4.2 Flood Retention Facility (FRO and FRFA)

Short-term impacts from construction of the Flood Retention Facility would be more substantial than short-term impacts from construction of the rest of the action elements, due to the magnitude of excavation, clearing, water diversion, and temporary road construction, and because construction would occur over 2 to 3 years rather than months. This action element also includes concrete production and use, development of a borrow pit and quarry pit, and installation of a new power line for construction and operation of power pumps, gates, instruments, and other facilities.

This section provides a summary of the primary long-term adverse impacts and benefits resulting from implementation of the Flood Retention Facility. More detailed descriptions of operations and associated impacts to support this analysis are provided in Appendix H. Unless otherwise noted, the term Flood Retention Facility is used in reference to both types (FRO and FRFA) of dams and associated reservoirs. When impacts or mitigation are applicable to only one type of facility, the specific facility type is noted (FRO facility or FRFA facility).

4.2.1 Water Resources

4.2.1.1 Short-term Impacts

The temporary impacts described in Table 4.1-1, and their effects on water resources during construction of the Flood Retention Facility, would be relatively short in duration (2 to 3 years) and generally limited to the dam and reservoir footprint. Avoidance and minimization measures would be employed when designing, constructing, and permitting the facility. Permanent or long-term impacts resulting from construction are discussed below.

4.2.1.2 Long-term Impacts

Long-term impacts on water quality are based on water quality modeling analysis and results for both the FRFA and FRO facilities. The results and findings of this analysis are presented in the following studies, some of which are currently in development:

- *Draft Reservoir Water Quality Model* (Anchor QEA 2016b)
- *Draft Development and Calibration of the Chehalis River CE-QUAL-W2 Water Quality Model* (PSU 2016)

Surface water quantity and water rights impacts are based on professional judgment and studies developed by water resource engineers, including hydraulic and hydrologic modeling, reservoir simulations, and the results and findings from the following studies:

- *Re-evaluation of Statistical Hydrology and Design Storm Selection for the Chehalis River Basin* (WSE 2014a)
- *Peer Review of December 2007 Peak and Hydrograph at Doty Gaging Station* (WSE 2014b)

- *Development and Calibration of Hydraulic Model* (WSE 2014c)
- *Chehalis River Basin I-5 Flood Protection near Centralia and Chehalis* (WSDOT 2014)

Impacts on groundwater are based on professional judgment, including known information about the existing groundwater aquifer system and the expected changes in water quantity and quality that would occur as result of dam operations scenarios. Existing groundwater characterization of the Chehalis Basin is summarized in the following report:

- *Hydrogeologic Framework and Groundwater/Surface-Water Interactions of the Chehalis River Basin, Southwestern Washington* (Gendaszek 2011)

Floodwaters would be retained in the reservoir (see Figure 4.2-1) when flows are predicted to exceed a major flood. Floods of this magnitude occur, on average, once every 7 years (15% probability of occurring in any given year). The FRO dam would allow the Chehalis River to pass through unimpeded, except during a major flood. Flows would be retained in the FRO reservoir during a major flood, then emptied over a period of up to 32 days after the flood peaks. The FRFA dam would maintain a permanent pool in the reservoir with extra capacity for flood retention when a major flood occurs. The specific operational details that would affect water resources are described in the *Draft Operations Plan for Flood Retention Facilities* (Anchor QEA 2016c).

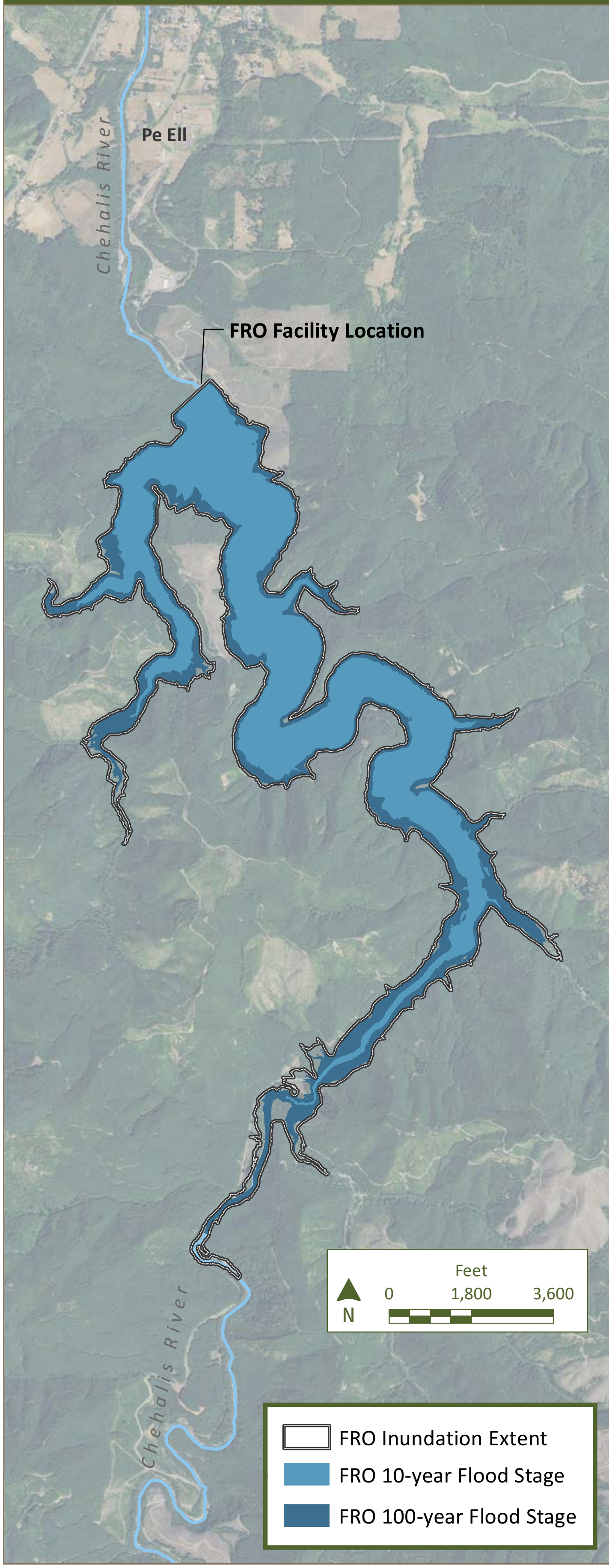
As part of the detailed water quality modeling completed to support this EIS, a preliminary optimization of reservoir flow and temperature releases was performed (Anchor QEA 2016b, 2016c). Different operating scenarios were reviewed and tested using the reservoir water quality model and the Chehalis River water quality model (PSU 2016). The optimized operating scenario is evaluated for this EIS.

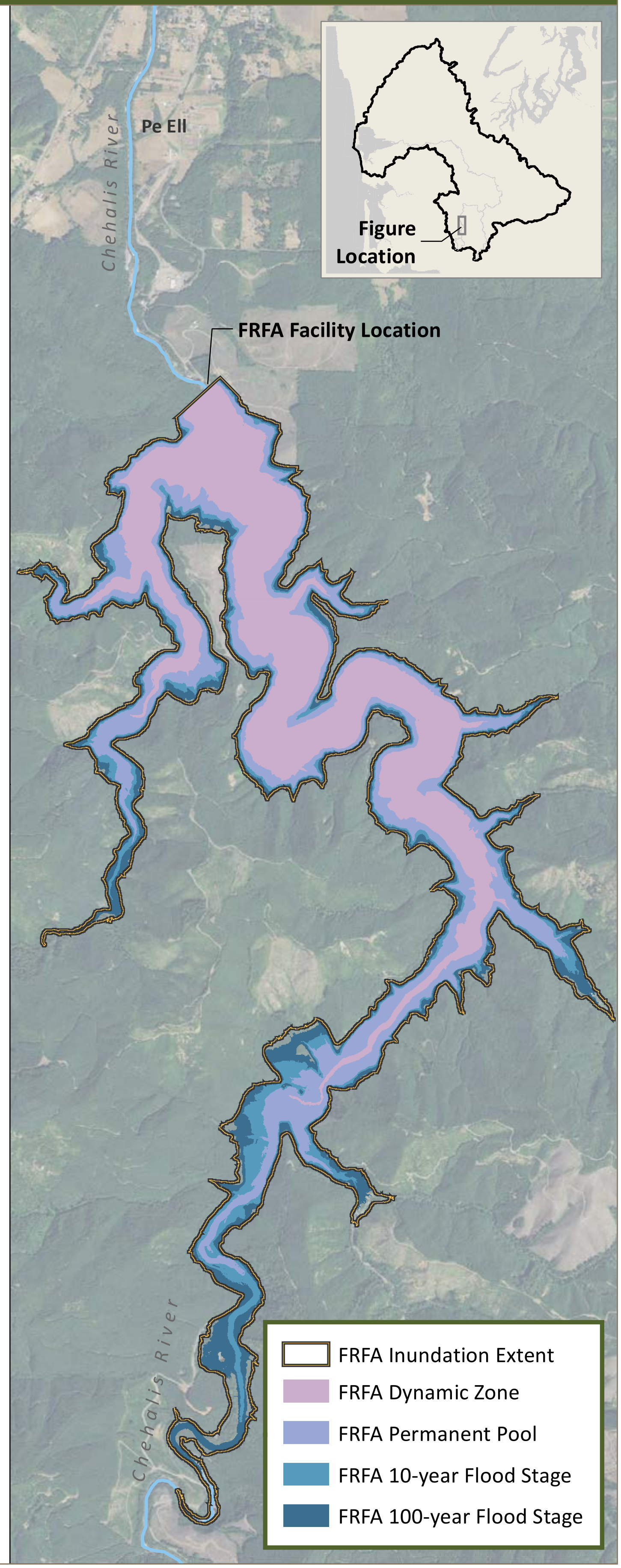
The operation of the Flood Retention Facility would have the potential to affect water resources through changes to surface water quality, surface water quantity, and groundwater through periodic or permanent inundation upstream of the dam, peak flow reduction, and low flow increases (for the FRFA facility) in the Chehalis River downstream of the dam.

