam and Fish Passage Conceptual Design Report – led by Elizabeth

Operations Period

- During normal operating conditions – both downstream and upstream passage is through conduits
    - Team understands that values in Table 11-4 from the FRO-FRFA Combined Dam and Fish Passage Conceptual Design Report were developed based on published culvert research and guidelines and best professional judgement by Fish Passage Technical Subcommittee. This is consistent with the SEPA approach.
    - FRE conduits are a little bit longer than FRO; 310 ft vs 240 ft, but team feels comfortable in applying the FRO numbers as long as NMFS and other established fish passage guidelines are followed.
- During storage in the FRE – upstream passage only will be trap and haul (CHTR)
    - Table 11-5 from the FRO-FRFA Combined Dam and Fish Passage Conceptual Design Report values are based on existing Oregon and Washington programs, real values from existing facilities. Team agrees that FRO developed values would be applicable to FRE.

Construction Period

- Upstream passage (primarily adult) via temporary CHTR
    - Reviewed FRE Alternative document, no survival values are provided
    - The NEPA team is currently discussing if the same passage values for the temporary trap and haul facility should be used. The temporary facility will not have same approach as permanent facility, but will have to follow same NMFS guidelines. Temporary facility will consist of a picket weir, fish ladder, holding tanks, and truck transport.
        - Diane: Recommended this be discussed in more detail at a future meeting. The SEPA team developed a cumulative survival rate, considering trapping efficiency, handling and transport survival, transport release, and delayed mortality. SEPA team talked to folks with experience using picket weirs.

    - Neala: suggests conversation with SEPA team on minor adjustments to juvenile upstream numbers and on more significant adjustments to adult upstream fish passage survival values.

- Downstream passage via diversion tunnel (much longer than the normal operation conduits, 1600 ft vs 300 ft)
  - NEPA team is currently discussing if the same passage values for the conduits should be used since the diversion tunnel is 1630 feet long relative to the conduits that are 310 feet long.
  - Diane – Recommended this be discussed in more detail at a future meeting.

Next steps – Diane and Janelle will determine communication plan between SEPA/NEPA, then will set up another meeting to talk with the two teams. This may occur during the June 24th meeting to coordinate on additional modeling items.

Diane said the SEPA team consulted Ed Meyer, NMFS Portland, on juvenile fish passage through diversion tunnel.

Scheduling – TBD

Deliverables and Deadlines

The group identified the following deliverables for which is it responsible and corresponding deadlines:

DELIVERABLE	DEADLINE(S)	NOTES

CHEHALIS NEPA EIS MEETING NOTES

Group/Committee:	Fish Modeling Discussion
Topic:	Discuss input parameters for EDT and NOAA Lifecycle models for NEPA EIS – Meeting #2
Date:	June 6, 2019
Time:	1:00 to 3:30pm
Location:	Webex

Attendees

Chip McConnaha (ICF, EDT Lead)
Laura McMullen (ICF, EDT Lead)
Tim Beechie (NOAA, LCM Lead)
Jeff Jorgensen (NOAA, LCM Lead)
Greg Hoffman (Corps, Fisheries Technical Lead)
Elizabeth Greene (Anchor QEA, Fisheries Technical Lead)
Sydney Gonsalves (Anchor QEA, Fisheries Support/Note Taker)

Action Item and Decision Summary

ASSIGNED TO	TOPIC	ACTION ITEM
Chip/Laura	Climate Change	Create list of attributes that are normally adjusted for climate change scenarios
Chip	SAR/Base run sizes	Coordinate communication and work with Tim and Jeff to finalize base salmon run numbers for model
Chip/Corp	Geo-morphology attributes	Check to see if NEPA team can use conclusions provided by Kathy Dube to score geomorphology attributes since those are consistent with NEPA assumptions. Will also check to see if NEPA can use the bed scour memo that Chip previously prepared for the same reason. The Corps is asking Ecology for both of these items.
Chip	FRE footprint attributes	Check with project management on sharing table of attributes in FRE footprint with NEPA team. (COMPLETED – this was sent by Chip on 6/10)

TOPIC	DECISION MADE
Modeling Scenarios	Model 2-year, 10-year, and 100-year scenarios with No Action and FRE/FRO alternatives for current, construction, mid-century, and late century time periods (TENTATIVE – need final confirmation)

TOPIC	DECISION MADE
Geographic Extent	Chehalis river mainstem, tributaries above and below dam, and tributaries flowing into Grays Harbor, but not Grays Harbor itself (TENTATIVE – need final confirmation)
Species	spring Chinook, fall Chinook, coho, steelhead (TENTATIVE – need final confirmation)
Metrics	Provide all four results metrics – productivity, capacity, abundance, diversity (TENTATIVE – need final confirmation)
Timeframe	Model current conditions, construction, mid-century, late-century (TENTATIVE – need final confirmation)

Notes

The purpose of these notes is to record key points, decisions, and discussion topics. They are not intended to be transcripts.

Review Action Items and Status from Meeting #1 – led by Elizabeth

Laura was to compile list of EDT attributes and previous values for team.

- Laura requests clarification on this. Should it be attributes and **sources** that were used previously? Yes.
    - Laura to go over much of this in presentation today

Overview of EDT-- details of how EDT works with examples of input parameters and scoring and example outputs– led by Laura

Slide Presentation on EDT (more details for team to review available in powerpoint file)

- Ecosystem Diagnosis and Treatment (EDT) Framework
    - Historic or template scenario – best reconstruction of system without human disturbance
    - Degraded scenario or worst possible scenario may be included
    - Current conditions, construction, mid-century, late-century – these would all be separate characterizations
    - For each scenario there will be a model run for each salmon species, evaluated in terms of habitat specific to the species
- Example of results: equilibrium abundance at different scenarios in time, including effects of current restoration or future climate change

- Results can be broken down by geography for each specific scenario and species
- Splice scenarios can be constructed – one reach is restored to historic condition to determine the effect on the rest of the reaches. Answers question of which reaches to restore to get greatest response.
    - Limiting Factors – can show which factors were most important in different reaches
- Elements that go into model:
    - System geometry (connectivity, length, obstructions)
    - Habitat attributes (vary by reach, month, and scenarios, dozens of environmental attributes)
    - Life histories (spawning locations, timing of life stage transition, speed; there are thousands of possible "trajectories" sampling the environment)
    - Combine habitat attributes with life histories using rules (survival factors- channel stability, temperature, sediment load) that degrade benchmark productivity and/or capacity by life stage. Benchmarks are:
        - Maximum fish density per life stage and species, survival per life stage, growth factor per life stage
    - Equilibrium abundance – overall system equilibrium based on capacity and productivity
- Other information
    - Salmon productivity is affected by environment at every life stage
    - Beverton-Holt function used to relate spawners, recruits, and carrying capacity
    - Life stages go into aggregated B-H function for each species
- Habitat attributes – characterized differently for each scenario while life histories and system geometry stay the same. This variation is what drives difference in model. Each can vary by monthly pattern if needed and by reach; 0 is very good habitat, 4 is poor habitat
    - Geometry – Width, Length
    - Passage – at obstructions or culverts- varies directly by species
    - Flow – diel variation, inter-annual high flow, inter-annual low flow, intra-annual variation, natural and regulated hydro regime (how different from natural flow regime from 0 to 4)
    - Channel structure – gradient, confinement (natural and artificial)
    - In-channel habitat – backwater pools, beaver ponds, glides, large cobble riffles, small cobble riffle, pool tails, scour pools. Must add to 100%

- Off-channel habitat – side-channel; seasonally inundated floodplain extent; floodplain ponds
- Temperature – daily maximum, one of the driving attributes of the model (number of days in month that are over a certain values); daily minimum; spatial variation of temperature
- Riparian function/Woody Debris
- Hydraulics/turbidity/stream bed – scour, embeddedness, fines, TSS
- Other water quality variables
- Biological – benthic richness; fish community richness; fish pathogens; non-native fish species; hatchery outplants; predation risk; salmon carcass
- Additional attributes – harassment (fishing, other disturbance); icing; water withdrawal

- Example attribute – non-native fish species, value rating = 0 for 1-2 non-natives, up to value rating = 4 for 15 or more non-native species
  - Would not vary by month, but would vary by geography
  - Values are backed up by literature on salmonid predation by non-native species
- Example attribute – maximum daily temp, value rating = 0 if warmest day is <10°C, up to value rating = 4 if >1 day is 27.5°C OR 3 consecutive days are > 25°C OR more than 24 days of >21°C
- Modeling of future scenarios – when there is no data, hypotheses are used to adjust currently available data

General Model Decisions – led by Elizabeth, Greg, Chip, Laura

- Project Description/Alternatives to model and scenarios
  - No Action
  - FRO/FRE are the same operationally but have different facility footprint and construction timeframes
    - Will be treated as one scenario in model
  - Scenarios to model: 10 year and 100 year flood recurrence intervals
    - How should these be characterized, by water year?
      - Chip: if you pick a specific year (for example to capture a spring flood) you are tied to the characteristic of that water year which might be have been otherwise a low-flow year.
      - Seasonality built into the model by the flows of the year chosen

        - Modeling a spring flood can be done, but would have to carefully look through water records for representative year
  - Include a 2-year event scenario – to show "normal" flow during periods when the FRE facility is not operating
  - Climate change – not included in baseline for NEPA, but may want to model as a scenario for discussion, but need to confirm
    - Tim: NOAA model will include the near term, how system bounces back from construction period, and 3 decades out for response to operations
      - 2025, construction, mid-century, late-century scenarios
    - Chip suggests putting together a list of attributes that are typically adjusted for climate change in case the Corps wants to model climate change. Action item: Chip/Laura
  - What about seasonality (winter storms vs spring storms), is this worth looking at?
    - Yes, timing of storm impacts different species spawning periods, versus winter storm impacting incubation period. See above discussion on choosing flow years.
    - Chip suggests communication with Ecology/SEPA on selection of future scenario flood years
  - What about back-to-back flood event scenarios?
    - This could be done by the NOAA Lifecycle model, normally assigned as a random event, but they can input additional events- back to back with another event, right after construction, etc.
  - **Tentative decision**—model 2-year, 10-year, and 100-year scenarios with No Action and FRE/FRO alternatives for current, construction, mid-century, and late century time periods. Need further discussion on modeling climate change, floods occurring in the spring, or back to back flood events.
- Geographic extent – Chehalis river mainstem, tributaries above and below dam, and tributaries flowing into Grays Harbor, but not Grays Harbor itself.
  - **Tentative decision** – still need final confirmation.
- Species – spring Chinook, fall Chinook, coho, steelhead.
  - **Tentative decision** – still need final confirmation.
  - Modeling habitat changes without salmon input can be used to evaluate impacts on other species

- Metrics (productivity, capacity, abundance, diversity)
  - Abundance and spatial structure are the most "popular" metrics. Adding additional output metrics doesn't add more time to modeling. All metrics are automatically generated as model results and can be used if needed.
  - Benefits – productivity is more reflective of quality of habitat vs quantity of habitat; abundance will be more reflective of width or amount of habitat. Chip cautions that additional outputs can also add confusion.
  - **Tentative decision**—provide all four metrics
- Timeframe-
  - **Tentative decision**—model current, construction, mid-century, late-century
- Smolt to Adult Return (SAR) estimates
  - Last meeting Chip had wanted to change name of this metric because it's more like relative run sizes (of salmon species) for input. Need to agree to a typical or representative run size for each species, so that we can look at relative changes in output metrics for different model scenarios. Inputs will not change by scenario
    - Chip suggests discussing with NOAA to get agreement on base run sizes to use. Action: Chip to coordinate communication with Tim/Jeff on finalizing base run sizes

Discussion of other models feeding into EDT – led by Elizabeth, Chip

- Hydrology (flow) 1D and 2D models (HEC-RAS)
  - Currently going through the process of requesting modeling runs that we will need
  - What work needs to be done before outputs can go into EDT? For the scenarios discussed today, this has been done by Anchor QEA (by Adam Hill and Bob Montgomery) and WSE and provided to ICF
  - Chip and Laura have the inputs for everything that has already been done. The Corps will request these inputs from the SEPA team.
- Temperature (CEQUALW2 Mainstem, Thermalscape/NorWest tributaries)
  - For the mainstem, been relying on PSU CEQUALW2, and it is currently undergoing an update that is way behind schedule.
    - If team wants to use what is currently available, ICF has FRO scenario modeling done in 2016, and current conditions update from 2017, so can use these datasets as a work around.
- Geomorphology

- EDT inputs are bed scour, wood, fine sediment, high and low flow shifts, and some habitat hypotheses come out of this on scour pools and backwater pools. Need geomorphology results to score the attributes and support hypotheses. Kathy Dube provided ICF a set of conclusions that were used to score the EDT inputs listed above. Action: Chip checking to see if NEPA team can use these conclusions since those are consistent with NEPA assumptions. Chip also checking to see if NEPA can use the bed scour memo that he previously prepared for the same reason. The Corps is officially asking Ecology for both of these items.

Preview of Meeting #3 – led by Elizabeth

- How will FRE change key attributes in footprint (wood in streams, riparian change). What are major changes above, within, and below FRE.
  - Chip suggests using table that was created for SEPA without the conclusions. Action: Chip to check with project managers about sending out table of FRE assumptions before next meeting. (Completed - This table has been provided by Chip).
- No Action Conditions to be discussed, but will mostly affect areas outside the study area
- Potentially move discussion of FRE Conditions that were scheduled in Meeting #4 into Meeting #3 if there is time
- Save salmon passage discussion for Meeting #4 as planned

Deliverables and Deadlines

The group identified the following deliverables for which is it responsible and corresponding deadlines. Please note that the listed dates are currently proposed and not final.

DELIVERABLE	DEADLINE(S)	NOTES
EDT Modeling	July 10 – Aug 6	
EDT QA/QC	Aug 7 – Aug 13	
NOAA Lifecycle Modeling	Aug 14 – Sept 10	
NOAA Lifecycle Modeling QA/AC	Sept 11 – Sept 17	
Draft Document	Sept 17 – Nov 1	

CHEHALIS NEPA EIS MEETING NOTES

Group/Committee:	Salmonid Impact Modeling Team
Topic:	Discuss input parameters for EDT and NOAA Lifecycle models for NEPA EIS – Meeting #3
Date:	June 13, 2019
Time:	1:30 to 3:00pm
Location:	Webex

Attendees

Chip McConnaha (ICF, EDT Lead)
Laura McMullen (ICF, EDT Lead)
Jeff Jorgensen (NOAA, LCM Lead)
Janelle Leeson (Corp, Project Manager)
Greg Hoffman (Corps, Fisheries Technical Lead)
Elizabeth Greene (Anchor QEA, Fisheries Technical Lead)
Sydney Gonsalves (Anchor QEA, Fisheries Support/Note Taker)

Action Item Summary

ASSIGNED TO	TOPIC	ACTION
Chip	Decisions for No Action Condition	Send out spreadsheet of attribute change due to tree growth
NEPA Team	Decisions for FRE Condition	Fill in FRE footprint attribute table of hypotheses. CURRENTLY IN PROCESS
Elizabeth	Decisions for FRE Condition	Check on details of tree/shrub height allowed in cleared area in current Vegetation Management Plan. (COMPLETED—Elizabeth checked with Matt Kuziensky and there has never been height criteria included in the Vegetation Management Plan.)
Jeff	Lifecycle Modeling	Look at historical record for characteristics of back-to-back events. (COMPLETED — Jeff provided Elizabeth the historical record to review to help identify the prevalence of previous 10-year and/or 100 year events in back to back years.)
Elizabeth/Ally	General	Change Meeting #4 to Friday morning on June 21st. Schedule Meeting #5 for Monday afternoon on June 24th (COMPLETED)

TOPIC	DECISION MADE

Notes

The purpose of these notes is to record key points, decisions, and discussion topics. They are not intended to be transcripts.

Meeting Objectives

1. Review decisions needed for No Action Conditions
2. Review decisions needed for FRE Conditions

Review Action Items and Status from Meeting #2 – led by Sydney and Elizabeth

- Run through actions from previous two meetings
- Janelle has another meeting with SEPA team tomorrow and will have an update on geomorphology attribute conclusions

Review EDT Environmental Attributes list – skip for now

- Good overview by Laura last time

Decisions for No Action Conditions – led by Elizabeth, Laura, Chip

- Notation: (+) assumed to have positive effect on salmon, (-) assumed to have negative effect on salmon
- Tree growth (+)
  - Chip: For the ASRP modeling effort, they convened a panel of experts to come up with hypotheses on what attributes are influenced by tree growth and how that will change aquatic conditions.
  - Panel tried to determine what would be the likely amount and direction of change from current conditions for attributes like temperature, channel stability, etc
  - Laura and Chip showed spreadsheets of attribute hypotheses and change calculations for riparian buffers of small and large streams. Attributes fall into the following categories:
    - Channel Form
    - Flow
    - Sediment
    - Water Quality
    - Community
    - Habitat type

    - Morphology
  -
- Culvert removal (+)
  - Chip received a table from WSDOT that included the culverts they expect to be removed because of the tribal injunction. There was no information provided on the specific timing; therefore, the ASRP model assumes 12 would be removed by 2040 and 12 more would be removed by 2080, but this timing is an estimate, not an exact schedule.
  - Locations of removed culverts are based on planning table from WSDOT

Q: Elizabeth – what are the relative benefits of tree growth and culvert removal?

A: Chip – culvert removal can be difficult to model, but in the end culverts don't have a large effect on model results. Most of existing culverts are in small tributaries, doesn't influence model very much because they are not big producing streams

A: Laura – tree growth has much larger effects on model results. Can reduce temperatures and covers a large area.

- Future climate (-) – skipping because it will not be included in baseline for NEPA modeling
- Habitat degradation (-)
  - Due to population increases – general change outside managed forest area is 5% degradation in 2040, 10% degradation in 2080, with additional focused change in high development areas
  - Same process was used as with tree growth to derive input parameters - panel of experts developed hypotheses about what the effects of development would likely be to determine which attributes to adjust
    - Received input from Ecology and WDFW on future projected land use patterns, which were used to determine the areas expected to have the greatest amount of development in 2040
    - Chrissy Bailey from the Office of the Chehalis Basin will be meeting with NEPA team tomorrow to discuss how future land use patterns were determined to support this effort.
  - Laura: without climate change, the effects of tree growth may cancel negative effects of habitat degradation from population growth.
- Future identified projects (e.g. ASRP) (+)
  - Includes five ASRP early action reaches, Chehalis Basin floodproofing improvement projects, USFWS fisheries restoration project, SRF Board projects

    - Team has already decided to include the five ASRP early action reaches in model; see notes from Meeting #1
    - Not enough information is known about floodproofing improvement projects, USFWS fisheries restoration projects, or SRF Board projects to include them in the model.

  - Chip: none of these no action elements besides tree growth will really change the modeled results for the two alternatives.

Decisions for FRE Condition – led by Chip, Elizabeth

- Confirm spatial components:
  - Above footprint
  - Within footprint
  - Below footprint (includes mainstem to reach with bedrock control near Adna, WA and tributaries)
- Fish Passage – Still working on these values
- Airport Levee – team decided not to include in model (see Meeting #1 notes)
- FRE Attributes table
  - Columns: attribute name, hypothesis, assumptions, source, and rational
  - Multiple tables provided to break down by seasonal conditions. Example: Winter, outlets in open positions
    - Above inundation footprint – no change
    - In inundation footprint – what is the story? Spatial extent, temp, channel width, sedimentation, flow etc.
    - When there is higher flow, but not enough to close dam, there will be some backup behind structure, but overall changes are small
    - Attributes are arranged in table in a cascading manner to direct reasoning
    - Then repeat the process for area below footprint, summer conditions, etc.
- Chip recommends team go through hypothesis column as an exercise, assigning expected change for each attribute
  - Chip and Laura available for guidance and would like to be included in the discussion
  - Laura: keep in mind what footprint is being considered, i.e. spatial extent for FRE floods, normal flow condition, flood interval, season
- In the model the 2-yr flow, open position is “normal”, punctuated by 10-yr and 100-yr events
  - No matter how long FRE flood storage actually is, model assumes that all production is lost in the footprint for that winter/year
  - Result is the same on fish production whether there are 1 or more FRE gate closures in a year

- Action: NEPA team to fill in table, loop in water resources and geomorphology teams to go through assumptions and rationale
  - Laura is available for additional help in this process
- FRE: Reservoir Degradation – this folds into the tables discussed above
  - Chip: littoral area has higher habitat value in the model than limnetic area of reservoir
  - Vegetation Management Plan: has changed slightly since 2016 on specifics of clearing and other details. Team has new information to work into FRE footprint tables
    - Chip: an important detail is if some growth is allowed (cottonwood, willow), and to what height, or if vegetation is completely cleared down to gravel. The amount of shading is important to temperature model
    - There will be some small shrubs/trees allowed. Action: Elizabeth to check on details of tree height allowed
- FRE: Mitigation —there is no information on mitigation; therefore it will not beincluded in model (see notes from Meeting #1)

Team Q and A

Q: Is anything else missing [in terms of modeling inputs] that needs to be discussed?
A: Chip, Laura, and Tim don't notice anything missing right now.

Q: Are any decisions needed from Corp for the Lifecycle model?
A: Jeff thinks he is set if all decisions are made for EDT. The exception is making decisions on sequential, back-to-back events to be included. For back-to-back events, what are the details of the events? Are they two 10-year floods, two 100-year floods, a mix? For construction period, what events will be added to the 2 to5 year period.

Q: For construction modeling is it important to know timing?
A: Jeff – yes, year and duration. There is a lot of work to be done, but as long as all EDT boxes are filled, they should be able to start after EDT is complete.

Q: Has NOAA looked at records to see if/when sequential or back-to-back events occurred?
A: Jeff has looked at some information. Needs to know if we expect any of these events to change in frequency in mid- late- century? Laura/Chip will be estimating conditions in mid- late- century. Could also just use statistical recurrence probability. Action: Jeff will take a look at the history of multiple events happening.

Plan for Meeting #4

- Are people available on Friday morning instead?
- Laura available (9am and after)
- Elizabeth: we need to spend time on homework of FRE footprint and pull some additional people in to assist with this
- Greg, Tim, are available at 9am as well. Janelle can be available.

- Action: Elizabeth/Ally will update meeting invite

Plan for Meeting #5

- Thursday afternoon doesn't work for Greg, possibly move to Monday 6/24, after 3
- Action: Elizabeth/Ally will update meeting invite

Deliverables and Deadlines

The group identified the following deliverables for which is it responsible and corresponding deadlines. Please note that this schedule is proposed and not finalized.

DELIVERABLE	DEADLINE(S)	NOTES
EDT Modeling	July 10 – Aug 6	
EDT QA/QC	Aug 7 – Aug 13	
NLC Modeling	Aug 14 – Sept 10	
NLC QA/AC	Sept 11 – Sept 17	
Draft Document	Sept 24?	Shortly after completing modeling QC

CHEHALIS NEPA EIS MEETING NOTES

Group/Committee:	Salmonid Modeling – Fish Passage Discussion
Topic:	Discuss passage survival with John Ferguson
Date:	June 21, 2019
Time:	12:00 to 1:30pm
Location:	Webex

Attendees

Greg Hoffman (Corps, Fisheries Technical Lead)
Elizabeth Greene (Anchor QEA, Fisheries Technical Lead)
John Ferguson (Anchor QEA, SEPA Fisheries Technical Lead
Sydney Gonsalves (Anchor QEA, Fisheries Support/Note Taker)

Action Item Summary

ASSIGNED TO	ACTION ITEM
Elizabeth	Confirm with Chip/ICF are planning to use latest temperature modeling data from 2017 (COMPLETE)
Sydney	Remove downstream adults and upstream smolt from salmon passage table for ICF (COMPLETE)
Sydney	Review passage references John sends (COMPLETE)

Meeting Objectives

1) Walk through the EDT Modeling Decisions the Corps has made

2) Walk through fish passage survival tables for construction and operation

Notes

The purpose of these notes is to record key points, decisions, and discussion topics. They are not intended to be transcripts.

EDT Modeling Decisions – led by Elizabeth

Elizabeth ran through the modeling decision table with John, only items where John gave input are recorded.

- NOAA Lifecycle model – comments received on PEIS were that the EDT modeling is too deterministic; John suggests identifying stochastic events that should be captured by NOAA

Lifecycle model. John recommends verifying the timeline that is assumed for the NOAA model (e.g., how long to model the fish lifecycle to see impacts).

- Spatial Extent –For the PEIS the whole basin was considered. John suggests using the hydraulic extent of change for the FRE to help make decisions. Hydraulic data describes how far down below FRE there will be physical habitat changes, but it's important to think about if EDT will pick up the change. Spatial extent helps get at the question, what are the basin-wide impacts?

- Species/Metrics – Chum aren't mainstem spawners and not in NOAA LCM. Productivity goes to "fishability" and this has been important to Quinault Indian Nation for ASRP work. John will send Elizabeth a spreadsheet of tribal comments on PEIS.

- Temperature – John suggests confirming that Chip is planning to use temperature modeling outputs related to FRO from 2017. This is the best available and includes reservoir adjustments by Bob Montgomery and Larry Karpack (WSE).

    - Action: Elizabeth to confirm with Chip/ICF are planning to use latest temperature modeling data from 2017.

- FRE Condition –

    - The benthic food condition is based on hypothesis, there are no specific studies that were conducted to address this condition.

    - John reiterated the important in carefully selecting the representative flood event year 2-yr (2011), 10-yr (1999), 100-yr (1996). The water year with the 10-year event could have overall more water than the year with 100-year event. Results are sensitive to years picked since its comparing the water years selected and not just a 10-yr or 100-yr flood event.

    - Floodplain – Fish need access to water but it has to be consistently available to provide a benefit. Short episodic flooding will not provide habitat for salmon.

- NOAA LCM – NEPA will be considering back to back flood events

- **Salmonid Passage** – EDT model can't handle downstream adults or upstream smolts. However, there is evidence of upstream juvenile movements in summer that can be included in written discussion. John suggests reviewing Winkowski and Zimmerman 2017 report (should be in resource library). Action: Sydney to remove downstream adults and upstream smolt from salmon passage table for ICF.

    - Reviewed NEPA assumptions/changes to passage tables for construction phase. John confirms talking to Ed Meyer on long tunnel passage will be a good idea.

- John suggests considering what will happen to downstream steelhead kelts because of weir
- John not clear on how temporary trap and transport would move juveniles upstream
- Neala Kendall may have information on effectiveness of weirs in western Washington, likely unpublished data
- Proposed capture efficiency will vary by species because of flow differences—weir has issues in the winter when steelhead and coho will be moving up
- Keefer et al. (2010) looked at effect of transporting fish on reproductive success. Post-release effects are worse if the water is warm and for Spring Chinook moving upstream, conditions in the river will be warm.
  - John doesn't think delayed survival was factored into the permanent CHTR. John to send some subsequent Willamette River studies. Action: Sydney to review passage references John sends.

CHEHALIS NEPA EIS MEETING NOTES

Group/Committee:	Salmonid Impact Modeling Team
Topic:	Discuss input parameters for EDT and NOAA Lifecycle models for NEPA EIS – Meeting #4
Date:	June 21, 2019
Time:	1:30 to 3:00pm
Location:	Webex

Attendees

Chip McConnaha (ICF, EDT Lead)
Laura McMullen (ICF, EDT Lead)
Jeff Jorgensen (NOAA, LCM Lead)
Janelle Leeson (Corp, Project Manager)
Greg Hoffman (Corps, Fisheries Technical Lead)
Elizabeth Greene (Anchor QEA, Fisheries Technical Lead)
Sydney Gonsalves (Anchor QEA, Fisheries Support/Note Taker)

Action Item Summary

ASSIGNED TO	TOPIC	ACTION
Laura	EDT Attributes	Laura to follow up on Chip's action to provide list of attributes that change with tree growth
Elizabeth	EDT Attributes	Elizabeth to finalized Food attribute hypotheses (COMPLETE)
Elizabeth	FRE Conditions Tables	Review tables and removed any conflicting information and clarify which attributes are referred to in Geomorphology Rating Table (COMPLETE)
Laura	SAR/Run ratios	Follow up with Chip and Tim to see when this task will be completed
NEPA Team	Modeling General	Finalize all EDT modeling tables and provide final decisions and input to ICF by early next week (COMPLETE)
Ally/Elizabeth	General	Cancel salmonid modeling meeting #5 on 6/24 (COMPLETE)

TOPIC	DECISION MADE
EDT and NOAA Lifecycle Modeling	See final Salmonid Modeling Matrix

Notes

The purpose of these notes is to record key points, decisions, and discussion topics. They are not intended to be transcripts.

Meeting Objectives

1. Review EDT attribute hypothesis Table for FRE and No Action Conditions
2. Review modeling decisions

Go over previous action items – Led by Sydney

- Laura takes tree growth attribute list Action Item that was assigned to Chip

Review of EDT attribute hypothesis Table for FRE – Led by Elizabeth

- Table 1: Assumed winter (September-February) conditions affected by the FRE dam: open position during 2-year flood year
    - In FRE - Reviewed "grey box" assumptions
        - Spatial extent – no change, no reservoir would form
        - TempMax – PSU CE-QUAL-W2 modeling output; PSU footprint no riparian shading scenario shows higher temperature than no project scenario
            - Elizabeth: will you use they results exactly from PSU model? Laura: Yes.
        - Channel Width – Use HEC-RAS modeling output; Based on the NEPA assumptions document, 8,000 cfs would flow freely through the FRE facility (>2yr flood event)
        - Review of geomorphology ratings table provided from yesterday's meeting with Kathy Dube
            - Has hypotheses for Bed Scour, LWD, Embeddedness, Fine Sediment, Min/Max Channel Width
            - Elizabeth: if we fill in this table will that be sufficient for ICF modeling?
            - Laura: Percent change (improvement or degradation) is sometimes preferable because template condition rating may not be 0. However,

this looks very well thought through by Kathy Dube. Yes, ICF can use ratings in table.

- Timing update: final information will come in from geomorphology team later today (6/21) and will be ready for ICF early next week

- Riparian Function – decrease by 80% in all impounded reaches, because of construction and maintenance that would remove most vegetation. There would be some woody/shrub regrowth but it would not be directly adjacent to channel. Herbaceous regrowth near channel expected to provide limited riparian function
- Food – benthic community would be degraded by 25%. Team still working on this one. Action: Elizabeth to finalized Food attribute hypothesis by 6/24.

- Below FRE-
    - Geomorphology attributes given in ratings table
    - Laura: Please change FRE Conditions table to say "see Geomorphology Ratings Table" for the attributes where ICF should refer to Kathy Dube's ratings table
    - FlowHigh – unchanged, HEC-RAS modeling output
    - Floodplain – unchanged, will not be affected by FRE
- Elizabeth: Does this all seem realistic? Laura: Yes.

- Table 2: Summer (March-August) following a winter with a 2-year flood when the FRE gates remain open.
    - Within FRE footprint- Reviewed "grey box" assumptions
        - MaxTemp – Use CE-QUAL-W2 model results, PSU modeling of No Riparian Shade
        - Channel Width – Use HEC-RAS model results
        - Flow Low – Use HEC-RAS model results
        - Riparian Function – 80% decreased hypothesis

- Geomorphology variable – use Kathy Dube's rating table (LWD, Fine Sediment, Habitat Types)
- Food – decrease 25% hypothesis. Elizabeth still working to finalize this attribute.

- Below FRE dam - review "grey box" assumptions
  - MaxTemp – Use CE-QUAL-W2 model results, PSU modeling of No Riparian Shade
  - Low Flow – Use HEC-RAS model results
  - Channel Width – Use HEC-RAS model results
  - Geomorphology attributes – use Kathy Dube's rating table (LWD, Fine Sediment)

- Table 3: Assumed 10 and 100 year flood event occurs during the winter (September-February) with FRE dam in the closed position during flood event.
  - Within FRE footprint – Reviewed "grey box" assumptions
    - Spatial Extent – fluvial habitat is eliminated, reservoir habitat created; use HECResSim modeling output
    - MaxTemp – use results from Anchor CE-QUAL-W2 modeling of 2007 and 2009 floods with October 2014 conditions
    - Channel Width – use model results from Anchor QEA HEResSim
    - Low Flow – use model results Anchor QEA HEC-REAS
    - Riparian Function – decreased by 90% within impounded reaches
    - Geomorphology attributes – use Kathy Dube's rating table (LWD, Fine Sediment, Habitat Types)
    - Food – decreased by 25%, still working on this
  - Below FRE
    - Geomorphology attributes – use Kathy Dube's rating table (Bed Scour, LWD, Fine Sediment)
    - FlowHigh – use model results from Anchor QEA HEC-RAS

        - Floodplain – incomplete, possibly use RiverFlow 2D data; rationale from wetland impact analysis report said that each floodplain inundation area will decrease by 9%
            - Laura hasn't seen this model output data yet. This may not make a large impact on the model.