No adverse impacts on water use and water rights downstream of the dam are anticipated because flow changes would not affect the ability of water users to divert their water right downstream of the dam during its operation. Water stored in the FRFA reservoir during the winter and released during low-flow periods would augment flows and improve temperature (for the benefit of aquatic species; other uses would be secondary). Because the proposed reservoir would impound more than 10 acre-feet of water, a reservoir permit, which is issued by Ecology, would be required per Chapter 90.03.370 RCW. To mitigate for adverse impacts on Pe Ell's water supply, the intake would be relocated or a new water source would be provided, requiring a change in the water right.

Figure 4.2-1

Reservoir Inundation Areas





4.2.1.2.1 Surface Water Quality

Adverse impacts on surface water quality are primarily related to the conversion of the upper Chehalis River to a temporary (FRO) or permanent (FRFA) reservoir, streamside and hillslope vegetation removal, peak flow reduction, and flow augmentation in the Chehalis River downstream of the dam. Adverse impacts on surface water quality are anticipated to include the following:

- Adverse impacts on water quality constituents, including violations of state water quality standards: sediment and turbidity; temperature, DO, and nutrients; and mercury (Hg)
- Potential pollutant loading at the Flood Retention Facility from operations, and reduction in downstream pollutant loading (heavy metals, hazardous materials) during peak floods

Flow augmentation and temperature reductions downstream of the dam in the mainstem Chehalis River (FRFA facility only) would result in a beneficial effect to surface water quality.

Water Quality Constituents

Suspended Sediment and Turbidity

FRO and FRFA facility operations have the potential to affect suspended sediment and turbidity in the reservoir footprint area, and downstream of the dam in the Chehalis River.

For both the FRO and FRFA facilities, sediment could be generated from surface runoff from exposed slopes along the reservoir footprint, and along shoreline areas from erosion (from wave action) at the reservoir water line. The area within the permanent pool of the FRFA reservoir would be cleared, and fluctuating reservoir levels would expose bare soils to erosion. Fine sediment previously deposited in the reservoir area could be re-suspended when reservoir water levels rise or fall, increasing suspended sediment and turbidity in the reservoir as the reservoir level fluctuates. The potential for increased turbidity and suspended sediments from slope erosion in the reservoir is greater for the FRFA facility than the FRO facility because of the bare slopes within the permanent pool of the FRFA reservoir. In addition, as compared to natural conditions, higher levels of sediment could be delivered to a temporary or permanent reservoir area from landslides that could potentially be triggered by fluctuating water levels, resulting in highly turbid conditions in the reservoir (see Section 4.2.2.2.1). The effects of these erosion processes have the potential to cause a significant adverse impact on water quality with respect to suspended sediment and turbidity conditions by violating the state water quality criterion for turbidity (5 Nephelometric Turbidity Units [NTU] over background).

Downstream of the dam, changes in the suspended sediment and turbidity levels in the Chehalis River would occur due to the following:

- Capture of sediment in the reservoir
- Change in the rate and timing of suspended sediment transport out of the reservoir

- Reduction in bank erosion by reducing peak flows
- Potential reduction in the downstream floodplain area that could settle sediment out

For both the FRO and FRFA facilities, the potential for prolonged, controlled releases of turbid water exists as the reservoir draws down after a major flood (occurrence once every 7 years on average). Based on proposed facility operations, this drawdown period could last up to 32 days. For both configurations, some fine sediment would be trapped during the flood retention period, reducing the overall quantity of suspended sediment released during that time. For the FRO facility, high flows that occur outside of flood retention periods can erode previously deposited fine sediment in the reservoir, causing higher rates of suspended sediment to be released than under existing conditions. This would create more frequently occurring turbid conditions in the Chehalis River downstream of the dam. The effects of these processes have the potential to result in a moderate to significant adverse impact on downstream water quality relative to suspended sediment and turbidity conditions.

Temperature, Dissolved Oxygen, and Nutrients

Within the FRO and FRFA reservoir inundation areas, streamside vegetation, especially mature conifers, would be removed in areas along the Chehalis River and its tributaries. This can affect temperature in the reservoir footprint as well as the Chehalis River downstream as discussed in the following sections. Flood retention is anticipated to only occur in the FRO reservoir during October to March when air and water temperatures are cooler. When in operation, the FRO facility flood retention periods are shorter than in the FRFA facility, limiting the potential for temperature and DO impacts as compared to the FRFA facility.

Reservoir Footprint

In the FRO reservoir, increased solar heating of the Chehalis River in the reservoir inundation area would occur due to reduction of riparian vegetation. Predictions of a water quality model that simulated the anticipated changes to temperature indicated a nearly 4˚C increase in summer water temperatures (over existing conditions) could occur along the mainstem at the dam site (RM 108.6; PSU 2016). In the Crim Creek tributary upstream of the dam, up to a 5˚C increase was predicted. Modeling predicts this temperature effect to diminish upstream along the mainstem Chehalis River, where at RM 114 the predicted increase is approximately 1˚C. Since warmer waters hold less DO, and can also stimulate biological activity that creates a greater demand for DO, lower DO concentrations in the reservoir area are expected. With the increase in temperature of nearly 4˚C along the mainstem at the dam site and a decrease in DO, there would be a significant adverse impact on water quality (temperature and DO).

Applicable Temperature Water Quality Criteria

The temperature surface water quality criteria for lakes and reservoirs states that "human actions may not exceed 0.3˚C (0.54˚F) above natural conditions" (WAC 173-201A). For this EIS evaluation, compliance with this standard cannot be determined because a reservoir is not currently established. Therefore, results of temperature modeling are compared to the core summer salmonid habitat temperature criterion of 16˚C (WAC 173-201A) and the supplemental spawning and incubation protection water temperature criterion (effective September 15 to July 1) of 13˚C, which supersedes the 16˚C criteria during this timeframe (Ecology 2011a). Some of the Chehalis River tributaries within the reservoir footprint also have the supplemental spawning and incubation temperature criteria applied from October 1 through May 15 (see Appendix D, Figure D-2 for the extent of these tributaries).

Model simulation of impacts during the wet period (late fall to early spring) for the FRO reservoir indicated that moderate impacts on water temperature could result if flood retention is necessary early in the wet period (October to November) when air temperatures are still warm relative to the peak wet period (December through March; PSU 2016). The associated water quality impacts (changes in DO and biological activity within the FRO reservoir) during the wet period are expected to be minor as a result of the minor predicted increases in temperature.

For the FRFA facility, the conservation pool would have varying water temperatures depending on the season and depth within the reservoir. Model predictions showed that the temperatures in the upper portions of the conservation pool would increase more rapidly than the lower layers due to surface heating from solar radiation, resulting in thermal stratification during the summer and fall months (see Figure 4.2-2). During July, the temperature differential between the conservation pool's surface layer and bottom layer can approach 18˚C, dependent on the year. Surface layer temperatures could reach approximately 20 to 25˚C depending on meteorological conditions, which is comparable to current conditions that exist in the summer in the Chehalis River without the reservoir (see Figure 4.2-2). The model predictions also show that algal activity (which produces oxygen) would be increased in the upper layers of the reservoir over late spring through mid-summer, resulting in a condition where DO exceeds 100% saturation (condition known as supersaturation). However, model simulations also showed that decomposition of the algae (that die and settle from the surface layers) and the organic matter (from the watershed that settles) in the reservoir sediments result in increased oxygen demand (i.e., consumption) in the lower layers, resulting in lower DO levels than at the surface. Since the reservoir is predicted to stratify, oxygen cannot mix from the surface layer to the lower layers to meet this oxygen demand, thereby resulting in lower oxygen concentrations (hypoxic conditions) in the bottom waters in late summer (see Figure 4.2-3).