- Table 4: Assumed summer (March to August) low flow conditions with FRE dam that was closed during previous winter under 10 and 100 year flood event.
    - In FRE footprint -
        - Spatial Extent – use results from Anchor QEA HEC-ResSim model
        - MaxTemp – use results from Anchor QEA CE-QUAL-W2 modeling
        - Channel Width – use results from Anchor QEA CE-QUAL-W2 modeling
        - FlowLow – use results from Anchor QEA CE-QUAL-W2 modeling
        - Riparian Function – decreased by 85% hypothesis
        - Geomorphology - use Kathy Dube's ratings table (LWD, Fine Sed, Habitat Types)
        - Food – decreased by 25%, not finalized
    - Below FRE
        - Geomorphology - use Kathy Dube's ratings table (Bed Scour, LWD, Fine Sediment)
        - MaxTemp – use CE-QUAL-W2 model results
        - FlowHIgh – use Anchor QEA HEC-RAS model results
        - Action: Elizabeth to go through table and remove any conflicting information and clarify which attributes are referred to Geomorphology Rating Table

Review of Salmonid Modeling Matrix master decision table – Led by Elizabeth

- NEPA team will give ICF the four tables
    - EDT Hypothesis table
    - Geomorphology Rating table

  - Salmonid Modeling Matrix
  - Fish Passage Survival Rates
- Decisions:
  - General Model: Alternatives – No Action/FRE/FRO; 2-yr (“normal flow”), 10-yr flood, 100-year flood scenarios, no climate change
  - General Model: Timeframe – Current, construction, mid-century, late century; climate change not considered.
  - Species – have gone over previously; Spring Chinook, Fall Chinook, Coho, Steelhead
  - Output metrics – Include all 4 metrics (abundance, spatial structure, productivity, and diversity) as outputs
  - Run ratio (SAR) – Chip and Tim were going to coordinate and determine. Action: follow up with Chip and Tim to see when they will complete this task.
  - Hydrology & Hydraulic – 2-yr (normal), 10-yr, 100-yr with and without project
  - Temp – use previously modeled temperatures from PEIS/ASRP with 2017 PSU update
  - Geomorphology – use Geomorphology Ratings Table
  - No Action – Use all assumptions used in ASRP except future climate, including inclusion of the 5 early action ASRP reaches. See Geomorphology Ratings Table for conditions.
  - FRE Spatial Components – Use three spatial components: above FRE footprint, within FRE footprint, below FRE (mainstem to point of bedrock control; tributaries)
  - Fish Passage – NEPA team has meeting with SEPA today, will provide additional table to ICF early next week
  - Airport Levee – not included in modeling
  - Modeling during FRE Construction – include in modeling
  - FRE Conditions Assumptions – conditions tables reviewed during this meeting
  - Mitigation Frame – not included in modeling

- Linking EDT to NOAA LCM – 2-year (normal), 10-year, 100-year flood scenarios; also include back to back events of a 10-year and a 100 -year flood events. Still making decision on which back to back events to include and order of events.

Questions/Discussion of Salmonid Modeling Decisions – Led by Elizabeth, Janelle

Q: What is the purpose of longer timeframes if we are not including climate change?

A: There is value in modeling future scenarios even without climate change because there are other future changes. Culvert removal, forest management, and development/land-use/population change will be included.

A: We could model climate change if we want to quantify differences, but will not be included in NEPA analysis.

Q: Would it add extra modeling time to model scenarios with and without climate change.

A: Yes, for EDT it would add time. For NOAA Lifecycle model it would not add extra time but they would need the inputs from EDT.

FINAL DECISION: do not model climate change in any scenarios since it adds time.

Janelle: her guidance then is not to run climate change for any scenario then.

Review of final plan – Led by Elizabeth

- Action: NEPA team to pull together all four tables for ICF and provide final decisions and input by early next week
- Likely won't need Meeting #5. Time will be better spent finalizing modeling tables
- Action: cancel meeting #5

CHEHALIS NEPA EIS MEETING NOTES

Group/Committee:	Salmonid Modeling – Fish Passage Discussion
Topic:	Discuss passage survival with Ed Meyer, NOAA
Date:	June 24, 2019
Time:	9:00 to 9:30am
Location:	Webex

Attendees

Ed Meyer (NOAA Fish Passage Engineer)
Greg Hoffman (Corps, Fisheries Technical Lead)
Elizabeth Greene (Anchor QEA, Fisheries Technical Lead)
Sydney Gonsalves (Anchor QEA, Fisheries Support/Note Taker)

Action Item Summary

ASSIGNED TO	ACTION ITEM
Sydney	Review any references sent by Ed or look on Bonneville Dam website for tunnel related reports.

Meeting Objectives

1) Discuss downstream diversion tunnel juvenile passage with Ed Meyer (NOAA). Specifically discuss the length of the diversion tunnel (1600 feet) relative to the conduit lengths (200 to 300 feet) and if the longer length of the diversion tunnel adds to mortality since the NMFS fish passage guidelines do not discuss culvert tunnel lengths that are 1600 feet long.

Notes

The purpose of these notes is to record key points, decisions, and discussion topics. They are not intended to be transcripts.

- Elizabeth gave a brief description of NEPA team's understanding of project, including construction period and passage options during construction
- Ed outlined areas for concern related to tunnel/conduit downstream passage for juvenile salmonids
  - Most injury and mortality is related to gate operation and debris build up on trash rack

    - There is a 12,000 ft tunnel at Bonneville 2nd power house, 4-5 ft diameter with water velocity in the 7-8 fps range that has good performance. Ed sent references for review.
    - Predators: concentrations at outfall when fish are disoriented
        - Cormorants
        - Bass
        - Observations mostly on the Columbia, less of an issue on smaller rivers
    - Upper end of operational velocity seems slightly high to Ed, unless the bottom is smooth concrete; if smooth concrete bottom, Ed did not think there would be much mortality associated with the diversion tunnel.
        - Concrete smoothness is important – it will probably be fine at first, but after a couple years as damage is caused by bed load and gravel, this could be problematic and cause injury to fish. Will depend on how long temporary diversion is in place.
    - The biggest problem Ed has seen with conduits is with gate operation. Closing gates up to 80% for flow regulation caused mortality and descaling
        - Gates should be open greater than 50% and this can also be a place that debris hangs up
    - Review Bonneville corner collector at Washington shore powerhouse. Ed will look for reference or look on Corp website under Bonneville. Action: Sydney to review any references sent by Ed or look in Bonneville website for tunnel related reports.
- Overall conclusion—the act of going through the longer diversion tunnel (1600 feet long) shouldn't cause any additional mortality than going through the conduits (200 to 300 feet long) and the biggest issue with going through the conduits is increased mortality when the gates are partially closed

Attachment D
Salmonid Modeling Matrix of Decisions

Chehalis NEPA EIS
7.26.2019
Salmonid Impact Modeling
Decisions Made by the Corps

MODEL	CATEGORY	CURRENT INPUTS/ASSUMPTIONS USED FOR ASRP AND PEIS	DECISION NEEDED FROM CORPS	CORPS DECISION	NOTES AND RATIONALE
EDT/NOAA LCM	General Model Decisions: Alternatives to Model		What alternatives will be modeled?	No Action and FRE /FRO ; 2 year ("normal flow"), 10-year flood, 100-year flood scenarios; and construction	The 10-year flood was chosen because it is similar to the 7-year flood, which will trigger operation of the flood retention facility. The 100-year flood scenario was chosen because the facility is being designed for up to a 100-year flood. The 2-year flood was chosen to represent "normal flow" when flood conditions are not occurring. Climate change will not be included in the model scenarios.
EDT	General Model Decisions: Timeframe	Current; Mid-century (2040); Late-century (2080)	What timeframes should be used in the model?	Use current/construction, mid-century, late century; overall the EIS analysis starts in 2025 and goes through 2080	No Action Alternative considers changing conditions through time. Construction = 2025-2030; mid-century = 2040; late century = 2080.
EDT	General Model Decisions: Geographic Extent	Chehalis River and tributaries above and below the proposed dam site down to Grays Harbor, but does not include Grays Harbor; based on NHD Hydrology Dataset and SWIFD fish distribution dataset	What should the geographic scope be for the model?	Chehalis River and tributaries above and below the proposed dam site down to Grays Harbor, including the tributaries that flow into Grays Harbor, but does not include Grays Harbor. Impacts to salmon species will be provided for the entire basin and by sub-basin.	Geographic extent is for modeling purposes only to capture conditions in the entire basin. The study area for aquatic species and habitat includes the Chehalis River from river mile (RM) 114 to approximately RM 33, near Porter, including the 100-year floodplain. The study area also includes areas related to the proposed flood retention facility, the full extent of the temporary reservoir, airport levee improvements, and all areas affected by construction (e.g., diversion tunnel site, staging areas, quarries, and improved access roads) and operation, plus a 100-foot
EDT/NOAA LCM	General Model Decisions: Species	4 species--spring CH; fall CH; coho; steelhead; No Chum because all production of Chum is in lower tribs not likely impacted by the proposed action; also #s were large and skewed results	What species should be included in the models?	Use Spring Chinook, Fall Chinook, Coho, and Steelhead	Chum are not included in the model because they spawn in tributaries to the Chehalis in the lower portion of the basin and not in the mainstem (Edwards and Zimmerman 2018) and therefore are assumed to not be impacted by the flood retention facility. Chum are also not included in the NOAA LCM.
EDT	General Model Decisions: Metrics	Metrics: Abundance and Spatial Structure (distribution of production across the landscape)	EDT can calculate 4 metrics, including: Abundance, Spatial Structure, Productivity (R/S), and Diversity (array of physical, behavioral, and life histories). Which of these metrics should the model be used to estimate?	Include all 4 metrics (abundance, capacity, productivity, and diversity) as outputs	Including all metrics to get the full picture of potential impacts on salmonids.
EDT	General Model Decisions: Marine survival estimates (Calibration number)		Use the same marine survival estimates as ASRP modeling?	Use the same numbers used for ASRP	This input scales population numbers by species relative to each other. The values do not change by scenario.
EDT	Status of H&H Model (feeds into EDT)	Hydrology (flow): 2D model; Hydraulic (HEC-RAS) HEC-RAS provides direct flow attributes, annual hydrograph, and channel width for the mainstem Chehalis; also provides extent of floodplain habitat	What flow recurrence intervals should be modeled?	2-year (normal), 10-year, 100 year with and without project	Use the HEC-RAS inputs that Adam Hill (AQ) prepared for the scenarios selected for use in the NEPA EIS, which have already been prepared.

Chehalis NEPA EIS
7.26.2019
Salmonid Impact Modeling
Decisions Made by the Corps

MODEL	CATEGORY	CURRENT INPUTS/ASSUMPTIONS USED FOR ASRP AND PEIS	DECISION NEEDED FROM CORPS	CORPS DECISION	NOTES AND RATIONALE
EDT	Temperature Model Results (feeds into EDT)	Tribs: Chehalis Thermalscape (CT) model expanded to estimate daily max temp (May-Sept) using WDFW data; will use NorWest model Mainstem: PSU: CE-QUAL-W2 model	What temperature data should be used?	Use temperature data that has been used previously for ASRP/PEIS, including a PSU model update from 2017.	This is the best available temperature data.
EDT	Geomorphology Model Inputs (bed scour, habitat types, large wood, sedimentation)		Decide on geomorphology conditions for 2 year, 10 year, and 100 year scenarios for FRE	See Geomorphology Ratings Tables in Appendix E	Geomorphology ratings table will be used as guidance; with alterations from table documented
EDT	No Action Conditions	Changing baseline over time 1. Tree growth within managed forests that will reduce temperature and increase LW (+) 2. Removal of culverts under tribal injunction 12 WSDOT culverts removed by 2040 and 12 by 2080 (+) 3. Future climate (-) 4. Habitat degradation due to population increases (General change outside managed forests: 5% degradation in 2040 and 10% degradation in 2080 for attributes directly impacted by development; Focused change in high development areas (additional degradation of habitat potential in the model)	What assumptions should be used for baseline conditions?	Use all assumptions used in ASRP except future climate, including incorporation of the 5 early action ASRP reaches	Chip and Laura reviewed the tree growth in riparian areas of managed forests through time assumptions and rationale as well as the culvert removal assumptions during Technical Meeting 3. The NEPA Team met with Chrissy Bailey (Office of the Chehalis Basin) on 6/14 to discuss the habitat degradation assumptions. The assumptions and rationale for all of these No Action conditions were well thought out and reasonable and for this reason, the NEPA Team agreed with including these conditions in the No Action Alternative. The Corps decided not to include future climate as part of the No Action Alternative.
EDT	No Action Conditions and Assumptions		Decide on geomorphology conditions for 2 year, 10 year, and 100 year scenarios without FRE	See Geomorphology Ratings Table in Appendix E.	Geomorphology ratings table will be used as guidance, with deviations from it documented by the modelers.
EDT	FRE: split into three spatial components	Above the FRE footprint Within the FRE footprint (+ fish passage survival) Below the FRE (mainstem to point of bedrock	Confirm spatial components	Use three spatial components: above FRE footprint, within FRE footprint, below FRE (mainstem to point of bedrock control	These are the spatial components needed to capture impacts of the flood retention facility on salmonids.
EDT	FRE: Fish Passage	PEIS used fish passage values developed by the Fish Passage Technical Subcommittee of the Chehalis Basin Water Retention Committee, using professional judgment and review of fish passage	What fish passage survival % should be used for both construction and operation?	See Fish Passage Survival Rates Tables in Appendix C.	
EDT	Airport Levee Consideration	Was not separated out in the model due to airport levee having minimal impacts on salmonid habitat	Should the Airport Levee portion of the project be modeled separately?	Do not include Airport Levee	Based on previous model results for the PEIS, the Airport Levee had minimal impacts on salmonid habitat. As such, these impacts will be discussed qualitatively in the EIS.

Chehalis NEPA EIS
7.26.2019
Salmonid Impact Modeling
Decisions Made by the Corps

MODEL	CATEGORY	CURRENT INPUTS/ASSUMPTIONS USED FOR ASRP AND PEIS	DECISION NEEDED FROM CORPS	CORPS DECISION	NOTES AND RATIONALE
EDT	FRE: Modeling during Construction	Construction of FRE expected to occur from 2025 to 2030	Should the construction phase be modeled?	Include construction phase	Use 2-year FRE Current scenario with different fish passage survival from Fish Passage Survival Rates Tables in Appendix C.
EDT	FRE: Conditions and Assumptions	Review Tables of key FRE condition assumptions	What are the FRE conditions and assumptions?	See FRE Conditions Tables in Appendix D.	
EDT	FRE: Mitigation Framework	Not included in the ASRP model	How should mitigation be incorporated, if at all?	Do not incorporate mitigation into the model	It is too early to include mitigation in the modeling.
EDT/NOAA LCM	Linking EDT to NOAA LCM	Approach: EDT estimates productivity and survival and those values are then plugged into the NOAA LCM to see how life cycles are impacted	Confirm that this approach is appropriate. Any other decisions needed on inputs?	2-year (normal), 10-year, 100 year flood scenarios; also include back to back events of a 10-year and a 100 -year flood event	Jeff Jorgenson (NOAA) provided a graph of the historic record, which shows that variability and frequency of flood events has been increasing through time and that back to back events have occurred in the past (back to back 10 year events), so it is realistic to consider. The 10 and 100 year events were selected because storms are getting more intense, so wanted to capture a larger event than a 10 year. The back to back modeling scenario will provide an indication of potential impacts associated with a back to back event and will allow us to qualitatively address the potential impacts of multiple back to back events.

Attachment E
Geomorphology Ratings Tables

Explanation of how variables were set
Kathy Dubé 4/2/19

VARIABLE	ASSUMPTIONS/DISCUSSION
Bed Scour	Bed scour was estimated based on measurements from scour monitor results described in 2017 geomorphology report (monitors placed upstream from RM 88). Changes were based on increases in peak flows under various scenarios (lower 10- and 100-year peaks between the FRE facility and Elk Creek with the FRE facility operating). Additional monitors were set in summer 2018 down to confluence with Newaukum but data have not been collected yet. Summer following assumes no bed scour since flows during summer months not high enough for scour.
LWD	LWD is based on observations made during float trip from RM 108-Newaukum River confluence during summer 2018, which is described in the 2019 Chehalis EIS Geomorphology and Sediment Transport report. Change in LWD is based on assumption that all LWD from upstream of the FRE facility will be removed from system since no specific information has been provided on what happens to LWD collected in impoundment.
Embeddedness	Embeddedness is based on observations made during float trip from RM 108-Newaukum River confluence during summer 2018, which is described in the 2019 Chehalis EIS Geomorphology and Sediment Transport report. With-FRE facility changes assume sediment deposition in FRE facility impoundment and subsequently eroded and moved downstream, but will take several years so summer-following impoundment is similar to winter conditions.
Fine Sediment	Fine sediment is based on observations made during float trip from RM 108-Newaukum River confluence during summer 2018, which is described in the 2019 Chehalis EIS Geomorphology and Sediment Transport report. With-FRE facility changes assume sediment deposition in FRE facility impoundment and subsequently eroded and moved downstream, but will take several years so summer-following impoundment is similar to winter conditions.
Max channel width	Changes in channel width are relative to existing (2018) conditions and are based on Anchor QEA HEC-RAS modeling results and observations of width change following 2007 event based on observations of aerial photographs and changes in peak flows (10- and 100-year peaks lower just downstream of the FRE facility) under with-FRE facility conditions.
Min channel width	
Change in Habitat Type (descriptive)	Changes in habitat type are based on changes from current (2018) conditions. Little change is anticipated except in FRE facility impoundment area.

Explanation of how variables for w/FRE options were changed from Kathy Dubé's values by NEPA Team (Kathy Ketteridge and Kyle List)
6/21/2019

VARIABLE	ASSUMPTIONS/DISCUSSION
Changes to EDT Values	Changes are noted in RED text in EDT Value Tables. Comment call-outs added to cells for reference in EDT Value Tables.
General	Noted in table titles that the summer inputs relate to LOW FLOW conditions following the specified flood event which actually occurs in the previous winter season. We assumed that NO ACTION values are correct because Kathy Dube based her analyses on field data, site recon and her significant knowledge of the system. We also assume that her evaluation of the system represented by the values for NO ACTION are also true (i.e., bed erosion for NO ACTION is more significant during flood events upstream and decreases downstream). In addition, no changes have been made to NO ACTION values from Kathy Dube's original numbers.
Bed Scour	Changes made to bed scour with FRE for Summer (following flood) conditions. We assume that some fine sediment will be deposited in the impoundment pool area and then will scour as the impounded waters move downstream.
LWD	No changes made.
Embeddedness	Changes made to embeddedness with FRE for Summer (following flood) conditions. We assume that some fine sediment will be deposited in the impoundment pool area and then will scour as the impounded waters move downstream.
Fine Sediment	Changes made to fine sediment with FRE for Summer (following flood) conditions. We assume that some fine sediment will be deposited in the impoundment pool area and then will scour as the impounded waters move downstream.
Max channel width Min channel width	No changes made.
Change in Habitat Type (descriptive)	No changes made.

Chehalis EDT - Geomorphology Input from Kathy Dube that was Updated by NEPA Team (Kathy Kette current hydrology

2-year @ Doty	10,000
10-year @ Doty	19,000
100-year @ Doty	36,000

NOTE: if "no change" assume for all cells in array unless noted

NO ACTION

Winter - means just after impoundment ends

No Action Current

2-YEAR FLOOD WINTER (Includes an actual 2 year flood event in winter season)

	Mainstem Chehalis Reach	River Mile	Bed Scour	LWD	Embeddedness	Fine Sediment	Max channel width	Min channel width	Change in Habitat Type (descriptive)
54-55	Newaukum to Sterns	75.5 to 80	0	2	4	4	no change	no change	no change
56-62	Sterns to South Fork	80 to 88	1	4	2	1			
63-66	South Fork to Bedrock reach	88 to 93.5	1	4	1	0			
67-77	Bedrock reach to Elk Creek	93.5 to 100	1	4	1	0			
78-83	Elk Creek to Pe Ell	100 to 106.5	2	3	0	0			
84-85	Pe Ell to Dam	106.5 to 108	2	3	0	0			
86+	Impoundment Area	108 to 114	3	3	0	0			

WITH FRE

FRE Current

2-YEAR FLOOD WINTER (Includes an actual 2 year flood event in winter season)

	Mainstem Chehalis Reach	River Mile	Bed Scour	LWD	Embeddedness	Fine Sediment	Max channel width	Min channel width	Change in Habitat Type (descriptive)
54-55	Newaukum to Sterns	75.5 to 80	0	2	4	4	no change	no change	no change
56-62	Sterns to South Fork	80 to 88	1	4	2	1			
63-66	South Fork to Bedrock reach	88 to 93.5	1	4	1	0			
67-77	Bedrock reach to Elk Creek	93.5 to 100	1	4	1	0			
78-83	Elk Creek to Pe Ell	100 to 106.5	2	3	0	0			
84-85	Pe Ell to Dam	106.5 to 108	2	3	0	0			
86+	Impoundment Area	108 to 114	3	3	0	0			

NO ACTION

Winter - means just after impoundment ends

2-YEAR FLOOD Following Summer (All low flow events FOLLOWING a 2 year flood in previous winter)

Bed Scour	LWD	Embeddedness	Fine Sediment	Max channel width	Min channel width	Change in Habitat Type (descriptive)
0	2	4	4	no change	no change	no change
0	4	2	1			
0	4	1	0			
0	4	1	0			
0	3	0	0			
0	3	0	0			
0	3	0	0			

10-YEAR FLOOD WINTER (Includes an actual 10 year flood event in winter season)

Bed Scour	LWD	Embeddedness	Fine Sediment	Max channel width	Min channel width	Change in Habitat Type (descriptive)
1	2	4	4	no change	no change	no change
1	4	2	1			
2	4	1	0			
2	4	1	0			
3	3	0	0			
4	3	0	0			
4	3	0	0			

WITH FRE

2-YEAR FLOOD Following Summer (All low flow events FOLLOWING a 2 year flood in previous winter)

Bed Scour	LWD	Embeddedness	Fine Sediment	Max channel width	Min channel width	Change in Habitat Type (descriptive)
0	2	4	4	no change	no change	no change
0	4	2	1			
0	4	1	0			
0	4	1	0			
0	3	0	0			
0	3	0	0			
0	3	0	0			

10-YEAR FLOOD WINTER (Includes an actual 10 year flood event in winter season)

Bed Scour	LWD	Embeddedness	Fine Sediment	Max channel width	Min channel width	Change in Habitat Type (descriptive)
1	2	4	4	no change	no change	no change
1	4	2	1			
2	4	1	0			
2	4	1	0			
2	4	0	0			
2	4	0	0			
3	4	**2**	**2**	slight incre	slight incre	fewer pools
				slight increase = +2-3 f		

NO ACTION

Winter - means just after impoundment ends

10-YEAR FLOOD Following Summer (All low flow events FOLLOWING a 10 year flood in previous winter)

Bed Scour	LWD	Embeddedness	Fine Sediment	Max channel width	Min channel width	Change in Habitat Type (descriptive)
0	2	4	4	no change	no change	no change
0	4	2	1			
0	4	1	0			
0	4	1	0			
0	3	0	0			
0	3	0	0			
0	3	0	0			

100-YEAR FLOOD WINTER (Includes an actual 100 year flood event in winter season)

Bed Scour	LWD	Embeddedness	Fine Sediment	Max channel width	Min channel width	Change in Habitat Type (descriptive)
3	2	4	4	increase	increase	no change
3	4	2	1			
3	4	1	0			
4	4	1	0			
4	3	0	0			
4	3	0	0			
4	3	0	0			

WITH FRE

10-YEAR FLOOD Following Summer (All low flow events FOLLOWING a 10 year flood in previous winter)

Bed Scour	LWD	Embeddedness	Fine Sediment	Max channel width	Min channel width	Change in Habitat Type (descriptive)
0	2	4	4	no change	no change	no change
0	4	2	1			
0	4	1	0			
0	4	1	0			
0	4	0	0			
0	4	0	0			
1	4	1	1	slight incre	slight incre	fewer pools
				slight increase = +2-3 f		

100-YEAR FLOOD WINTER (Includes an actual 100 year flood event in winter season)

Bed Scour	LWD	Embeddedness	Fine Sediment	Max channel width	Min channel width	Change in Habitat Type (descriptive)
3	2	4	4	increase	increase	no change
3	4	2	1			
3	4	1	0			
3	4	1	0			
2	4	0	0			
2	4	0	0			
4	4	3	3	increase	increase	fewer pools
				** increase = +5 feet		

Bed scour:	10 cm	0.328084	feet
	18 cm	0.590551	
	24 cm	0.787402	

NO ACTION ***Winter - means just after impoundment ends***

100-YEAR FLOOD Following Summer (All low flow events FOLLOWING a 100 year flood in previous winter)

Bed Scour	LWD	Embeddedness	Fine Sediment	Max channel width	Min channel width	Change in Habitat Type (descriptive)
0	2	4	4	increased	increased	no change
0	4	2	1			
0	4	1	0			
0	4	1	0			
0	3	0	0			
0	3	0	0			
0	3	0	0			

WITH FRE

100-YEAR FLOOD Following Summer (All low flow events FOLLOWING a 100 year flood in previous winter)

Bed Scour	LWD	Embeddedness	Fine Sediment	Max channel width	Min channel width	Change in Habitat Type (descriptive)
0	2	4	4	increased	increased	no change
0	4	2	1			
0	4	1	0			
0	4	1	0			
0	4	0	0			
0	4	1	1			
2	4	2	2	increase	increase	fewer pools

** increase = +5 feet

Attachment F
Historical Flood Graph

Chehalis River flows at Grand Mound

Here are Chehalis River flow data at Grand Mound, from the Grand Mound USGS (12027500) gage:

```
# Get flow data:
require(EGRET)
```

```
## Loading required package: EGRET
```

```
siteNumber <- "12027500" #Grand Mound USGS gage
startDate <- "" # Get earliest date
endDate <- "2018-09-30" # through water year 2018
Daily <- readNWISDaily(siteNumber, "00060", startDate, endDate)
```

```
## There are 32872 data points, and 32872 days.
```

Here is a plot of the flow data:

```
# Plot of data:
#  Get daily maximum flows and use
#  a multiplier to convert flows to thousand cubic feet per second
#  from library(EGRET)'s printqUnitCheatSheet:
flows <- tapply(Daily$Q, Daily$waterYear, max)*0.03531467
flow.trigger <- 38 # what is the proposed FRE-closure flow trigger value?
plot(as.numeric(names(flows)),
     flows, type="b",
     xlab="", ylab="Maximum flow (kcfs)",
     ylim=c(0,70), yaxs="i", xlim=c(1920, 2020), xaxs="i",
     las=1, main="Grand Mound, WA USGS 12027500",
     pch=21, bg=ifelse(flows >= flow.trigger, "orangered", "black"),
     col=ifelse(flows >= flow.trigger, "orangered", "black"))
abline(h=flow.trigger, lty=2, lwd=2)
flows.high <- flows[flows >= flow.trigger]
text(as.numeric(names(flows.high)), flows.high + 3,
     as.numeric(names(flows.high)),
     col="black", cex=0.8)
legend("topleft",
       legend=c(paste("At or above ", flow.trigger, " kcfs"),
                paste("Below ", flow.trigger, " kcfs")),
       bty="n", pch=21, pt.bg=c("orangered", "black"),
       col=c("orangered", "black"))
```

A plot of the maximum flow (in units of a thousand cubic feet per second, kcfs) in a given water year, for water years 1929 - 2018, shows that year-to-year variability of maximum flows increased in more recent years compared to earlier years in the time series, and that there were more frequent maximum flows above 38 kcfs (dashed line; what is the proposed FRE gate closure flow

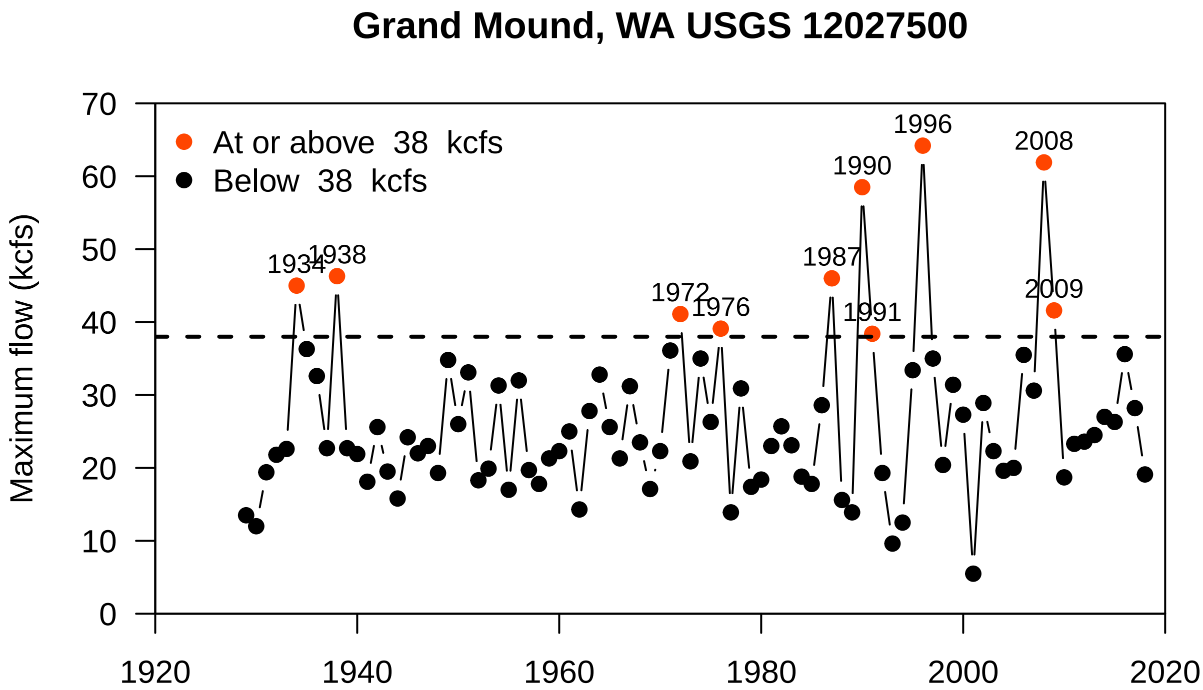


Figure 1: Chehalis River maximum daily at Grand Mound, WA, USGS gage 12027500.

trigger level?) at the Grand Mound USGS gage in more recent years. Also, in the more recent period there were two times when maximum flows reached or exceeded 38 kcfs in two consecutive years, water years 1990 - 1991, and 2008 - 2009.