Figure 4.2-2

Modeled Temperature Profile Within FRFA Reservoir Conservation Pool

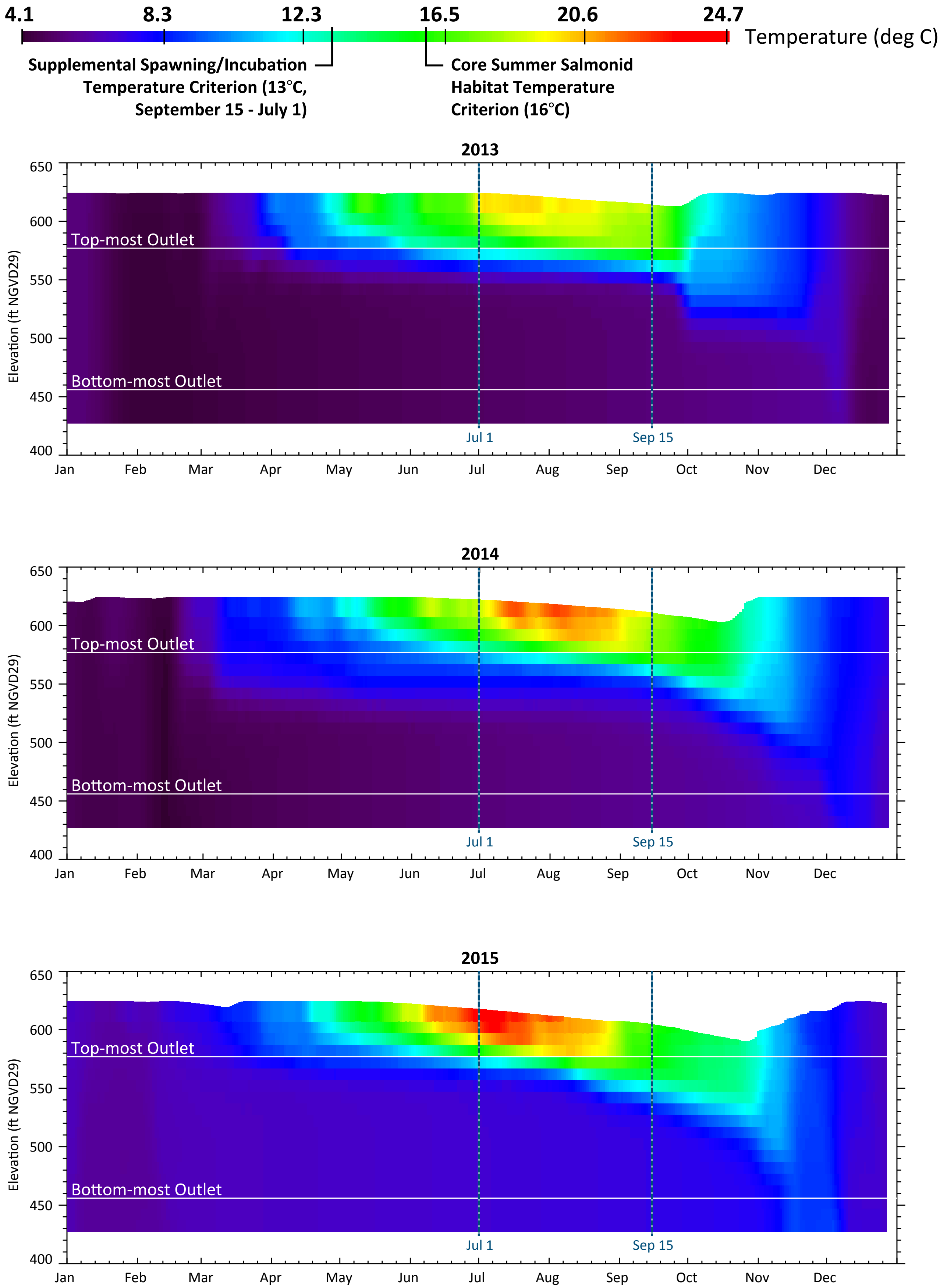


Figure 4.2-3

Modeled Dissolved Oxygen Profile Within FRFA Reservoir Conservation Pool

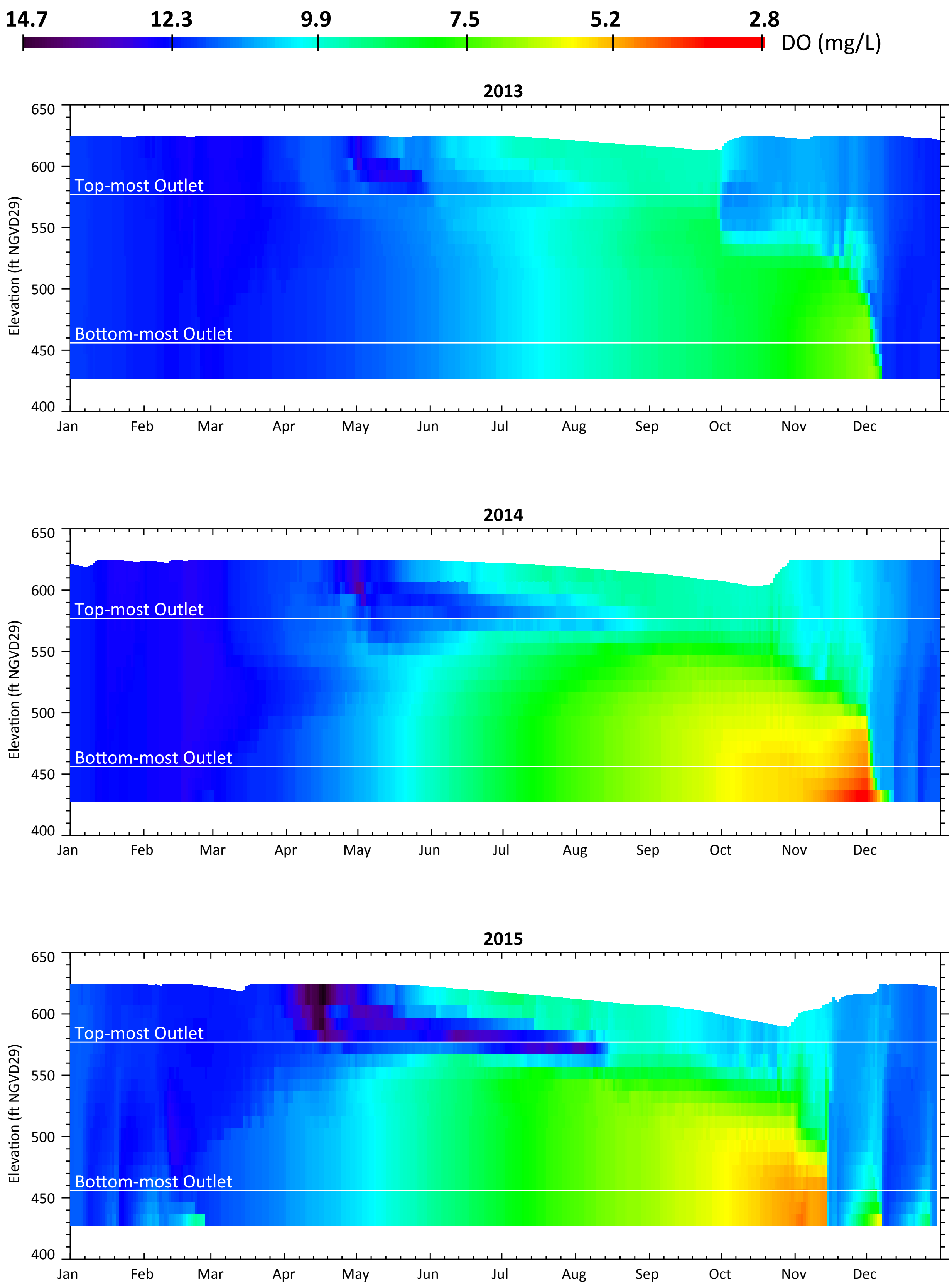


Figure 4.2-2 shows that upper portions of the conservation pool do not meet the core summer salmonid habitat criterion (of 16°C), whereas Figure 4.2-3 shows that portions of the lower waters do not meet the DO criterion (of 9.5 mg/L) in late summer. Model simulations showed that over certain depths in the reservoir (from an elevation of approximately 560 to 580 feet), both the temperature and DO criteria are met simultaneously over portions of the summer period, but there are other periods when at least one criterion is not met throughout the water column. However, there are also periods where neither criterion is met in the top portion of the conservation pool during summer. Therefore, a moderate adverse impact on water quality (temperature and DO) in the reservoir during late summer and early fall is anticipated because surface water quality criteria are not predicted to be met during water storage in the reservoir.

Water quality standards are based on the protection of existing and designated uses. As noted in the sidebar, the area that would be inundated by a permanent FRFA reservoir is protected by the designated use "Core Summer Salmon Habitat" (WAC 173-201A-200). The FRFA reservoir would permanently inundate existing spawning areas, and eliminate habitat features necessary for spawning and emergence of salmonids, as is required for this designated and existing use.

Waterbody Use Terms

- **Designated uses –**These are defined in the surface water quality standards, which specify the quality of aquatic life uses that must be protected in each waterbody. This designation applies regardless of whether the associated numeric criteria are fully attained.
- **Existing uses –** USEPA regulations define existing uses as "those uses actually attained in a water body on or after November 28, 1975 whether or not they are included in the water quality standards." A waterbody's existing uses serve as the baseline or 'floor' of the uses that must be maintained, including the habitat and water quality conditions necessary to protect them. Any change in the designated uses may not result in a lesser aquatic life use or numeric criteria than those that have been determined necessary to meet existing uses.

Downstream of Flood Retention Facility

Impacts on the water temperature in the Chehalis River downstream of the dam were evaluated with a temperature model that simulated both baseline and with a reservoir upstream for both the FRO and FRFA facilities (PSU 2016). The predicted changes in downstream temperatures relative to existing conditions for both the FRO and FRFA facilities in July (during a period of predicted high water temperatures) are shown in Figure 4.2-4.