Attachment G
FRE Facility Conditions for EDT

*Table 1. Assumed **winter** (September-February) conditions affected by the FRE dam: **open** position during 2-year flood year*

EDT Attribute	Direction	Assumption	Source	Rationale
Above inundation footprint				
No change from Current modeled condition				
Within Inundation footprint (Open Position) The 2-year flow condition would be assumed in the intervening years between the 10- and 100-year floods. During a 2-year flood, we assume that the FRE gates would remain open. An area above the dam, delineated by the 10-year flood inundation footprint, is assumed to be affected by the periodic inundations in all years (expanded in the 100-year flood condition. Within this footprint, habitat would be degraded in the 2-year flood condition: riparian function would be decreased due to tree removal from the riparian corridor during the initial construction phase, and sediment would increase due to inundation during larger floods. There would be a progression of improvement in riparian function in response to the length of time between FRE retention events. Longer periods of time between successive retention events would allow the vegetation in the riparian corridor to more fully develop without disturbance from flooding or sediment deposition. Worst case scenario would be a situation where there would be a recent retention event. Best case scenario would be a period of 7 to 10 years between retention events where routine tree removal has yet to be performed. Assumptions included in the table are for the worst case scenario.				
Spatial Extent	*Unchanged*	*No reservoir would form*		*Based on the NEPA assumptions document, 8,000 cfs would flow freely through the FRE facility, which is higher than a 2yr flood event.*
TempMax (winter)	*Use model results*		*PSU CE-QUAL-W2 modeling*	*PSU footprint no-riparian shading scenario shows higher temperature*

EDT Attribute	Direction	Assumption	Source	Rationale
				than no-project scenario in early winter (Sept.) (PSU 4/2017 report Figure 181)
Channel Width	*Use model results*		*Anchor QEA HEC-RAS*	*Based on the NEPA assumptions document, 8,000 cfs would flow freely through the FRE facility, which is higher than a 2yr flood event.*
Habitat types	*See Geomorphology Ratings Tables*			*Geomorphology ratings table will be used as guidance, with deviations documented*
Large Wood	*See Geomorphology Ratings Tables*			*Geomorphology ratings table will be used as guidance, with deviations documented*
Fine Sediment	*See Geomorphology Ratings Tables*			*Geomorphology ratings table will be used as guidance, with deviations documented*
FlowHigh	*Use model results*		*Anchor QEA HEC-RAS modeling*	*The 2-year flow and high baseflows will not be affected by the FRE.*
Flow Shape	*Use model results*		*Anchor QEA HEC-RAS modeling*	*The 2-year flow and high baseflows will not be affected by the FRE.*
Riparian Function	*Decreased*	*Decrease current riparian function by 80% within*	*Hypothesis*	*Riparian function attribute in EDT is strongly linked to riparian vegetation. All riparian forest would*

EDT Attribute	Direction	Assumption	Source	Rationale
		all impounded reaches		*be eliminated along inundated reaches during reservoir construction. Continuing maintenance would remove all trees ≥6 inches dbh on a 7 to 10 year maintenance cycle. Willows and other shrubs are expected to develop in the floodplain but many are not directly adjacent to the channel. Herbaceous vegetation that does develop in riparian areas is expected to provide limited riparian function and will be dormant or dead during the winter. No quantitative estimate of riparian condition is available.*
Food	*Decreased*	*Degrade benthos ratings by 25%*	*Hypothesis*	*Benthic community would be disrupted by inundations plus increased fine sediment. Reduction in riparian zone would also disrupt input of land based food sources. There is no quantitative estimate of food availability.*
Below FRE Dam				

EDT Attribute	Direction	Assumption	Source	Rationale
Bed Scour	*See Geomorphology Ratings Tables*			*Geomorphology ratings table will be used as guidance, with deviations documented*
Large wood	*See Geomorphology Ratings Tables*			*Geomorphology ratings table will be used as guidance, with deviations documented*
Fine sediment	*See Geomorphology Ratings Tables*			*Geomorphology ratings table will be used as guidance, with deviations documented*
FlowHigh	*Use model output*		*Anchor QEA HEC-RAS modeling*	*The 2-year flow and high baseflows will not be affected by the FRE.*
Floodplain	*Unchanged*			*The 2-year flow will not be affected by the FRE.*

*Table 2. **Summer** (March-August) following a winter with a 2-year flood when the FRE gates remain open.*

EDT Attribute	***Hypothesis***	***Assumption***	***Source***	***Rationale***
Above inundation footprint				
No change from Current modeled condition				
Within inundation footprint *During the summer following a winter in which the FRE gates remained open (i.e. 2-year flood condition), it is assumed that habitat within the inundation footprint (10-year flood) would be degraded due to the effects of periodic inundation, increased sedimentation and removal of riparian forest. There would be an increase in vegetation, but it is expected to be herbaceous species rather than shrubs. There would be a progression of improvement in riparian function in response to the length of time between FRE retention events. Longer periods of time between successive retention events would allow the vegetation in the riparian corridor to more fully develop without disturbance from flooding or sediment deposition. Worst case scenario would be a situation where there would be a recent retention event. Best case scenario would be a period of 7 to 10 years between retention events where routine tree removal has yet to be performed. Assumptions included in the table are for the worst case scenario. Some recovery of habitat would occur in the intervening years, however, and it is assumed that the degradation of habitat would be less than would occur in a summer following a winter in which the FRE gates would be closed to store a 10 or 100-year flood.*				
Maximum Temperature	*Use model results*		*PSU CE-QUAL-W2 modeling*	*Use PSU modeling for No Riparian Shade alternative (PSU 4/2017 report Figure 181).*
Channel Width	*Use model results*		*Anchor QEA HEC-RAS modeling*	*Based on the NEPA assumptions document, 8,000 cfs would flow freely through the FRE facility, which is higher than a 2yr flood event.*

EDT Attribute	Hypothesis	Assumption	Source	Rationale
Low Flow	*Use model results*		*Anchor QEA HEC-RAS modeling*	*Low flows will not be affected by the FRE.*
Riparian Function	*Decreased*	*Decrease current riparian function by 80% within all impounded reaches*	*Hypothesis*	*Riparian function attribute in EDT is strongly linked to riparian vegetation. All riparian forest would be eliminated along inundated reaches during reservoir construction. Continuing maintenance would remove all trees ≥6 inches dbh on a 7 to 10 year maintenance cycle. Willows and other shrubs are expected to develop in the floodplain but not directly adjacent to the channel. Herbaceous vegetation is expected to develop in many riparian areas but provide limited riparian function. No quantitative estimate of riparian condition is available.*
Large Wood	*See Geomorphology Ratings Tables*			*Geomorphology Ratings Table will be used as guidance and deviations from it will be documented*
Fine sediment	*See Geomorphology Ratings Tables*			*Geomorphology Ratings Table will be used as guidance and deviations from it will be documented*

EDT Attribute	Hypothesis	Assumption	Source	Rationale
Habitat types	*See Geomorphology Ratings Tables*			*Geomorphology Ratings Table will be used as guidance and deviations from it will be documented*
Food	*Decreased*	*Degrade benthos ratings by 25%*	*Hypothesis*	*Benthic community would be disrupted by inundations plus increased fine sediment. Reduction in riparian zone would also disrupt input of land based food sources. No quantitative estimate of change is available.*
Below FRE Dam *Below the FRE dam during a summer following a winter in which the FRE dam was not closed (i.e. 2-year flood) conditions in the mainstem channel below the dam would be affected by the presence of the dam and by dam closures in other, higher flood, winters. We assume that these changes would extend downstream as far as the geomorphic control.*				
Maximum Temperature	*Use model results*		*PSU CE-QUAL-W2 modeling*	*Use PSU modeling for No Riparian Shade alternative.*
Low Flow	*Use model results*		*Anchor QEA HEC-RAS modeling*	*Low flows will not be affected by the FRE.*
Channel Width	*Use model results*		*Anchor QEA HEC-RAS modeling*	*Use model results*

EDT Attribute	***Hypothesis***	***Assumption***	***Source***	***Rationale***
Large wood	*See Geomorphology Ratings Tables*			*Geomorphology Ratings Table will be used as guidance; deviations from it will be documented*
Fine sediment	*See Geomorphology Ratings Tables*			*Geomorphology Ratings Table will be used as guidance; deviations from it will be documented*

*Table 3. Assumed 10 and 100 year flood event occurs during the **winter** (September-February) with FRE dam in the **closed** position during flood event.*

EDT Attribute	Direction	Assumption	Source	Rationale
Above inundation footprint				
Decreased length according to reservoir footprint during flood. Affected reaches converted to reservoir. Above the inundation footprint currently modeled habitat conditions would be assumed.				
Within Inundation footprint (Closed Position): Assumed for entire period *During winters in which the FRE gates would be closed to capture large storms (10- and 100-year floods), stream and river areas inundated by the dam would be converted to reservoir habitat thereby temporarily eliminating all spawning within the inundated area. This condition would be assumed for the entire winter period.*				
Spatial Extent	*Fluvial habitat eliminated, reservoir habitat created*		*Anchor QEA HECResSim modeling*	*Spatial extent included in the modeling of the reservoir for a 10-year event and 100-year event.* *Modeled reaches at least 50% inundated by each respective footprint will be included as reservoir habitat.*
Maximum Temperature	*Use model results*		*PSU CE-QUAL-W2 modeling*	*PSU modeled temperatures for reservoir conditions used.*

EDT Attribute	Direction	Assumption	Source	Rationale
Channel Width	*Use model results*		*Anchor QEA HECResSim*	*Increased due to inundation*
Low Flow	*Use model results*		*Anchor QEA HEC-RAS modeling*	
Riparian Function	*Decreased*	*Decrease current riparian function by 90% within all impounded reaches*	*Hypothesis*	*Riparian function attribute in EDT is strongly linked to riparian vegetation. All riparian forest would be eliminated along inundated reaches during reservoir construction. Continuing maintenance would remove all trees ≥6 inches dbh on a 7 to 10 year maintenance cycle. Willows and other shrubs are expected to develop in the floodplain but many would not be directly adjacent to the channel and some may be*

EDT Attribute	Direction	Assumption	Source	Rationale
				partially buried by sediment accumulation from retention events. Shrubs would also likely be dormant and leafless in the winter. Herbaceous vegetation that would have developed in riparian areas would likely be buried by sediment from the retention event. Vegetation not buried would be dormant or dead during the winter. No quantitative estimate of riparian condition is available.
Large Wood	*See Geomorphology Ratings Tables*			*Tables used as guidance with deviations documented.*
Fine sediment	*See Geomorphology Ratings Tables*			*Tables used as guidance with deviations documented.*
Habitat types	*See Geomorphology Ratings Tables*			*Tables used as guidance with deviations documented.*
Food	*Decreased*	*Degrade benthos ratings by 40%*	*Hypothesis*	*Benthic community would be disrupted by inundations plus increased fine sediment.*

EDT Attribute	Direction	Assumption	Source	Rationale
				Reduction in riparian zone would also disrupt input of land based food sources. No quantitative estimate of change is available. Benthic community would be impacted more during an inundation due to the lack of riffle/pool habitats that would reform between flood events.
Below FRE Dam (Closed Position)				
Bed Scour	See Geomorphology Ratings Tables			Tables used as guidance with deviation documented
Large wood	See Geomorphology Ratings Tables			Tables used as guidance with deviation documented
Fine sediment	See Geomorphology Ratings Tables			Tables used as guidance with deviation documented
FlowHigh	Use model results		Anchor QEA HEC-RAS modeling	FRE largely affects peak storm flow and has little effect on average maximum flow.
Floodplain	Unchanged			Normal extent of winter floodplain habitat should not

EDT Attribute	***Direction***	***Assumption***	***Source***	***Rationale***
				change with FRE that will only affect peak winter floods.

*Table 4. Assumed **summer** (March to August) low flow conditions with FRE dam that was **closed** during previous winter under 10 and 100 year flood event.*

EDT Attribute	Direction	Assumption	Source	Rationale
Above inundation footprint				
Reaches above the inundation footprint will assume currently modeled condition				
Within Inundation footprint: Assumed for entire period				
Spatial Extent	*Fluvial habitat degraded by presence of reservoir during the winter*		*Anchor QEA HECResSim modeling*	*Spatial extent included in the modeling of the reservoir for a 10-year event and 100-year event. Modeled reaches at least 50% inundated by each respective footprint will be included as reservoir habitat.*
Maximum Temperature	*Use model results*		*PSU CE-QUAL-W2 modeling*	*PSU modeled temperatures used.*

EDT Attribute	Direction	Assumption	Source	Rationale
Channel Width	*Use model results*		*Anchor QEA HEC-RAS modeling*	
Low Flow	*Use model results*		*Anchor QEA HEC-RAS modeling*	
Riparian Function	*Decrease*	*Decrease current riparian function by 85% within all impounded reaches*	*Hypothesis*	*Riparian function attribute in EDT is strongly linked to riparian vegetation. All riparian forest would be eliminated along inundated reaches during reservoir construction. Continuing maintenance would remove all trees ≥6 inches dbh on a 7 to 10 year maintenance cycle. Willows and other shrubs are expected to develop in the floodplain but are not directly adjacent to the channel and some may be partially buried by*

EDT Attribute	Direction	Assumption	Source	Rationale
				sediment accumulation from retention events. Herbaceous vegetation that has developed in riparian areas will likely be buried by sediment from retention event, however, new herbaceous vegetation would be developing. No quantitative estimate of riparian condition is available.
Large Wood	*See Geomorphology Ratings Tables*			*Tables used as guidance with deviations documented.*
Fine sediment	*See Geomorphology Ratings Tables*			*Tables used as guidance with deviations documented.*
Habitat types	*See Geomorphology Ratings Tables*			*Tables used as guidance with deviations documented.*

EDT Attribute	Direction	Assumption	Source	Rationale
Food	*Decreased*	*Degrade benthos ratings by 40%*	*Hypothesis*	*Benthic community would be disrupted by inundations plus increased fine sediment. Reduction in riparian zone would also disrupt input of land based food sources. No quantitative estimate of change is available. Ratings should be decreased more with presence of reservoir. Benthic community would be impacted more during an inundation due to the lack of riffle/pool habitats that would re-form between flood events.*
			Below FRE Dam	
Bed Scour	*See Geomorphology Ratings Tables*			*Tables used as guidance with deviations documented.*
Large wood	*See Geomorphology Ratings Tables*			*Tables used as guidance with deviations documented.*

EDT Attribute	***Direction***	***Assumption***	***Source***	***Rationale***
Maximum Temperature	*Use model results*		*CE-QUAL-W2 modeling*	*Removal of riparian forest within reservoir will decrease shade and increase summer temperature as captured in PSU modeling.*
Fine sediment	*See Geomorphology Ratings Tables*			*Tables used as guidance with deviations documented.*
FlowHigh	*Use model results*	*Rate from Anchor modeling*	*Anchor QEA HEC-RAS modeling*	*Current flow pattern and amount is assumed during free-flow periods.*

Attachment H
Salmon Fish Passage Survival Tables

Table H-1
Construction - Tunnel

DIRECTION	AGE	SPECIES	PERFORMANCE	SURVIVAL	PROPOSED TOTAL SURVIVAL	ASSUMED PASSAGE TYPE
Downstream	Juvenile	Spring Chinook	1	0.85	0.85	FRE Alternative 1: will need some design modifications to be suitable for downstream passage
		Fall Chinook	1	0.85	0.85	
		Coho	1	0.85	0.85	
		Winter Steelhead	1	0.95	0.95	

JUSTIFICATION*
Survival from the numbers developed by the Fish Passage Technical Subcommittee (FPTS) already take into account injury and mortality associated with flow control and trash racks (FRO-FRFA Final Conceptual Combined Dam Fish Passage Design Report, Appendix G - Attachment G). The diversion tunnel length is longer than those considered in design criteria (NMFS 2011, WDFW 2013), but the additional length is not expected to decrease survival (Ed Meyer, NOAA, personal communication) if designed and constructed consistent with the NMFS 2011 fish passage guidelines.

*Justification based on research compiled on Research Summary tab

Table H-2
Construction - Trap and Transport

DIRECTION	AGE	SPECIES	PICKET WEIR CAPTURE EFFICIENCY	PERFORMANCE	PROPOSED PERFORMANCE	SURVIVAL	DELAYED SURVIVAL	PROPOSED TOTAL SURVIVAL	ASSUMED PASSAGE TYPE
Upstream	Adult	Spring Chinook	0.85	0.93	0.79	0.98	0.81	0.63	FRE Alternative 3: temporary wier and fish ladder to holding tanks
		Fall Chinook	0.80	0.93	0.74	0.98	0.90	0.66	
		Coho	0.45	0.93	0.42	0.98	0.99	0.41	
		Winter Steelhead	0.50	0.93	0.47	0.98	0.99	0.45	

JUSTIFICATION*
Picket weir capture efficiency values in literature vary from 15-100% (Schroeder 1996; Wilson et al. 2018). Picket weir more likely to fail from weather and flow related events that allow fish to pass over, under, or around in the winter and therefore have lower efficiency for coho and winter steelhead and higher efficiency for spring and fall Chinook when flows are low. Adults for all species may avoid ladder entrance and/or jump or attempt to jump weir, but documented mortality at the weir is low (Engle et al. 2010; Wilson et al. 2018). We have assumed that NMFS (2011) passage guidelines for temporary trap, holding, and transport would be followed, including picket barrier and fish ladder design guidlines and monitoring. Mean weekly pre-spawn survival probabilities for spring Chinook salmon after trap and transport release ranged from 0.8 - 1.0 (Keefer et al. 2010). We picked the mid-range weekly pre-spawn survival value of 0.9 since not all pre-spawn mortality can be attributed to trap and trasport, but then adjusted this upward for cooler temps and shorter transport at the project site to 0.95. This corresponds to a monthly 0.81 survival (0.95^4). Keefer et al. (2010) found that pre-spawn mortality after trap and transport on the Willamette was strongly temperature dependent, so winter migrating species (coho, steelhead) would likely have better survival.

*Justification based on research compiled on Research Summary tab

Table H-3
Permanent - Conduits

DIRECTION	AGE	SPECIES	PERFORMANCE	SURVIVAL	TOTAL SURVIVAL	JUSTIFICATION	NOTES
Upstream	Adult	Spring Chinook	0.95	0.99	0.94	FRO-FRFA Final Conceptual Combined Dam Fish Passage Design Report	No changes to FRO-FRFA Final Conceptual Combined Dam Fish Passage Design Report values proposed
		Fall Chinook	0.95	0.99	0.94		
		Coho	0.95	0.99	0.94		
		Winter Steelhead	0.97	0.99	0.96		
Downstream	Juvenile	Spring Chinook	1	0.85	0.85	FRO-FRFA Final Conceptual Combined Dam Fish Passage Design Report	No changes to FRO-FRFA Final Conceptual Combined Dam Fish Passage Design Report values proposed
		Fall Chinook	1	0.85	0.85		
		Coho	1	0.85	0.85		
		Winter Steelhead	1	0.95	0.95		

Table H-4
Permanent - CHTR

DIRECTION	AGE	SPECIES	PERFORMANCE	SURVIVAL	DELAYED SURVIVAL	TOTAL SURVIVAL	JUSTIFICATION	NOTES
Upstream	Adult	Spring Chinook	0.93	0.98	0.99	0.90	FRO-FRFA Final Conceptual Combined Dam Fish Passage Design Report	Assumed Chinook would have low delayed mortality since most will pass through the FRE conduits (Ronne et al. 2018).
		Fall Chinook	0.93	0.98	0.99	0.90		
		Coho	0.93	0.98	0.99	0.90		Assumed coho and steelhead would have low delayed mortality because temperature will be cool and less stressful for winter migrating species (Keefer et al. 2010, Ronne et al. 2018).
		Winter Steelhead	0.93	0.98	0.99	0.90		

Table H-5
Research Summary

AUTHOR	YEAR	TITLE	TYPE	FISH INFO	STREAM/BASIN SIZE	PASSAGE TYPE	PASSAGE DIRECTION	FINDINGS	NOTES
Schroeder, Kirk.	1996	A Review of Capture Techniques for Adult Anadromous Salmon	Literature Review	Adult anadromous salmonids	various	Picket weir	upstream	up to 100%, On average >10 sq. mi = 25% <10 sq. mi = 60%	capture efficiency is dependent primarily on the amount of flooding, basin size, and total time in water, greatly reduced by -top of weir going under water -erosion around the sides of the structure -scour beneath the weir during high water -failure under water force
NMFS	2011	Anadromous Facility Passage Desgn	Guideline	Anadromous salmonids	All	Picket weir	upstream/downstream	Design criteria, including picket spacing, through velocity, and head drop specified.	Nearly continuous monitoring for debris buildup and impingement
NMFS	2011	Anadromous Facility Passage Desgn	Guideline	Adult anadromous salmonids	All	Trap and transport	upstream	Section 6 specifies WQ parameters, flow, anaethesia, trapping type, holding requirements, etc	Trap and haul not preferred due to the risks of handling and transport of adult upstream migrants. Furthermore, trap and haul programs tend to not operate at the beginning and end of migration periods because there are only a few individuals present, truncating the tails of the migration and likely adversely affecting on salmon population diversity.
Wilson, J. B. Glaser, D. Rawding, and T. Buehrens.	2018	Monitoring of Grays River Fall Chinook Salmon using an Instream Weir	Study	Adult (>60cm FL, ages 3,4, 5,6) fall Chinook	2nd order trib to Columbia, basin 321 sq.km (123 sq.mi)	Hybrid resistance board/picket weir	upstream	15.7%, 23.7%, 44.1% weir efficiency over the 3 years (2008-2010), no size selectivity found, weir performance was strongly flow dependent. Mortality rate for all salmonids (incl. coho, chum, pink, st) was 0.42%, 0%, 0%, delayed mortality not evaluated, no fallback fish recovered	exclusion barrier chosen for ability to withstand high water events. Had central fish passage chute and live trap
Engle, Rodney O., William R. Brignon, Joseph Skalicky	2010	Evaluation of a Resistance Board Weir in the White Salmon River for Capture of Lower Columbia River Fall Chinook Salmon (Oncorhynchus tshawytscha) for Transport During the Year of Condit Dam Removal.	Study	Adult coho, fall chinook, spring chinook, steelhead, upriver bright fall chinook	approx 400 sq.mi	Picket weir with fish ladder and volitional passage options	upstream	0.5% mortality at weir, thought be related to attempted downstream movement back over weir. On days that both fish ladder and volitional passage past weir were available <50% all fish ascended fish ladder to storage pond. (60% natural Coho, 23% natural steelhead, 61% natural fall Chinook) Weir jumping behavior (upstream) was observed.	
Larson, EI, KA Meyer, B High.	2014	Incidence of spinal injuries in migratory Yellowstone cutthroat trout captured at electric and waterfall-velocity weirs.	Study	cutthroat trout	7-13 m stream width at weir, 55-188 km sq. basin areas	Velocity weir (1), electrified weir (2)	upstream	Spinal Injury - 4.5-6% at velocity weir, 6.5-21.3% at electrified weir Capture efficiency, 88-98%	
Nelson, M. Lee	1999	Evaluation of the potential for resident bull trout to reestablish the migratory life-form	Study	Adult and juvenile bulltrout		two-way picket wier with central traps	upstream/downstream	Capture efficiency of marked downstream moving juveniles at the weir was 47% 1% mortality in upstream trap boxes, 4% mortality in downstream boxes	
Favrot, S.D. and Kwak, T.J.	2016	Efficiency of two-way weirs and prepositioned electrofishing for sampling potamodromous fish migrations	Study	multiple potamodromous species		Weir was a two-way resistance board picket weir	upstream/downstream	sampling mortality at the weir was 5% and 15%	
Engle, R. and J. Skalicky.	2009	Capture, transportation and reintroduction of lower Columbia River Fall Chinook salmon into the upper White Salmon River – A conservation measure in preparation for Condit Dam Removal.	Study	Adult fall Chinook	approx 400 sq.mi, 600-800 cfs (pre-dam removal)	transport above dam in 150 gallon totes moved by seining motor boat, hold time 1-3 hrs	upstream	Of 99 fish captured, 1 mortality, 3 escapees, 5 selectively removed for poor fish health	

Table H-5
Research Summary

AUTHOR	YEAR	TITLE	TYPE	FISH INFO	STREAM/BASIN SIZE	PASSAGE TYPE	PASSAGE DIRECTION	FINDINGS	NOTES
Null, R, J Newtown, C Brownfield, S Hamelberg, K Niemela (USFS)	2011	Monitoring and Evaluation of the Modified Fish Ladder and Barrier Weir at the Coleman National Fish Hatchery.	Study	Adult Chinook	357 sq.mi	Barrier weir and fish ladder	upstream	108/135 (80%) of radio tagged Chinook released downstream successfully navigated the weir and fish ladder system In the current study there were 600+ jump attempts in 2008, 7000+ jump attempts in 2009. Five jump attempts were successful in 2009, based on size 3 were thought to be steelhead/rainbow trout and 2 were thought to be Chinook	Past observations demonstrated some fall Chinook adults were able to jump past the weir, particularly as creek flows increased above 350 cfs.
NMFS	2011	Anadromous Facility Passage Desgn	Guideline	Anadromous salmonids	All	Culvert	upstream/downstream	velocity guidelines are species specific. Length categories for this project would be 200-300ft for the permanent conduits or >300ft for the construction diversion channel. >300ft is the largest size category, probably because there are not many examples of longer culverts. Lighting should be provided for culverts over 150ft in length and distance between lighting is 75ft.	Velocity guidance is discussed in the FRE-Alternative document. The NMFS suggested velocity is 2fps, however the fish passage technical committee determine that the site specific velocity could be increased 6 fps based on the natural stream characteristics. Velocity, lighting, and other design guidelines are included in the FRE Alternative 1 discussion.
WDFW	2013	Water Crossing Design Guideline	Guideline	Anadromous salmonids	All	Culvert	upstream/downstream	Stream simulation culverts with a length-to-width ratio > 10 are considered long and need special design consideration and an increase in recommended width. Meander width begins to become constrained when the culvert is 8 to 10 channel widths in length	
WDFW	2013	Water Crossing Design Guideline	Guideline	Anadromous salmonids	All	Trap and transport	upstream/downstream	Should only be used when volitional passage is impossible	
Forest Service	2008	Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings	Guideline	Aquatic Organisms	All	Culvert	upstream/downstream	Section 6.1.1.1 Risks of Longer Culverts notes that any design flaws will be exacerbated over the longer culvert. Recommends shortest possible culvert to manage risk.	
NMFS	2014	Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion, Conference Opinion And Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation Mud Mountain Dam, Operations, and Maintenance White River, HUC 17110014 Pierce and King Counties, Washington	BiOp	Puget Sound Chinook and steelhead	494 sq.mi	Tunnel	downstream	Two downstream only passage tunnels (one is 9ft diameter, one is 23 ft diameter, both are ~1600ft [500m]) 9 ft diameter had very poor juvenile steelhead survival (18%) during 2012 AT evaluation 23 ft diameter tunnel had ok survival 12/30 test fish (72% after detection efficiency) NMFS expects the 1600 ft L x 23 ft diam. tunnel to meet the 95% downstream survival metric after the upgrades required by 2014 BiOp	

Table H-5
Research Summary

AUTHOR	YEAR	TITLE	TYPE	FISH INFO	STREAM/BASIN SIZE	PASSAGE TYPE	PASSAGE DIRECTION	FINDINGS	NOTES
NMFS	2014	Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion, Conference Opinion And Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation Mud Mountain Dam, Operations, and Maintenance White River, HUC 17110014 Pierce and King Counties, Washington	BiOp	Puget Sound Chinook and steelhead	494 sq.mi	Trap and haul	upstream	Chinook salmon with head lesions have ranged from 10 to 20%, and about 40% of the fish hauled upstream of MMD are not accounted for in spawning surveys The amount of take would be exceeded if more than: 20% of the returning adult PS Chinook or 20% of PS steelhead are severely injured or killed in 2015; 10% of PS Chinook salmon or 10% of PS steelhead are severely injured or killed in any year from August 2015 through December 2020 (use of new apron on front of diversion dam); and, 2% of returning adult PS Chinook salmon and PS steelhead are severely injured or killed after December 2020	
PacifiCorp	2016	Lewis River Fish Passage Program Annual Report	Report	Adult Coho, Chinook, steelhead, cutthroat		Trap and haul	upstream	Adult Passage Survival: Coho 99.7%, Chinook NA, Steelhead 99.9%, Cutthroat 100% Adult Trap Efficiency: Steelhead 73%	
Keefer et al.	2010	Prespawn mortality in adult spring Chinook salmon outplanted above barrier dams	Study	Adult Spring Chinook	3500 km2	Trap and haul	upstream	Total prespawn mortality was 48%, but variability was high, ranging from 0% to 93% for individual release groups. Prespawn mortality was strongly condition dependent, consistently higher for females than males and higher for early release groups. Across years, warm water temperature in the migration corridor and at the collection site was associated with sharply higher mortality.	
Kock et al.	2018	Responses of Hatchery- and Natural-Origin Adult Spring Chinook Salmon to a Trap-and Haul Reintroduction Program	Study	Adult Spring Chinook	6,698 km2	Trap and haul	upstream	A larger percentage of NOR Chinook Salmon (80.6%) than HOR Chinook Salmon (66.9%) moved upstream from the reservoir release site and entered the Cowlitz River or Cispus River	
Leidtke et al.	2013	Evaluation of the Behavior and Movement Patterns of Adult Coho Salmon and Steelhead in the North Fork Toutle River, Washington, 2005–2009	Report (USGS)	Adult Coho, Steelhead	780 km2	Trap and haul	upstream	Trapping efficiency at the fish collection facility was very low (0% coho, 27% steelhead, but the numbers of tagged fish was small n= 9 coho, n = 11 steelhead). Also, the steelhead seemed to learn to leave the trapping facility on days when staff would come to move fish from holding to transport	
Ferguson et al.	2007	Bypass System Modification at Bonneville Dam on the Columbia River Improved the Survival of Juvenile Salmon	Study	Juvenile	>600,000 km2	Bypass Tunnel	downstream	Evaluated a 12,000 foot (3.7 km) bypass tunnel and survival. Survival was between 0.87 and 0.95 for subyearling CH and between 0.95 and 0.97 for yearling CH. The lower survival (0.87) was during the daytime and was attributed to low flows experienced that year.	

Table H-5
Research Summary

AUTHOR	YEAR	TITLE	TYPE	FISH INFO	STREAM/BASIN SIZE	PASSAGE TYPE	PASSAGE DIRECTION	FINDINGS	NOTES
Lusardi & Moyle	2017	Two-Way Trap and Haul as a Conservation Strategy for Anadromous Salmonids	Review	Adult Salmonids		Trap and haul	upstream	Trap and haul in some basins and systems has been successful (Sockeye at Sunset Falls, WA; Atlantic salmon on the Penobscot). However for spring Chinook in the Willamette the female cohort replacement rate was low (0.31-0.40). Pre-spawn spring Chinook mortality is high for trap and transport in the Willamette and Butte Creek systems. At Toule River, WA, mortality of coho after transport was 20%.	

Attachment I
PHABSIM Results Summary

Table I-1
Native Fish

REACH	SPECIES	LIFE STAGE	PERCENT WEIGHTED USABLE HABITAT CHANGE											
			January	February	March	April	May	June	July	August	September	October	November	December
Upper Chehalis (Upstream of FRE/FRO Facility)	Largescale Sucker	juv rearing					-4%	-4%	-14%	-6%	-2%	-4%		
		spawning					-28%	-33%						
	Mountain Whitefish	adult rearing					-7%	-8%	-13%	-6%	-3%	-7%		
		juv rearing					-7%	-8%	-13%	-6%	-3%	-7%		
		spawning									-100%	0%		
	Pacific Lamprey	juv rearing					-4%	-7%	-18%	-7%	-6%	-4%		
		spawning					0%	-7%	-39%					
	Speckled Dace	adult rearing					-4%	-4%	-33%	-11%	-2%	-1%		
		juv rearing					-4%	-4%	-33%	-11%	-2%	-1%		
		spawning					0%	-90%						
Pe Ell to Elk Creek (Downstream of the FRE/FRO Facility)	Largescale Sucker	juv rearing	0%	0%	0%	0%	0%	-2%	-7%	-18%	-4%	0%	0%	0%
		spawning				0%	0%	-17%						
	Mountain Whitefish	adult rearing	0%	0%	0%	0%	0%	-5%	-6%	-16%	-8%	0%	0%	0%
		juv rearing	0%	0%	0%	0%	0%	-5%	-6%	-16%	-8%	0%	0%	0%
		spawning	0%									0%	0%	0%
	Pacific Lamprey	juv rearing	0%	0%	0%	0%	0%	-4%	-9%	-23%	-7%	0%	0%	0%
		spawning			0%	0%	0%	-4%	-17%					
	Speckled Dace	adult rearing	0%	0%	0%	0%	0%	-2%	-6%	-14%	-4%	0%	0%	0%
		juv rearing	0%	0%	0%	0%	0%	-2%	-6%	-14%	-4%	0%	0%	0%
		spawning	0%	0%	0%	0%	0%	-67%					0%	0%

Table I-2
Non-Native Fish

			PERCENT WEIGHTED USABLE HABITAT CHANGE											
REACH	SPECIES	LIFE STAGE	January	February	March	April	May	June	July	August	September	October	November	December
Pe Ell to Elk Creek	Largemouth Bass	juv rearing				0%	0%	0%	-2%	-6%	-1%	0%		
Pe Ell to Elk Creek	Largemouth Bass	spawning					0%	0%						
Pe Ell to Elk Creek	Smallmouth Bass	juv rearing				0%	0%	0%	-2%	-6%	-1%	0%		
Pe Ell to Elk Creek	Smallmouth Bass	spawning				0%	0%	0%						

Appendix B
Species Information Tables

Table B-1
Salmonid Species

		SPECIAL STATUS			STUDY AREA		COUNTIES			EDT-LCM MODELING		
COMMON NAME	SPECIES[2]	WNHP LISTED	WDFW LISTED	FEDERALLY LISTED	FLOOD RETENTION FACILITY PROJECT AREA	CHEHALIS RIVER 100-YEAR FLOODPLAIN AREA	GRAYS HARBOR	LEWIS	THURSTON	MODELED	NOT MODELED	REFERENCES
Bull Trout	*Salvelinus confluentus*	G4T2Q, S1S2	SC	FT		●	●	●	●		●	3, 5
Spring-Run Chinook Salmon[1]	*Oncorhynchus tshawytscha*	G5T4Q, SNR	SC, VA, RCTI		●	●	●	●	●	●		1, 3, 4, 5, 6
Fall-Run Chinook Salmon[1]	*Oncorhynchus tshawytscha*	G5T4Q, SNR	SC, VA, RCTI		●	●	●	●	●	●		1, 3, 4, 5, 6
Coho Salmon[1]	*Oncorhynchus kisutch*	G4TNR, SNR	VA, RCTI		●	●	●	●	●	●		1, 3, 4, 5, 6
Winter-run Steelhead[1]	*Oncorhynchus mykiss*	G5T3Q, SNR	SC		●	●	●	●	●	●		1, 3, 4, 5, 6
Mountain Whitefish[1]	*Prosopium williamsoni*	G5, S5			●	●	●	●	●		●	1, 4, 5, 6
Rainbow Trout[1]	*Oncorhynchus mykiss*	G5, S5			●	●	●	●	●		●	2, 3, 4, 5
Resident Cutthroat Trout[1]	*Oncorhynchus clarkii*	G4T3Q, SNR			●	●	●	●	●		●	4, 5, 7
Coastal Cutthroat Trout[1]	*Oncorhynchus clarkii clarkii*	G4T4, SNR		FSC	●	●	●	●	●		●	3, 4, 5, 6, 7
Chum Salmon[1]	*Oncorhynchus keta*	G5, S3	SC, VA, RCTI			●	●	●	●		●	3

Notes:

1: Species identified during field investigations and confirmed to be present in the indicated project area(s) within the study area.