For the FRO facility, Figure 4.2-4 shows that the greatest downstream impact is predicted immediately below the reservoir (approximately 2 to 3°C warmer than existing conditions) during summer (July 15) with negligible impacts below the confluence of the South Fork Chehalis River (RM 88). This would result in a moderate adverse downstream impact with regard to stream temperature during peak summer temperatures. Model simulations indicated that downstream impacts resulting from flood storage could result in minor changes in temperature (increase or decrease) relative to current conditions, depending on whether the flood occurs during the peak wet season (December to February) or during the early or later stages of the wet season (see Appendix H; PSU 2016). However, these changes were not predicted to result in a violation of temperature criteria beyond what would occur under current conditions. Therefore, the FRO reservoir release is expected to have a minor adverse impact on downstream temperature from late fall through early spring (see Appendix H; PSU 2016).

The potential also exists for reduced DO concentrations in floodwater discharged from the FRO reservoir as a result of any water temperature warming, decay of organic material, and periodic sediment inputs at and upstream of the dam. Based on water quality modeling for the FRFA reservoir (which would store nearly twice the volume proposed for the FRO reservoir), adverse impacts on DO were predicted within the reservoir over the wet season (October through March) near the bottom (see Figure 4.2-3). Moreover, the impacts predicted for the FRFA facility are the result of warmer conditions over the summer when productivity in the reservoir resulted in a higher oxygen demand at the bottom of the reservoir in the fall. For the FRO facility, the impact is likely to be minor because flood retention operations would occur in cool months and the retention time is short. In addition, the reservoir would be drained between flood retention operations and sediment and organic materials would be transported out of the reservoir by river flows. Therefore, it is estimated that there is potential for a minor adverse impact as a result of FRO dam operations, particularly if flood storage is required earlier in the wet season (for example during October and November). Dry season FRO facility scenarios are not presented or discussed because the FRO facility would not be operational.

For the FRFA facility, temperature modeling of the controlled releases of waters from different parts of the FRFA reservoir (flow augmentation) showed that downstream water temperatures in the Chehalis River can be improved during late spring through early fall. The predicted effects of flow augmentation on downstream river temperatures are shown in Figure 4.2-4. In particular, in the upper sections of the reaches designated as core summer salmonid habitat, improvements of up to 10°C were predicted, which would bring these reaches into compliance with the 16°C criterion during the summer immediately downstream of the dam. The model simulations also showed that the anticipated downstream benefits attenuate to existing background conditions to near the confluence of the Skookumchuck River (approximately RM 65; see Figure 4.2-4).

Modeling predicts that the release of cooler waters from the lower depths of the reservoir (see Figure 4.2-2) would also result in release of waters to the Chehalis River that are lower in DO and rich in nutrients and dissolved organic matter. Adverse impacts on DO near the bottom of the reservoir were predicted over the wet season (October through March; see Figure 4.2-3). Based on the conceptual design and operations plan for the FRFA facility, it is anticipated that DO levels would be enhanced in the outflow through engineered aeration. However, the nutrients in the reservoir outflow have a potential to cause an adverse impact on downstream water quality by stimulating algal growth in summer and fall (lowering DO concentrations). The extent of such impacts is presently being evaluated in the downstream water quality model. If adverse impacts are determined, then reservoir operations would be revised to reduce nutrient-rich waters from the bottom of the reservoir to minimize the downstream impacts, while still providing the downstream temperature-reduction benefit. The multi-outlet tower proposed in the operations plan would allow for such modifications.

Mercury

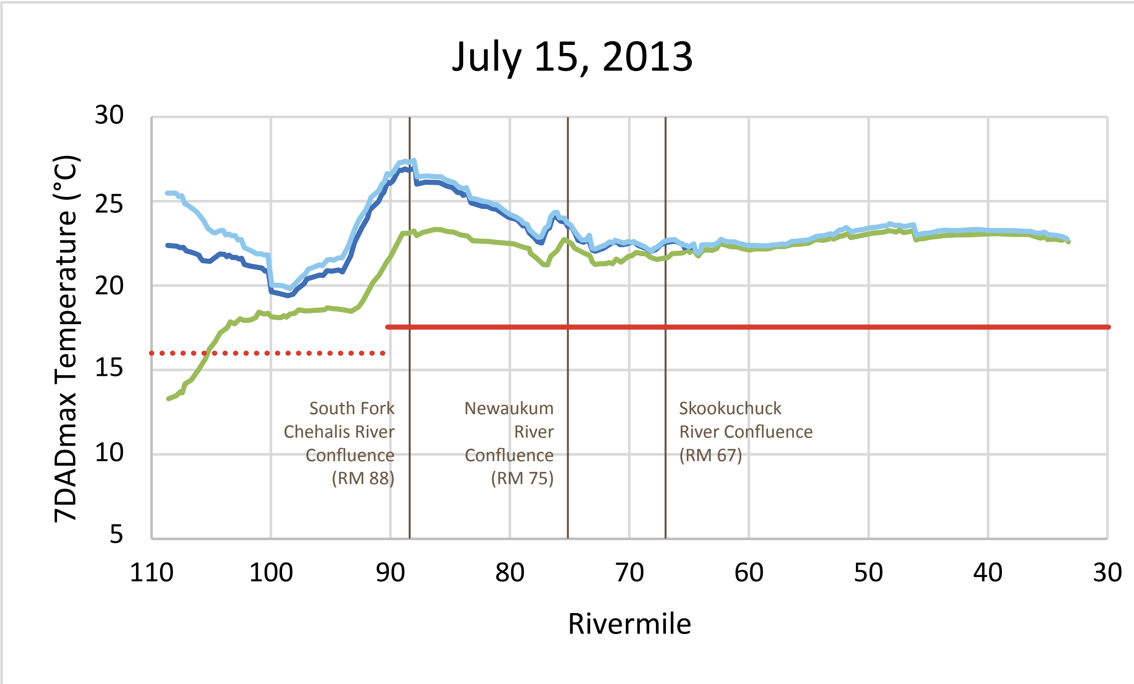
The potential exists in the FRFA reservoir for the conversion of atmospheric inorganic Hg to organic methylmercury (MeHg), a more toxic form that accumulates in the food web and in fish. The local atmospheric levels of Hg are not quantified at this time, but could be evaluated during project-level environmental review. The FRFA reservoir could provide an environment for the growth of the sulfite-reducing bacteria that convert Hg to MeHg. Non-salmonid species (e.g., mountain whitefish, rainbow trout, Northern pikeminnow) have the potential to spend extended periods of time in the reservoir, and salmonids have the potential to spend up to 1 year in the reservoir (see Section 4.2.4.2 for effects to fish). The local atmospheric source (the Chehalis Power Plant) would no longer exist after the year 2020, which is before a Flood Retention Facility would be constructed, thereby reducing a potential local source of atmospheric Hg. An additional source of Hg would be from the exposed sediment in the reservoir footprint and from sediment entering the reservoir from surface erosion and landslides. This would likely be a minor adverse impact due to the short reservoir residence times (less than 100 days) and lack of local atmospheric sources.

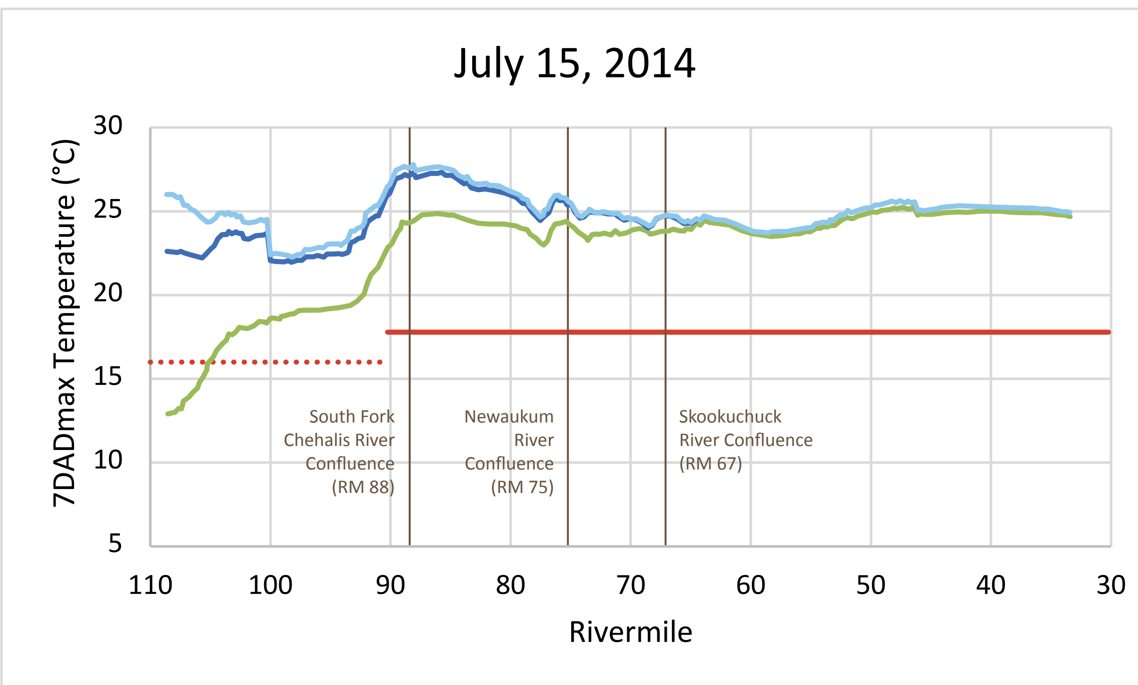
Pollutant Loading

Operations and maintenance of the Flood Retention Facility has the potential to introduce pollutants by spills or contamination, use of hydraulic fluids, and other potential pollutants related to facility operations. This potential exists at and in the vicinity of the Flood Retention Facility. This potentially could be a minor to moderate adverse impact in the vicinity of the dam.