2: Aquatic species that have the potential to be present in the study area, identified to the county level (e.g. Grays Harbor, Lewis, and Thurston) based on publicly available sources

(FSC) Federal Species of Concern

(FT) Federally Threatened

(G#) Global Rank

(S#) State Rank

(1) Critically Imperiled

(2) Imperiled

(3) Vulnerable

(4) Apparently Secure

(5) Secure

(G#T#) A numeric range rank (e.g. G2T3) is used to inducate uncertainty about the exact status of a taxon or ecosystem type

(Q) Questionable-questions exist about the taxonomic validity of a species, subspecies, or variety

(RCTI) Species of recreational, commercial, or tribal importance that are vulnerable

(SC) State Candidate

(SNR) Unranked

(TNR) Population is unranked

(VA) Animal Aggregations Considered Vulnerable

(WDFW) Washington Department of Fish and Wildlife

(WNHP) Washington Natural Heritage Program

References

(1) Ronne, L., N. Vanbuskirk, C. Holt, and M. Zimmerman, 2018. Spawner Abundance and Distribution of Salmon and Steelhead in the Upper Chehalis River, 2017-2018. FPT 18-09. Olympia, Washington: Washington Department of Fish and Wildlife

(2) Seamons, T., C. Holt, S. Ashcraft, and M. Zimmerman, 2017. Population genetic analysis of Chehalis River Watershed Winter Steelhead (Oncorhynchus mykiss). FPT 17-14. Olympia, Washington: Washington Department of Fish and Wildlife

(3) WDFW 2019. Priority Habitats and Species (PHS). Accessible at https://wdfw.wa.gov/species-habitats/at-risk/phs

(4) Winkowski, M., N. Kendall, and M. Zimmerman, 2016. Upper Chehalis Instream Fish Study 2015. FPT 16 11. Olympia, Washington: Washington Department of Fish and Wildlife.

(5) Winkowski, J.J., E.J. Walther, and M.S. Zimmerman, 2018a. Summer riverscape patterns of fish, habitat, and temperature across the Chehalis River basin. FPT 18-01. Olympia, Washington: Washington Department of Fish and Wildlife

(6) Winkowski, M., N. Kendall, and E. Cropper, 2019a. Movement and Home Range Study of Select Native Fishes in the Chehalis River, Washington State. June 2019. Washington State Department of Fish and Wildlife, Fish Program, Fish Science Division.

(7) Winkowski, J., and M.S. Zimmerman, 2019. Chehalis River Smolt Production, 2018. FPA 19-01. Olympia, Washington: Washington Department of Fish and Wildlife.

Table B-2
Lamprey and Other Native Fish Species

COMMON NAME	SPECIES[2]	SPECIAL STATUS			STUDY AREA		COUNTIES			REFERENCES
		WNHP LISTED	WDFW LISTED	FEDERALLY LISTED	FLOOD RETENTION FACILITY PROJECT AREA	CHEHALIS RIVER 100-YEAR FLOODPLAIN AREA	GRAYS HARBOR	LEWIS	THURSTON	
Pacific Lamprey[1]	*Lampetra tridentata*	G4, S1	RCTI	FSC	●	●	●	●	●	2, 3, 4, 5, 6, 9, 10
River Lamprey[1]	*Lampetra ayresi*	G4, S2	SC		●	●	●	●	●	5, 6
Western Brook Lamprey[3]	*Lampetra richardsoni*	G4G5, S3S4			●	●	●	●		2, 6
Largescale Sucker[1]	*Catostomus macrocheilus*	G5, S5			●	●	●	●	●	2, 3, 6, 7, 9
Longnose Dace[1]	*Rhinichthys cataractae*	G5, S5			●	●	●	●	●	6, 7, 9
Northern Pikeminnow[1]	*Ptychocheilus oregonensis*	G5, S5				●	●	●		2, 6, 7
Olympic Mudminnow[1]	*Novumbra hubbsi*	G3, S2S3	SS			●	●	●	●	2, 4, 5
Peamouth chub[1]	*Mylocheilus caurinus*	G5, S5				●		●	●	6, 9
Prickly Sculpin[1]	*Cottus asper*	G5, S5				●	●	●	●	2, 6, 9
Redside Shiner[1]	*Richardsonius balteatus*	G5, S5			●	●	●	●	●	1, 2, 6, 7, 9
Reticulate Sculpin[1]	*Cottus perplexus*	G4, S5			●	●	●	●	●	2, 6, 9
Riffle Sculpin[1]	*Cottus gulosus*	G5, S5				●	●	●	●	2, 6, 9
Speckled Dace[1]	*Rhinichthys osculus*	G5, S5			●	●	●	●	●	2, 3, 5, 6, 7, 9
Threespine Stickleback[1]	*Gasterosteus aculeatus*	G5, S5				●	●	●	●	2, 7, 9
Torrent Sculpin[1]	*Cottus rhotheus*	G5, S5			●			●	●	6, 9
Leopard Dace	*Rhinichthys falcatus*	G4, S2S3	SC		●			●		5, 11
Mountain Sucker	*Catostomus platyrhynchus*	G5, S2S3	SC		●	●		●		5, 11
Salish Sucker	*Catostomus carli*	G1, S1			●			●		6
Shorthead sculpin	*Cottus confusus*	G5, S5			●	●		●	●	6, 9
White Sturgeon	*Acipenser transmontanus*	G4, S3B, S4N				●	●	●	●	5

Notes:

1: Species identified during field investigations and confirmed to be present in the indicated project area(s) within the study area.

2: Aquatic species that have the potential to be present in the study area, identified to the county level (e.g. Grays Harbor, Lewis, and Thurston) based on publicly available sources

3: Western Brook Lamprey is potential present in both project areas of the study area, but has only been confirmed in the Chehalis River 100-year Floodplain Project Area.

(B), (M) or (N) Qualifiers used to indicate breeding, nonbreeding, and migrant status

(FSC) Federal Species of Concern

(FT) Federally Threatened

(G#) Global Rank

Table B-2
Lamprey and Other Native Fish Species

(S#) State Rank
(1) Critically Imperiled
(2) Imperiled
(3) Vulnerable
(4) Apparently Secure
(5) Secure
(G#T#) A numeric range rank (e.g. G2T3) is used to inducate uncertainty about the exact status of a taxon or ecosystem type
(Q) Questionable-questions exist about the taxonomic validity of a species, subspecies, or variety
(SS) State Sensitive
(SC) State Candidate
(SNR) Unranked
(WDFW) Washington Department of Fish and Wildlife
(WNHP) Washington Natural Heritage Program

References:

(1) ASEPTC (Aquatic Species Enhancement Plan Technical Committee), 2014. Aquatic Species Enhancement Plan. Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species. Accessed on October 7, 2019. Accessed from: http://chehalisbasinstrategy.com/wp-content/uploads/2015/09/Aquatic-Species-Restoration-Program-Report_Final.pdf

(2) Hayes, M., J. Tyson, J. Layman, K. Douville, 2019. Intensive Study of Chehalis Floodplain Off-Channel Habitats. March 26, 2019. Washington State Department of Fish and Wildlife, Fish Program, Fish Science Division.

(3) Kendall, N., and M. Zimmerman, 2018. Validation of Habitat Preferences for Select Native Freshwater Fishes in the Chehalis River, Washington State. FPT 18-02. Olympia, Washington: Washington Department of Fish and Wildlife

(4)Kuehne, L.M. and J.D. Olden, 2016. Environmental Drivers of Occupancy and Detection of Olympic Mudminnow. Transactions of the American Fisheries Society 145:17–26, 2016.

(5)WDFW 2019. Priority Habitats and Species (PHS). Accessible at https://wdfw.wa.gov/species-habitats/at-risk/phs

(6) Winkowski, M., N. Kendall, and M. Zimmerman, 2016. Upper Chehalis Instream Fish Study 2015. FPT 16 11. Olympia, Washington: Washington Department of Fish and Wildlife.

(7) Winkowski, J.J., E.J. Walther, and M.S. Zimmerman, 2018a. Summer riverscape patterns of fish, habitat, and temperature across the Chehalis River basin. FPT 18-01. Olympia, Washington: Washington Department of Fish and Wildlife

(8) Winkowski, J.J., M.S. Zimmerman, 2018c. "Summer habitat and movements of juvenile salmonids in a coastal river of Washington State." Ecology of Freshwater Fish. Volume 27, Issue 1. January 2018. Pages 255-269.

(9) Winkowski, M., N. Kendall, and E. Cropper, 2019a. Movement and Home Range Study of Select Native Fishes in the Chehalis River, Washington State. June 2019. Washington State Department of Fish and Wildlife, Fish Program, Fish Science Division.

(10)Winkowski, M., E. Cropper, and N. Kendall, 2019b. Chehalis Basin Fish Density Study – Pilot Study 2018 Interim results summary. Olympia, Washington: Washington Department of Fish and Wildlife

(11) NatureServe Explorer Species Report. Accessed at: http://explorer.natureserve.org/

Table B-3
Non-Native Fish Species

COMMON NAME	SPECIES[1,2]	SPECIAL STATUS			STUDY AREA		COUNTIES			REFERENCES
		WNHP LISTED	WDFW LISTED	FEDERALLY LISTED	FLOOD RETENTION FACILITY PROJECT AREA	CHEHALIS RIVER 100-YEAR FLOODPLAIN AREA	GRAYS HARBOR	LEWIS	THURSTON	
American Shad	*Alosa sapidissima*	G5, SNA				•	•	•	•	1, 4
Black crappie	*Pomoxis nigromaculatus*	G5, SNA				•	•			2
Bluegill	*Lepomis macrochirus*	G5, SNA				•	•	•	•	2, 3, 4
Brown bullhead	*Ameiurus nebulosus*	G5, SNA				•	•	•		2
Common Carp	*Cyprinus carpio*	G5, SNA				•	•	•	•	1, 2
Largemouth Bass	*Micropterus salmoides*	G5, SNA				•	•	•	•	2, 3, 4
Pumpkinseed	*Lepomis gibbosus*	G5, SNA				•	•	•		2
Rock Bass	*Ambloplites rupestris*	G5, SNA				•	•	•	•	2, 4
Smallmouth Bass	*Micropterus dolomieu*	G5, SNA				•		•	•	3, 4
Yellow Perch	*Perca flavescens*	G5, SNA				•	•	•	•	1, 2
Catfish	*Ictalurid sp*	G5, SNA				•	•	•	•	1

Notes:

1: Species identified during field investigations and confirmed to be present in the indicated project area(s) within the study area.

2: Aquatic species that have the potential to be present in the study area, identified to the county level (e.g. Grays Harbor, Lewis, and Thurston) based on publicly available sources

(G#) Global Rank

(5) Secure at very low risk

(SNA) A conservation status rank is not applicable because the species or ecosystem is not a suitable target for conservation activities

(WDFW) Washington Department of Fish and Wildlife

(WNHP) Washington Natural Heritage Program

References:

(1) ASEPTC (Aquatic Species Enhancement Plan Technical Committee), 2014. Aquatic Species Enhancement Plan. Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species. Accessed on October 7, 2019. Accessed from: http://chehalisbasinstrategy.com/wp-content/uploads/2015/09/Aquatic-Species-Restoration-Program-Report_Final.pdf

(2) Hayes, M., J. Tyson, J. Layman, K. Douville, 2019. Intensive Study of Chehalis Floodplain Off-Channel Habitats. March 26, 2019. Washington State Department of Fish and Wildlife, Fish Program, Fish Science Division.

(3) Winkowski, J.J., E.J. Walther, and M.S. Zimmerman, 2018a. Summer riverscape patterns of fish, habitat, and temperature across the Chehalis River basin. FPT 18-01. Olympia, Washington: Washington Department of Fish and Wildlife

(4) Winkowski, M., N. Kendall, and E. Cropper, 2019a. Movement and Home Range Study of Select Native Fishes in the Chehalis River, Washington State. June 2019. Washington State Department of Fish and Wildlife, Fish Program, Fish Science Division

Table B-4
Freshwater Mussels

COMMON NAME	SPECIES[1,2]	SPECIAL STATUS			STUDY AREA		COUNTIES			REFERENCES
		WNHP LISTED	WDFW LISTED	FEDERALLY LISTED	FLOOD RETENTION FACILITY PROJECT AREA	CHEHALIS RIVER 100-YEAR FLOODPLAIN AREA	GRAYS HARBOR	LEWIS	THURSTON	
Floaters	*Anodonta sp*				●	●	●	●	●	1, 2
Western Pearlshell	*Margaritifera falcata*	G5, S3S4			●	●	●	●	●	1, 2
Western Ridged Mussel	*Gonidea angulata*	G3, S2S3			●	●	●	●	●	1, 2

Notes:

1: Species identified during field investigations and confirmed to be present in the indicated project area(s) within the study area.

2: Aquatic species that have the potential to be present in the study area, identified to the county level (e.g. Grays Harbor, Lewis, and Thurston) based on publicly available sources

(G#) Global Rank

(S#) State Rank

(3) Vulnerable

(5) Secure at very low risk

(S#S#) A numeric range rank (e.g. S2S3) is used to inducate uncertainty about the exact status of a taxon or ecosystem type

(S) State Rank

(S2) Imperiled

(S3) Vulnerable

(S4) Apparently Secure

(SC) Species of Concern

(WDFW) Washington Department of Fish and Wildlife

(WNHP) Washington Natural Heritage Program

References:

(1) Blevins, E., L. McMullen, S. Jepsen, M. Blackburn, A. Code, S.H. Black, 2018. Conserving the Gems of Our Waters.

(2) Winkowski, J.J., E.J. Walther, and M.S. Zimmerman, 2018a. Summer riverscape patterns of fish, habitat, and temperature across the Chehalis River basin. FPT 18-01. Olympia, Washington: Washington Department of Fish and Wildlife

Table B-5
Plant Species

COMMON NAME	SPECIES[2]	SPECIAL STATUS			STUDY AREA		COUNTIES			NATIVE PLANT SPECIES	NON-NATIVE PLANT SPECIES	REFERENCES
		WNHP LISTED	WDFW LISTED	FEDERALLY LISTED	FLOOD RETENTION FACILITY PROJECT AREA	CHEHALIS RIVER 100-YEAR FLOODPLAIN AREA	GRAYS HARBOR	LEWIS	THURSTON			
Water Howellia	*Howellia aquatilis*	G3, S2	ST	FT		•	•	•	•	•		3,4
Canadian waterweed[1]	*Elodea canadensis*					•		•		•		2
Common duckweed[1]	*Lemna minor*				•	•		•		•		2
Common liverwort[1]	*Marchantia spp*				•			•		•		1
Common liverwort1	*Pellia spp*				•			•		•		1
Common moss[1]	*Racomitrium spp*				•			•		•		1
Common moss1	*Scleropodium spp*				•			•		•		1
Common pondweed[1]	*Potamogeton natans*					•		•		•		2
Yellow pond lily (or yellow waterlily or spatterdock)[1]	*Nuphar lutea* or *Nuphar polysepala*					•	•	•		•		2
Brazilian elodea[1]	*Egeria densa*					•		•	•		•	3
Parrotfeather[1]	*Myriophyllum aquaticum*					•	•	•	•		•	3
Blunt-leaved pondweed	*Potamogeton obtusifolius*	G5, S2	SS			•			•	•		4
Humped bladderwort	*Utricularia gibba*					•	•	•	•	•		3
Lesser bladderwort	*Utricularia minor*					•	•	•	•	•		3

Notes:

1: Species identified during field investigations and confirmed to be present in the indicated project area(s) within the study area.

2: Aquatic species that have the potential to be present in the study area, identified to the county level (e.g. Grays Harbor, Lewis, and Thurston) based on publicly available sources

(?) Questionable- questions exist about the assigned G, T, or S rank of a taxon

(BS) Bureau of Land Management Sensitive

(FS) Forest Service Sensitive

(FT) Federally Threatened

(G) Global Rank

(G3) Vulnerable

(G4) Apparently Secure

(G5) Secure at very low risk

(S) State Rank

(S2) Imperiled

(ST) State Threatened

(SS) State Sensitive

(WDFW) Washington Department of Fish and Wildlife

(WNHP) Washington Natural Heritage Program

Table B-5
Plant Species

References:

(1) Anchor QEA, 2018b. Chehalis River Basin Flood Damage Reduction Project: Wetland, Water, and OHWM Delineation Report. Prepared for U.S. Army Corps of Engineers, Washington Department of Ecology, and Washington Department of Fish and Wildlife. December 2018.

(2) Hayes, M., J. Tyson, J. Layman, K. Douville, 2019. Intensive Study of Chehalis Floodplain Off-Channel Habitats. March 26, 2019. Washington State Department of Fish and Wildlife, Fish Program, Fish Science Division.

(3) Simon, B. (WSDA) and M. Peoples (WDFW), 2006. Integrated Aquatic Plant Management Plan For The Chehalis River Basin. December 16, 2006.

(4) WDNR, 2019a. 2019 Vascular Review Group 1 and Review Group 2 Lists. Natural Heritage Program. July 25, 2019. Accessed October 8, 2019. Accessed at: https://www.dnr.wa.gov/NHPlists

(5) WDNR, 2019b. 2019 Washington Vascular Plant Species of Special Concern List. Natural Heritage Program. July 25, 2019. Accessed October 8, 2019. Accessed at: https://www.dnr.wa.gov/NHPlists

(6) USFWS, 2019a. Endangered Species Online Search Tool. Accessed October 8, 2019. Accessed at: https://www.fws.gov/endangered/

Table B-6
Native Fish Species Habitat

		STUDY AREA		COUNTIES			NATIVE FISH SPECIES		
COMMON NAME	SPECIES	FLOOD RETENTION FACILITY PROJECT AREA	CHEHALIS RIVER 100-YEAR FLOODPLAIN AREA	GRAYS HARBOR	LEWIS	THURSTON	OTHER SALMONIDS	OTHER NATIVE SPECIES	REARING/SPAWNING HABITAT
Mountain Whitefish	*Prosopium williamsoni*	•	•	•	•	•	•		Adults prefer to spawn in shallow, riffled streams with gravel substrate or along lakeshores over gravel shoals. Mountain whitefish reside in larger, low-gradient pool-riffle channels with woody material, and can also be found in deeper pools during winter months.
Rainbow Trout	*Oncorhynchus mykiss*	•	•	•	•	•	•		Rainbow trout spawn in small streams with fine gravel substrate. Rainbow trout are non-anadromous and prefer cooler, high-velocity water in pool-riffle channels with woody material, but can also survive in warmer water.
Coastal Cutthroat Trout	*Oncorhynchus clarkii clarkii*	•	•	•	•	•	•		Genetic stocks of coastal cutthroat trout are distinguishable by the geographic distribution of spawning grounds. *Resident* - spawn in freshwater in areas upstream and downstream of anadromous barriers. *Fluvial* - migrate in freshwater within rivers and spawn in mainstem and accessible tributary reaches. *Anadromous* - spawn in mainstem and accessible tributary reaches. *Adfluvial* - spawn and rear in freshwater streams.
Chum Salmon	*Oncorhynchus keta*		•	•	•	•	•		Chum salmon prefer big rivers with low gradients to medium rivers with moderate gradient, with pool and riffle habitat. Adults return to spawn in streams where they hatched, sometimes moving up to 2,000 km upstream, but usually spawning not far from salt water (usually within 100 km). Spawning occurs in gravel riffles in rivers and streams of various sizes. The female digs a redd, or nest, by displacing gravel and making depressions in an area of about 2.25 sq meters.
Largescale Sucker	*Catostomus macrocheilus*	•	•	•	•	•		•	Seasonal migrations coinciding with spawning and rearing suggest complex habitat preferences depending on geographic region and life stage. Spawning habitat ranges from higher gradient, faster-moving water with riffles and glides, to deeper pools and glides, to shallower habitats with little to no flow. Largescale suckers are often found in deeper wetland habitat and permanent and ephemeral off-channel ponds with seasonably varying water depths.
Longnose Dace	*Rhinichthys cataractae*	•	•	•	•	•		•	Spawning occurs over gravel or cobble substrate of shallow riffled streams. Longnose dace often reside in steep-gradient headwater streams with shallow, high-velocity water and gravel and rock substrate.
Northern Pikeminnow	*Ptychocheilus oregonensis*		•	•	•			•	Spawning occurs in areas with gravel, cobble, or rubble substrate with medium- to high-velocity water. Larval and juvenile northern pikeminnow rear in areas with fine-grained substrate, instream vegetation, and shallow, low-velocity water. Adults prefer low-light environments, low- to medium-velocity water, and overhanging structures to provide cover while preying on unsuspecting fish, which often include juvenile salmonids. Adults have also been found in deeper wetland habitats and permanent and ephemeral off-channel ponds with seasonably varying water depths.
Olympic Mudminnow	*Novumbra hubbsi*		•	•	•	•		•	Olympic mudminnows prefer low-velocity streams, shallow water, shaded areas with aquatic vegetation, and mud or silt substrate. Several species of mudminnow use wetlands and ponds for spawning habitat. Spawning activities have been observed from late November to the following June and eggs hatch approximately ten days after being deposited in vegetation. Olympic mudminnow tend to be less abundant in areas where other native and non-native species are present, likely due to predation.
Peamouth chub	*Mylocheilus caurinus*		•		•	•		•	Spawning occurs in the inlets and outlets of rivers, in areas with gravel substrate and shallow water. Peamouth chub can tolerate brackish water for limited periods but are often found in rivers in areas with shallow water and instream vegetation and move to deeper water during winter months.

Table B-6
Native Fish Species Habitat

		STUDY AREA		COUNTIES			NATIVE FISH SPECIES		
COMMON NAME	SPECIES	FLOOD RETENTION FACILITY PROJECT AREA	CHEHALIS RIVER 100-YEAR FLOODPLAIN AREA	GRAYS HARBOR	LEWIS	THURSTON	OTHER SALMONIDS	OTHER NATIVE SPECIES	REARING/SPAWNING HABITAT
Prickly Sculpin	*Cottus asper*		•	•	•	•		•	The saline-tolerant form prefers estuarine habitats and the interior form prefers freshwater streams. Both prefer low-velocity water, shorelines, and pools, with sand, gravel, or rubble substrate, and in areas with or without cover. Prickly sculpin have also been found in deeper wetland habitat and permanent and ephemeral off-channel ponds with seasonably varying water depths. Adults use rocks, logs, and other structures in low-velocity water for spawning. Prickly sculpins provide forage for largemouth bass, cutthroat trout, northern pikeminnow, and yellow perch.
Redside Shiner	*Richardsonius balteatus*	•	•	•	•	•		•	Redside shiners spawn over gravel substrate in riffled streams. Adults reside in upstream locations and migrate to lower reaches during winter months. Adults have also been observed in deeper wetland habitats and permanent and ephemeral off-channel ponds with seasonably varying water depths.
Reticulate Sculpin	*Cottus perplexus*	•	•	•	•	•		•	Reticulate sculpins can tolerate brackish water but are typically found in freshwater, usually in small, low-velocity riffled streams, backwaters, and wetlands, and in areas with woody material and mud, sand, gravel, and rubble substrate. Adults use rocks, logs, or other structures for spawning. Reticulate sculpins are forage for trout and large juvenile salmonids.
Riffle Sculpin	*Cottus gulosus*		•	•	•	•		•	Riffle sculpin can tolerate brackish water but are typically found in freshwater, usually in small, low-velocity riffled streams, backwaters, and wetlands, and in areas with woody material and mud, sand, gravel, and rubble substrate. Adults use rocks, logs, or other structures for spawning. Riffle sculpins spawn in faster riffled areas. Riffle sculpins are forage for trout and large juvenile salmonids.
Speckled Dace	*Rhinichthys osculus*	•	•	•	•	•		•	Speckled dace prefer shallower, faster-velocity habitats with gravel substrate for spawning and deeper and lower-velocity habitats with cobble substrate for rearing. Speckled dace have also been observed in deeper wetland habitat and permanent and ephemeral off-channel ponds with seasonably varying water depths.
Threespine Stickleback	*Gasterosteus aculeatus*		•	•	•	•		•	Threespine sticklebacks are often found near the bottom of a waterbody in habitats ranging from brackish coastal streams, to freshwater perennial and ephemeral streams, and backwater areas with low-velocity water and instream vegetation. Adults use woody material and other debris in shallow areas with sandy substrate for spawning. Threespine sticklebacks are forage for trout and salmon.
Torrent Sculpin	*Cottus rhotheus*	•			•	•		•	Torrent sculpin prefer fast-moving streams with gravel, cobble, and boulder substrate. Adults use rocks and other debris in swift streams for spawning.
Salish Sucker	*Catostomus carli*	•			•			•	Salish suckers are often found in headwater streams with reduced river flow, deep pools, and instream vegetation. Adults spawn in riffled areas and juveniles rear in well-vegetated shallow pools or glides.
Shorthead sculpin	*Cottus confusus*	•			•	•		•	Shorthead sculpin typically occupy cooler upstream habitats with fast riffles and gravel and cobble substrates but may also occur in open water or occupy the edges of larger rivers. Adults use rocks, cobble, and other debris in larger streams for spawning.
White Sturgeon	*Acipenser transmontanus*		•	•	•	•		•	White sturgeon are typically found close to the bottom of large, cold rivers. Spawning occurs in the mainstem in areas with several miles of gravel, cobble, and boulder substrates.
Leopard Dace	*Rhinichthys falcatus*	•			•				Similar to other dace, Leopard dace usually occur in stream habitats with fast moving current, but prefer deeper water than some species (Wydoski and Whitney 2003). They inhabit streams with clean substrates of rock, boulders and cobble where water velocity is strong enough to prevent siltation from embedding interspaces. Spawning occurs in May to July, depending on location. Eggs are adhesive and attach to gravel and stones. They feed on both aquatic and terrestrial insects and other aquatic invertebrates.

Table B-6
Native Fish Species Habitat

COMMON NAME	SPECIES	STUDY AREA		COUNTIES			NATIVE FISH SPECIES		REARING/SPAWNING HABITAT
		FLOOD RETENTION FACILITY PROJECT AREA	CHEHALIS RIVER 100-YEAR FLOODPLAIN AREA	GRAYS HARBOR	LEWIS	THURSTON	OTHER SALMONIDS	OTHER NATIVE SPECIES	
Mountain Sucker	*Catostomus platyrhynchus*	•	•		•				This sucker appears to prefer clear, cold creeks and small to medium rivers with clear rubble, gravel or sand substrate. May favor pool-like habitats in some areas, or faster water in other regions. Young usually inhabit slower moving waters in side channels, or weedy backwaters. In some areas, juveniles tend to occur closer to reservoirs than do adults. The species is most abundant where there is some form of cover in the water (used as daytime refuge). Spawning occurs over gravel riffles in streams.

Note:
See Table B-7 for references.

Table B-7
References for Native Fish Species

COMMON NAME	SPECIES	PROJECT AREA		COUNTIES		
		FLOOD RETENTION FACILITY	CHEHALIS RIVER 100-YEAR FLOODPLAIN	GRAYS HARBOR	LEWIS	THURSTON
Mountain Whitefish	*Prosopium williamsoni*	Winkowski et al. 2016; Ronne et al. 2018	Winkowski et al. 2016, 2019; Ronne et al. 2018	Winkowski et al 2018a	Winkowski et al. 2016; Ronne et al. 2018	Winkowski et al. 2019
Rainbow Trout	*Oncorhynchus mykiss*	Winkowski et al. 2016; Seamons et al. 2017	Winkowski et al. 2016; Seamons et al. 2017	PHS, Winkowski et al 2018a; Seamons et al. 2017	PHS, Winkowski et al. 2016; Seamons et al. 2017	PHS
Coastal Cutthroat Trout	*Oncorhynchus clarkii clarkii*	Winkowski et al 2016,2018a	Windowski and Zimmerman 2019	PHS	PHS, Winkowski et al 2016	PHS, Winkowski et al. 2019
Largescale Sucker	*Catostomus macrocheilus*	Winkowski et al. 2016; Kendall et al. 2018	Winkowski et al. 2016; Kendall et al. 2018; Hayes et al. 2019	Winkowski et al. 2018a; Hayes et al. 2019	Winkowski et al. 2016; Kendall et al. 2018; Hayes et al. 2019	Winkowski et al. 2019
Longnose Dace	*Rhinichthys cataractae*	Winkowski et al. 2016	Winkowski et al. 2016	Winkowski et al 2018a	Winkowski et al. 2016	Winkowski et al. 2019
Northern Pikeminnow	*Ptychocheilus oregonensis*		Winkowski et al. 2016; Hayes et al. 2019	Winkowski et al. 2018a; Hayes et al. 2019	Winkowski et al. 2016; Hayes et al. 2019	
Olympic Mudminnow	*Novumbra hubbsi*		Kuehne et al 2016; Hayes et al. 2019	PHS; Kuehne et al 2016; Hayes et al. 2019	PHS	PHS
Peamouth chub	*Mylocheilus caurinus*	0 - Potent pres (Winkowski et al 2016)	Winkowski et al 2016		Winkowski et al 2016	Winkowski et al. 2019
Prickly Sculpin	*Cottus asper*	0 - Potent pres (Winkowski et al 2016)	Winkowski et al 2016; Hayes et al. 2019	Hayes et al. 2019	Winkowski et al 2016; Hayes et al. 2019	Winkowski et al. 2019
Redside Shiner	*Richardsonius balteatus*	Winkowski et al. 2016	Winkowski et al. 2016; Hayes et al. 2019	Winkowski et al. 2018a; Hayes et al. 2019	Winkowski et al. 2016; Hayes et al. 2019; ASEPTC 2014	Winkowski et al. 2019
Reticulate Sculpin	*Cottus perplexus*	Winkowski et al 2016	Winkowski et al 2016; Hayes et al. 2019	Hayes et al. 2019	Winkowski et al 2016; Hayes et al. 2019	Winkowski et al. 2019
Riffle Sculpin	*Cottus gulosus*	0 - Potent pres (Winkowski et al 2016)	Winkowski et al 2016; Hayes et al. 2019	Hayes et al. 2019	Winkowski et al 2016; Hayes et al. 2019	Winkowski et al. 2019
Speckled Dace	*Rhinichthys osculus*	Winkowski et al. 2016; Kendall et al. 2018; WDFW	Winkowski et al. 2016; Kendall et al. 2018; Hayes et al. 2019	Winkowski et al. 2018a; Hayes et al. 2019	Winkowski et al. 2016; Kendall et al. 2018; Hayes et al. 2019	Winkowski et al. 2019

Table B-7
References for Native Fish Species

COMMON NAME	SPECIES	PROJECT AREA		COUNTIES		
		FLOOD RETENTION FACILITY	CHEHALIS RIVER 100-YEAR FLOODPLAIN	GRAYS HARBOR	LEWIS	THURSTON
Threespine Stickleback	*Gasterosteus aculeatus*		Winkowski et al. 2018a; Hayes et al. 2019	Winkowski et al. 2018a; Hayes et al. 2019	Winkowski et al. 2018a; Hayes et al. 2019	Winkowski et al. 2019
Torrent Sculpin	*Cottus rhotheus*	Winkowski et al 2016			Winkowski et al 2016	Winkowski et al. 2019
Salish Sucker	*Catostomus carli*	0 - Potent pres (Winkowski et al 2016)			Winkowski et al 2016	
Shorthead sculpin	*Cottus confusus*	0 - Potent pres (Winkowski et al 2016)			Winkowski et al 2016	Winkowski et al. 2019
White Sturgeon	*Acipenser transmontanus*			PHS (see notes)	PHS (see notes)	PHS (see notes)
Leopard Dace	*Rhinichthys falcatus*	NatureServe Species Report			PHS	
Mountain Sucker	*Catostomus platyrhynchus*	NatureServe Species Report	NatureServe Species Report		PHS	