Flood retention operations would reduce downstream flooding, thereby reduces the area from which floodwaters have the potential to accumulate toxins and pollutants during a flood, which is a beneficial effect. A reduction in the area of the floodplain inundated by a major flood downstream of a dam could reduce the contamination of surface water, and the release of pollutants and hazardous materials from flooding urban areas and agricultural fields and facilities. Mobilization of pollutants to the Chehalis River would be reduced from sources such as livestock grazing (e.g., fecal coliform bacteria), atmospheric deposition of Hg (as dry fall-out and precipitation), and fuel and chemicals stored in the Chehalis River floodplain. Section 4.2.15.2 describes the improvements to environmental health and safety as a result of these effects.

Figure 4.2-4
Modeled Temperatures Downstream of Flood Retention Facility





Modeled Baseline Conditions
FRFA Modeled Temperature Scenario
FRO Modeled Temperature
Core Summer Salmonid Habitat Temperature Criterion (16°C)
Spawning, Rearing, and Migration Criterion (17.5°C)

Downstream Flow Augmentation

No flow augmentation would occur with FRO facility operations. Currently, the mainstem Chehalis River experiences high summer and early fall water temperatures that routinely exceed applicable criteria (WAC 173-201A; Ecology 2012). The FRFA facility operations would improve water quality in the Chehalis River downstream of the dam to approximately the confluence of the Skookumchuck River (RM 65) during the late summer and early fall due to cool-water flow augmentation from the reservoir pool (see Figure 4.2-4). From the late spring to early fall (mid-May to October), natural flows in the upper Chehalis River are low; median flows are currently from 20 to 160 cfs. The minimum discharge at the dam would range from 80 to 160 cfs during this timeframe. This flow augmentation would increase flows and reduce temperatures at and downstream of the proposed dam. The model predicted temperature improvements would be in the range of 10°C immediately downstream of the dam, with the proposed flow range (80 to 160 cfs) during the summer. In the fall, warmer water in the range of 1 to 2°C (higher than baseline condition) could potentially be discharged as a result of warming in the upstream reservoir. This flow would be cooler in temperature than existing flows in the mainstem Chehalis River during the late summer through early fall (see water quality benefits described for temperature and DO). This increase in cool-water flow could improve habitat conditions in the mainstem Chehalis River (downstream of the dam) for cool-water dependent aquatic species that use this area by lowering water temperatures and improving DO conditions (see Section 4.2.4 for effects to fish and wildlife).

4.2.1.2.2 Surface Water Quantity

The primary purpose of the Flood Retention Facility is to retain floodwater during a major flood. For FRO facility operations, river flows would be retained in a reservoir on the Chehalis River only during and after a major flood or greater. For the FRFA facility, the Chehalis River would be converted to a permanent reservoir for 6.3 miles upstream of the dam. Adverse impacts on surface water quantity are anticipated to be related to the following:

- Changes in flows and inundation of the mainstem Chehalis River at and upstream of the Flood Retention Facility
- Retention of a major flood and changes in downstream flow regimes

The dam would alter the Chehalis River from a free-flowing river to a reservoir. For the FRO facility, these changes would result in a moderate adverse impact on surface water quantity because the river within the reservoir footprint would be periodically inundated once every 7 years on average (or 15% probability of occurring in any given year) for a period of up to 32 days. When the FRO facility is not operational, the river would continue to be a free-flowing river. For the FRFA facility, these changes would result in a significant adverse impact because the Chehalis River would be changed from a free-flowing river to a permanent reservoir, affecting instream habitat conditions currently used by aquatic species in the system. Table 4.2-1 provides a summary of the potential changes to surface water quantity at and above the dam.

Table 4.2-1
Flood Retention Facility Reservoir Conditions for Surface Water Quantity

CONDITIONS	FRO FACILITY[1]	FRFA FACILITY[1]
Reservoir permanency	Reservoir inundation upstream of the FRO dam would be temporary (up to 32 days)	Permanent reservoir pool would be maintained with additional capacity to retain floods
Inundation extent	Temporary reservoir would extend 5.3 miles, on average, during a major flood	Permanent reservoir would extend 6.3 miles (at full conservation pool extent)
Maximum periodic inundation extent	6.2 miles to account for floods similar to the 2007 flood	7.6 miles to account for floods similar to the 2007 flood
Maximum inundated area	778 acres	1,264 acres
Median (mid-point) reservoir elevation during flood operations	513 feet	602 feet
Maximum reservoir elevation during flood operations	620 feet	683 feet
Median (mid-point) reservoir depth during flood operations	88 feet	177 feet
Maximum reservoir depth during flood operations	195 feet	258 feet
Capacity	65,000 acre-feet	Conservation pool: 65,000 acre-feet Flood storage pool: 65,000 acre-feet Total: 130,000 acre-feet

Note:
1. Elevation of the river bed at the proposed dam site is 420 feet

Outside of flood operations, the FRFA reservoir level would fluctuate in response to inflow and outflow. The proposed operations of the FRFA facility would limit the reservoir drawdown to provide flexibility for releasing cool water in the summer and better downstream passage conditions for juvenile fish. Anchor QEA (2016c) provides details of facility operations related to surface water quantity.

Downstream of the dam, discharge from the reservoir would be reduced during a major flood in order to decrease downstream flooding. Modeled flood flow reductions at Grand Mound are provided in Table 4.2-2.

Table 4.2-2
Peak Flow Comparison of Chehalis River at Grand Mound

FLOOD	EXISTING PEAK FLOW (cfs)	PEAK FLOW WITH FLOOD RETENTION (cfs)	DIFFERENCE IN PEAK FLOW (%)
100-year	70,600	58,400	-17.3%
10-year	43,800	37,500	-14.4%
1996	72,100	61,200	-8.5%
2007	71,100	52,100	-26.7%
2009	57,300	48,600	-15.2%

Downstream of the Flood Retention Facility, flood elevations would be reduced along the mainstem Chehalis River from the dam to the mouth of the river. The reduction in flood elevations would vary depending on the location and magnitude of the flood, with larger reductions generally closer to the dam and smaller reductions farther downstream. Modeled flood elevation reductions for a 100-year flood at various locations along the Chehalis River are provided in Table 4.2-3.

Table 4.2-3
Flood Retention Facility Flood Elevation Reductions along Chehalis River (100-year Flood)

LOCATION	EXISTING 100-YEAR FLOOD PEAK ELEVATION (FEET)	100-YEAR FLOOD PEAK ELEVATION WITH FLOOD RETENTION (FEET)	DIFFERENCE IN FLOOD ELEVATION (FEET)
Near Doty	319.2	308.1	-11.1
Downstream of South Fork	222.2	217.1	-5.1
Along airport levee	180.5	179.0	-1.5
Behind airport levee	180.3	173.3	-7.0
Mellen Street	177.7	176.0	-1.7
Galvin Road	168.2	166.5	-1.7
Grand Mound	147.5	146.6	-0.9
Near Rochester	124.4	123.4	-1.0
Black River confluence	93.5	92.5	-1.0
Satsop River confluence	33.9	33.3	-0.6
Montesano	18.6	17.9	-0.7

Source: WSE 2014d

The Flood Retention Facility would not reduce flood elevations or associated flood damage to structures along tributaries to the Chehalis River, except in the downstream-most areas of tributaries that are subject to flooding from high water levels in the Chehalis River. In those tributaries, such as the South Fork Chehalis River, Newaukum and Skookumchuck rivers, flood levels would be reduced indirectly as a result of a Flood Retention Facility reducing flood flows in the Chehalis River.

Modeled results related to structures that are no longer flooded have been developed for the combined Flood Retention Facility and Airport Levee Improvements and are described in more detail in Chapter 5.

4.2.1.2.3 Groundwater

Adverse impacts on groundwater could be related to the following:

- Changes to groundwater recharge in the reservoir footprint
- Changes to groundwater flow regime in downstream floodplain areas

Very little groundwater exists in the area where the reservoir would be located because it is situated in a narrow canyon, and a thin layer of alluvial material overlies bedrock throughout the length of the proposed reservoir site. Hillsides in and adjacent to the reservoir footprint also have limited groundwater storage capacity because of steep slopes and thin layers of soil over bedrock. During operation of either Flood Retention Facility (when the flood pool is filled), additional recharge could occur along hillsides and the reservoir bed would be saturated, slightly increasing groundwater storage. Groundwater conditions would return to existing when the flood pool is drawn down, and no adverse impacts on groundwater quantity are anticipated in the dam and reservoir footprint. When the FRO facility is not operational, groundwater recharge would be similar to existing conditions.

Downstream of the dam, a reduction in groundwater recharge could occur due to a reduction in the Chehalis River floodplain area that is inundated during floods with a greater than 7-year recurrence interval. The Chehalis River floodplain would be reduced by about 4,480 acres during a 100-year flood, which is about 10% of the existing floodplain area. This reduction in floodplain area would be realized along the entire mainstem Chehalis River; however, more reduction would occur throughout the upper mainstem. The extent of floodplain reduction would be less during smaller (less than 7-year recurrence) floods. The potential reduction in recharge could be partially offset by higher stages in the river for a longer duration than existing as the reservoir empties, but this has not been quantified to support this programmatic-level analysis. Localized modifications of the hyporheic zone could occur because of changes to flow and inundation areas. See Section 4.2.4 for a discussion of how changes to groundwater could affect aquatic species.

Summer flow augmentation with the FRFA facility could contribute to some groundwater recharge in losing reaches (i.e., reaches where flow is presently from river to groundwater) compared to existing conditions. Overall, significant adverse impacts on groundwater flow regimes are not expected downstream of the Flood Retention Facility. However, this has not been quantified to support the preliminary analysis for this programmatic EIS.

Hyporheic Zone

The hyporheic zone is a region beneath and alongside the river bed, where there is mixing of shallow groundwater and surface water. The flow dynamics and behavior in this zone is recognized to be important for surface water/groundwater interactions, as well as fish spawning, among other processes.

No adverse impacts on groundwater quality are anticipated from either FRO or FRFA reservoir operations either within the reservoir footprint or downstream of the dam.

4.2.1.3 Mitigation

Potential mitigation measures for short-term impacts on water resources are described in Table 4.1-1. Potential avoidance, minimization, and mitigation measures for long-term impacts on water resources are described in the following sections.

4.2.1.3.1 Surface Water Quality

Compensatory mitigation for actions that are anticipated to have long-term, significant, or unavoidable impacts on surface water quality is detailed in this section.

At this time, it is not known whether completely eliminating and indefinitely removing an existing and designated use within a broad geographic area, such as the FRFA reservoir, could be mitigated, and if this action would be allowable within the state's authority under CWA Section 401. The FRO reservoir could periodically affect or modify a portion of the waterbody's existing designated use, but the designated use as a whole could remain. If proposed mitigation for the FRO facility provides evidence that habitat features and types associated with the existing designated use would remain intact and water quality standards would be met, this type of Flood Retention Facility may not be subject to the same CWA Section 401 certification challenges as the FRFA facility with regard to meeting water quality standards.

Sediment and Turbidity

Avoidance and minimization measures to limit sediment and turbidity in the reservoir area could include the following:

- Revegetating cleared areas (for both FRO and FRFA reservoirs) with trees that could withstand periodic inundation (e.g., partially submerged in the reservoir pool)
- Keeping trees that could withstand inundation in areas requiring thinning
- Maintaining a reservoir drawdown rate that limits slope instability (10 to 20 feet per day; Shannon & Wilson 2014a)
- Maintaining a minimum pool of water in the FRFA reservoir to reduce potential mobilization of sediments and associated nutrients and contaminants from the reservoir
  - For example, the maximum drawdown would be 40 vertical feet (below the elevation of the conservation pool), minimizing the exposed area during operations

Compensatory mitigation for potential impacts from sediment and turbidity could include implementation of a Reservoir Operations and Management Plan that includes monitoring riparian vegetation and shoreline erosion, and treating erosion areas to reduce sediment impacts. The potential for soil erosion associated with periods of pool drawdown would also be monitored and evaluated within the plan, and would be used to adaptively manage dam operations and reservoir drawdown rates.

Temperature and Dissolved Oxygen

Avoidance and minimization measures to address water temperatures downstream of the dam could include managing FRFA facility operations to optimize cool temperatures and flow benefit for aquatic species (in the Chehalis River) and maintain DO conditions that are compliant with the state water quality criterion of greater than 9.5 mg/L.

Compensatory mitigation measures to address losses of riparian shade within the reservoir and downstream of the dam could include planting riparian vegetation that is more flood tolerant within the reservoir footprint (for either the FRO or FRFA facilities). This would likely not mitigate all of the riparian loss at the reservoir site, and additional downstream riparian planting could be required.

Mercury and Pollutants

Avoidance and minimization measures for potential spills or contamination, hydraulic fluids, and other potential pollutants related to Flood Retention Facility operations could include implementation of a project-specific Spill Prevention and Response Plan.

4.2.1.3.2 Surface Water Quantity

Avoidance and minimization measures for surface water quantity could include managed reservoir drawdown rates, release rates, debris management, and other factors. No long-term compensatory mitigation measures are proposed for water quantity impacts because the overall effect would be beneficial due to the reduction in flooding (FRO and FRFA facilities) and the improvement in instream flow (FRFA facility).

4.2.1.3.3 Groundwater

No long-term adverse impacts on groundwater quantity or quality are anticipated, so no mitigation is proposed.

4.2.2 Geology and Geomorphology

4.2.2.1 Short-term Impacts

4.2.2.1.1 Geology

The potential short-term impacts on geology that would occur during construction are described in Table 4.1-1. In addition, the construction of a temporary river bypass tunnel would require the permanent placement of tunnel muck outside of the dam and reservoir footprints. This impact would be confined to the immediate area around the waste sites where muck would be permanently placed. The conceptual design proposes using on-site quarries to provide aggregate for construction. If off-site quarries were also used, the local supply of these construction materials could be reduced, thereby driving up prices for the materials or limiting development that uses those materials.

4.2.2.1.2 Geomorphology

The potential short-term impacts on geomorphology are described in Table 4.1-1. Additional short-term impacts include the interruption of sediment and wood transport regimes throughout the construction work zone, and the loss of channel function for the river segment that is re-routed through the work zone.

4.2.2.2 Long-term Impacts

In addition to references by others, the impacts on geology are informed by field work and studies that have been completed by engineering geologists and geotechnical engineers for the Chehalis Basin Strategy since 2009. They include geologic mapping, landslide identification and analysis, rock quarry material identification and evaluation, seismicity analysis, seismic engineering studies, logging of deep drill holes, downhole and seismic refraction geophysical surveys, rock and soil laboratory testing, and preliminary geotechnical engineering analyses. The reference documents that present this work include the following (in chronological order):

- *Reconnaissance-Level Geotechnical Report, Proposed Chehalis River the South Fork Dam Sites, Lewis County, Washington (*Shannon & Wilson 2009)
- *Preliminary Desktop Landslide Evaluation* (Shannon & Wilson 2014b)
- *Quarry Rock Desktop Study* (*S*hannon & Wilson 2014c)
- *Landslide Reconnaissance Evaluation of the Chehalis Dam Reservoir* (Shannon & Wilson 2015)
- *Phase 1 Site Characterization Technical Memorandum* (HDR and Shannon & Wilson 2015)
- *Phase 2 Site Characterization Technical Memorandum* (HDR and Shannon & Wilson 2016)

Adverse impacts on geomorphology are based on field work by geologists and geomormorphologists, sediment transport modeling, analysis of existing and historical geomorphic conditions, and the results and findings from the following studies:

- *Geomorphology and Sediment Transport Draft Technical Memorandum* (Watershed GeoDynamics and Anchor QEA 2014)
- *Draft: Summary of the Effects on the Chehalis Flood Retention Only (FRO) Reservoir Operations on Aquatic Habitat in the Reservoir Area* (Dubé 2016)
- *Geomorphology, Sediment Transport, and Large Woody Debris* (Watershed GeoDynamics and Anchor QEA 2016)

4.2.2.2.1 Geology

The potential adverse impacts on geology are related to the following:

- Shallow rapid and deep-seated landslides triggered by fluctuating reservoir water levels and tree removal
- Erosion along the reservoir perimeter (from wave action and erosion of exposed slopes in areas of vegetation removal) increasing sedimentation and turbidity in the reservoir
- Increased low-level induced seismicity from the weight of water in the FRFA reservoir

In the reservoir area, fluctuating water levels and removal of trees could trigger shallow landslides and deep-seated landslides around the reservoir footprint (RM 108 to RM 114; see Figure 4.2-5). Because shallow landslides have the potential to occur around the reservoir perimeter with impacts isolated to the reservoir area, the adverse impact on geology would be moderate. For deep-seated landslides, there would be a minor to moderate adverse impact for the FRO facility due to the limited presence of a fluctuating reservoir (once every 7 years) and slightly smaller reservoir footprint, and a moderate adverse impact for the FRFA facility because the risk for slope instability could be higher and more widespread due to the larger reservoir footprint and increased saturation of the landslide masses.

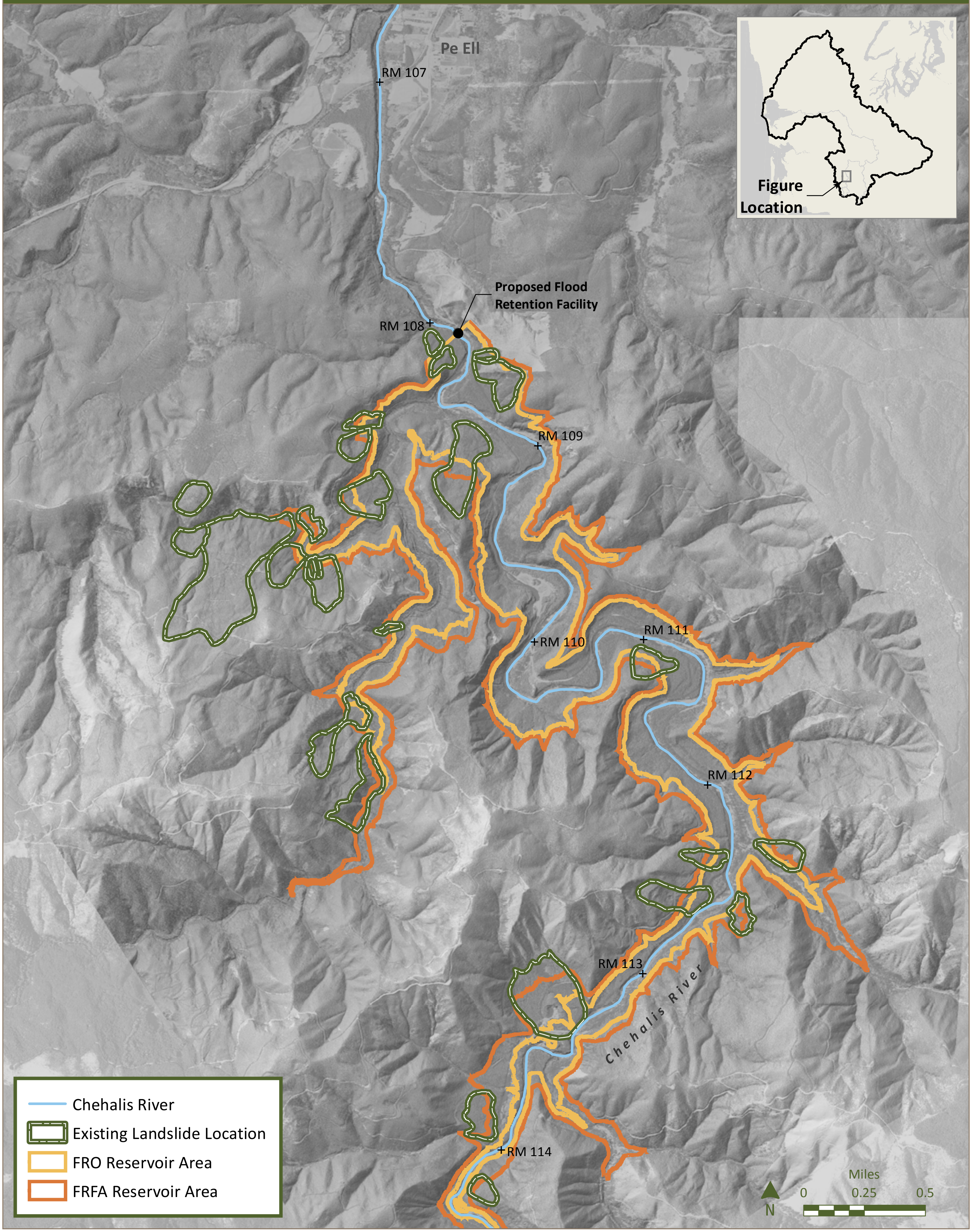
Over the long term, small-scale sloughing or slumping would periodically occur along the temporary FRO or permanent FRFA reservoir perimeter, especially in areas of dynamic water-level fluctuations, releasing fine-grained sediment and woody material into the reservoir. There would be a moderate adverse impact due to its limited geographic extent and periodic nature.

In the FRFA reservoir, a minor adverse impact could result from low-level seismicity induced by the weight of the water in the reservoir, potentially damaging the dam and appurtenant structures and causing concern among local residents. Because the water loading in the FRO reservoir will be short-lived, it is unlikely that a low-magnitude earthquake would be induced by the temporary FRO reservoir (Gupta 1992).

Over the life of the Flood Retention Facility, an earthquake on the CSZ to the west or Doty Fault Zone to the north could occur, and cause damage to the dam due to strong shaking. This would result in a significant adverse impact, if it were to occur. Damage to the dam would require repair and potentially cause a temporary shutdown. If an earthquake were to occur when the reservoir was full during flood operations, and the dam were damaged (despite being designed for this situation), it could have an adverse impact on downstream communities, as discussed in Section 4.2.15.2.

Figure 4.2-5

Landslides in Reservoir Areas



4.2.2.2.2 Geomorphology

The potential adverse impacts on geomorphology are related to the following:

- Changes in sediment load and sediment transport processes
- Changes in large wood load, transport, and recruitment
- Changes in geomorphic function and channel complexity

The potential changes in wood and sediment transport processes resulting from implementation of both the FRO and FRFA facilities would have a significant adverse impact on geomorphology due to the interruption of these processes upstream and downstream of the dam, as described here.

The Flood Retention Facility would disrupt both bedload and suspended load sediment transport processes (see Figure 4.2-6). The FRO facility would disrupt sediment transport continuity temporarily (when operational), whereas the FRFA facility would retain most sediment permanently. Sediment transport would be disrupted through the FRO dam during and after flood retention until the system reaches equilibrium. The potential adverse impacts on geomorphology include the following:

- Deposition and erosion of sediments in the zone of the reservoir that experiences water level fluctuations during flood retention operations (this zone could extend 3 to 5 miles for the FRO reservoir and 1.5 miles for the FRFA reservoir)
- Changes to sediment and large wood transport upstream and at the dam
- Changes to sediment and wood transport and deposition downstream of the dam to downstream of the Skookumchuck River confluence (approximately RM 62)

Changes to geomorphic processes (i.e., changes in sediment transport) are not anticipated to result in effects below RM 62. Reduced sediment transport could deplete substrates used for fish spawning and rearing downstream of the dam, in particular, spawning gravels for salmon, coarser substrate used as refuge by juvenile salmon and other fish, and fine substrate used by larval lamprey (Watershed GeoDynamics and Anchor QEA 2014). Potential effects to fish resulting from these geomorphic changes are discussed in Section 4.2.4.

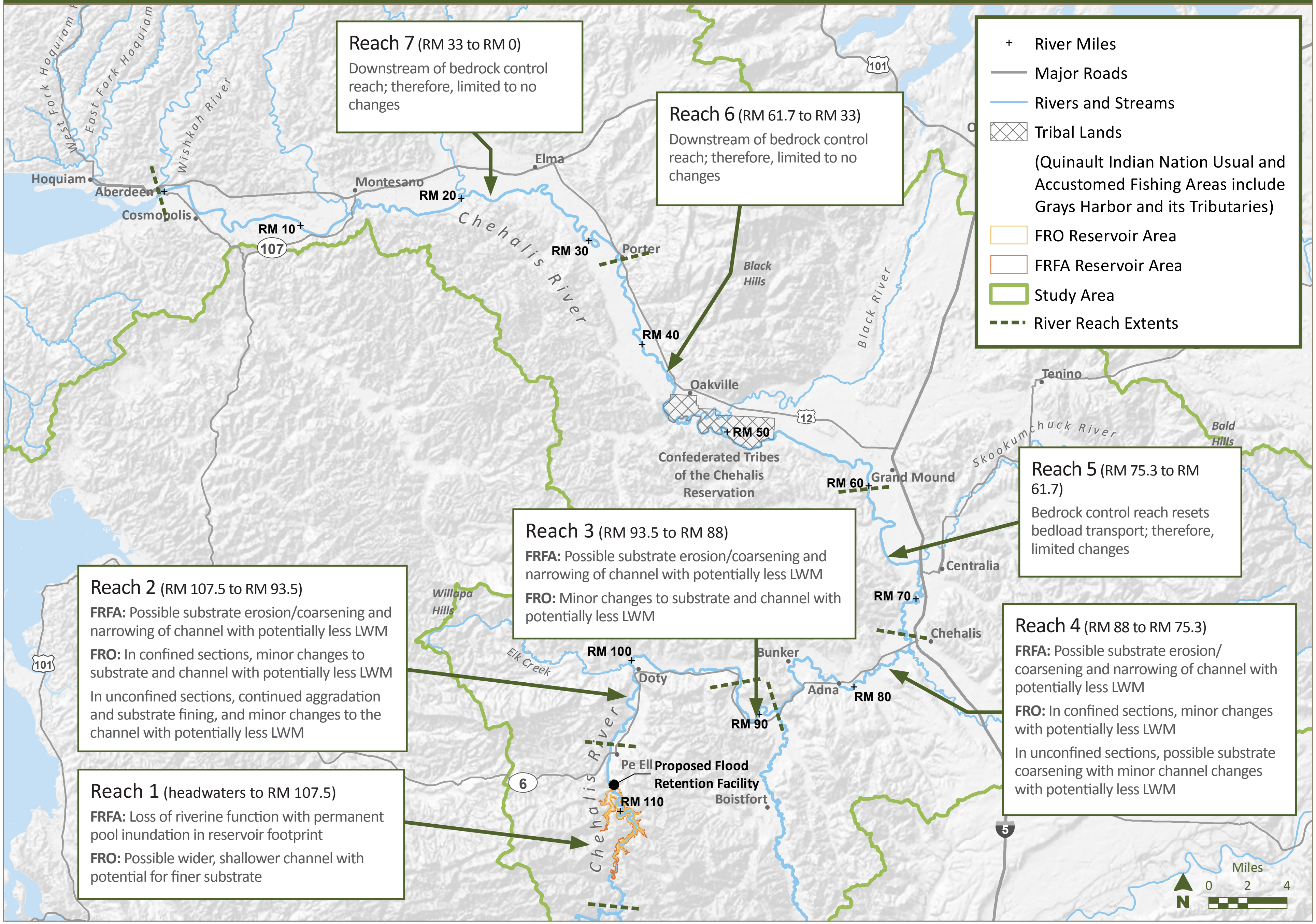
In the long term, 25% to 50% of the bedload would be retained by the FRO facility—amounting to approximately 9,000 to 17,500 tons per year on average (Watershed GeoDynamics and Anchor QEA 2014). Based on preliminary modeling results, sediment entrainment of up to 1 foot could occur upstream of the FRO dam throughout the reservoir footprint (based on modeling results for large floods; Dubé 2016). The FRFA facility would retain most sediment in the reservoir upstream of the FRFA dam (Watershed GeoDynamics and Anchor QEA 2014). For the FRFA facility, all bedload and 86% to 93% of the suspended load would be retained, which is equivalent to approximately 85,000 tons per year on average.

Large wood would also be trapped in either reservoir during flood operations. During non-flood operations, the FRFA facility would trap all large wood while the FRO facility would allow wood up to 15 feet in length and 3 feet in diameter to be transported through the dam with the flow. However, most wood is supplied during floods, and the FRO dam would trap it when retaining floods. Based on an aerial photograph interpretation of past floods, the estimated volume of wood that would be trapped during a 7-year flood is approximately 6,000 to 7,000 cy for both the FRO and FRFA facilities (Watershed GeoDynamics and Anchor QEA 2016). Wood recruitment occurs primarily from upstream mass wasting, with some wood input from entrainment of wood stored along the channel margins. Wood could be supplied from the Chehalis River upstream of the reservoir, from tributaries, from landslides in the reservoir area, or from trees in the reservoir area that are uprooted when inundated. Trapping of large wood at and upstream of the dam would reduce the potential wood load in the Chehalis River downstream, resulting in a direct impact on the downstream wood supply.

Changes to water flow and sediment transport would have adverse impacts on the channel geomorphology downstream of the dam. Operating the FRO facility would alter the timing and rate of sediment transport, and potentially the rate and occurrence of channel migration due to potential changes in channel conditions (e.g., an increase in channel bed elevation) and changes in flow. The change in the temporal discharge of sediment (bedload and suspended load) and the reduction in the quantity of sediment transported from the FRFA facility would affect the sediment transport continuity in the mainstem Chehalis River downstream of the dam. This change in sediment transport could potentially have a significant adverse impact on channel processes, channel migration, and channel structure downstream of the dam. The largest impact would occur immediately downstream of the dam, where the sediment supply would be most depleted.

Figure 4.2-6

Geomorphic Characteristics of the Chehalis River with Flood Retention Facility



4.2.2.3 Mitigation

4.2.2.3.1 Geology

In addition to the avoidance and minimization measures described in Table 4.1-1, the following measures could be employed to address short-term impacts on geology during construction:

- The tunnel muck waste area would be isolated from the temporary river bypass system and tunnel spoils would be compacted to reduce soil particle erosion outside of the reservoir footprint
- Rock quarries would be developed, or existing forestland quarries would be expanded, within a few miles of the dam and reservoir footprint, so there would be no strain on local commercial rock resources
  - The need for rounded gravel would be incidental, and it could be obtained from local commercial sources in the Centralia-Rochester area with little to no effect on local supply
  - The aggregate used would be crushed basalt that is local to the area and would not be sourced from local commercial quarry sites; therefore, local resources would not be depleted

Long-term landslide avoidance and minimization measures could consist of one or more stabilizing strategies at each landslide site, such as constructing surface and subsurface drainage to lower groundwater levels in the landslide hazard area(s), excavating landslide debris above the landslide plane, installing earth or rock buttresses, and controlling the drawdown rate of the reservoir (anticipated to be 10 to 20 feet per day). For potential low-level induced seismicity of the FRFA facility, the proposed reservoir depth would be designed to be shallower than reservoirs elsewhere that have incurred seismicity. Induced seismicity is associated with active faults, and no known active faults in the reservoir area exist.

To minimize the risk of earthquake-generated landslides to the dam, the following avoidance and minimization measures would be implemented:

- The dam and appurtenant structures would be designed to withstand the effects of shaking on the CSZ and other nearby faults (including the Doty Fault) considered to have the most effect
  - The dam would be designed accordingly, and instrumentation would be installed to measure motions in the structure in the event of a seismic event
- The design of the dam would include incorporation of local seismic criteria
  - The seismic design criteria would result in a dam designed to withstand a seismic event about four orders of magnitude greater than a seismic event that could be generated by reservoir conditions

For unavoidable adverse long-term impacts associated with shallow landslides that result in loss of nearshore riparian or aquatic habitats, compensatory mitigation could include improvements to or creation of other habitats within the Chehalis Basin to compensate for lost habitat functions or aquatic species impacts (see Section 4.2.3.3). A Post-construction Monitoring Plan would be developed as part of the Reservoir Operations and Management Plan and any monitoring of shoreline and reservoir footprint conditions for potential landslide impacts that could occur.

4.2.2.3.2 Geomorphology

Potential mitigation measures for short-term impacts on geomorphology are described in Table 4.1-1. To avoid and minimize short-term sediment transport disruption impacts through the construction zone, a temporary river bypass tunnel would be designed and constructed to pass all river flows, suspended sediment load, and bedload. Compensatory mitigation for the disruption of large wood transport would entail relocating large wood meeting the minimum criteria (12-inch-diameter breast height and 25-foot length) to a downstream channel location.

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

- The FRO dam would be designed to pass suspended sediment load, bedload, and most wood (up to 15 feet in length and 3 feet in diameter) at all times except during flood operations
- A Reservoir Operations and Management Plan would be developed to minimize impacts on geomorphology
  - This plan would include allowing moderate floods (less frequent than a 7-year flood) to pass the dam to maintain peak flows downstream, and to maintain sediment transport, erosion, and deposition processes, including flows necessary to maintain gravel-sorting and deposition in spawning areas
- Spawning gravel areas downstream of the dam would be monitored to determine whether gravel augmentation is necessary to preserve existing gravel bars used for spawning
  - The locations and quantities of this augmentation would be determined based on post-construction monitoring results (i.e., adaptive management would include developing a specific mitigation measure to address a specific impact)
  - This monitoring could include channel cross sections and substrate (bed material) sizes (i.e., pebble counts) to quantify and document changes

For project elements that are anticipated to have long-term, significant, or unavoidable impacts on geomorphology, compensatory mitigation to address modifications of sediment transport quantities and timing, modifications of large wood recruitment and transport, and channel and bank erosion could include the following:

- If monitoring of spawning gravel areas downstream indicates gravel bars are becoming too coarse or significantly reducing in size because of gravel retention in the reservoir, gravel augmentation within the Chehalis River channel could occur

- To mitigate for the potential interruption of wood transport through the dam, large wood captured in the reservoir could be collected and relocated to an appropriate location downstream of the dam (during both flood and non-flood dam operations)
  - Locations of wood placement and quantities would be determined at the time of placement based on channel and habitat conditions present.

A Flood Retention Facility may cause adverse impacts that cannot be fully mitigated by the compensatory actions described here.

4.2.3 Wetlands and Vegetation

4.2.3.1 Short-term Impacts

The potential short-term impacts on wetlands and vegetation from construction activities such as excavating, clearing, filling, and staging equipment and materials are described in Table 4.1-1. Short-term impacts include the temporary disturbance (ranging from 19 acres for the FRO facility to 21 acres for the FRFA facility) of mixed coniferous/deciduous upland forest vegetation of varying sizes and age classes, as well as some scattered wetland communities, from the construction of temporary access roads and construction equipment and material staging areas.

4.2.3.2 Long-term Impacts

The potential adverse impacts on wetlands and vegetation are similar for the FRO and FRFA facility types, but vary in magnitude due to the larger footprint of the FRFA facility and the fact that most of the area would be converted to open water with the conservation pool. Anticipated adverse impacts are related to the following:

- Permanent loss of wetlands and vegetation
- Conversion, disturbance, and reduction of existing wetland, riparian, and vegetation communities

These impacts include vegetated areas and wetlands that would be permanently replaced with facility structures (e.g., dam and spillway).

Over the long term, each of these impacts could in turn affect fish, amphibians, and wildlife currently using these areas; and change the types of available habitat through the modification of river flows, floodplain connectivity, habitat structure, and habitat-shaping processes. These potential adverse impacts on wetlands and vegetation are considered significant due to the substantial loss, disturbance, or conversion of existing habitat. When considered on a Basin-wide scale, the potential loss of vegetation and conversion of vegetated habitat is a small percentage of existing forest habitat.

4.2.3.2.1 Wetlands

Although a formal delineation has not been completed, the 2011 *Modeled Wetlands Inventory* (Ecology 2011b) provides a conservative estimate of total acreage for the wetland types present in the reservoir upstream of the dam (ranging from up to 68 acres for the FRO facility and up to 89 acres for the FRFA facility; see Table 4.2-4 and Figure 4.2-7).

Downstream of the Flood Retention Facility, wetlands in the Chehalis River floodplain could be affected by reduced water inputs from overbank flooding events. Since the FRO and FRFA facilities are designed to reduce flooding from a major flood, many floodplain wetlands would continue to receive floodwater inputs from smaller floods. Wetlands in the outer edges of the Chehalis River floodplain could experience a reduction in the frequency of floodwater inputs; however, as flooding there is already infrequent, these potential changes are unlikely to result in any major changes to the hydrology of these wetlands. Modeled results for the decreased area of floodplain inundation and its potential effect on wetlands have been developed for the combined Flood Retention Facility and Airport Levee Improvements (Alternative 1) and are described in more detail in Chapter 5.

Figure 4.2-7
Wetland Areas Mapped Within the Reservoir Footprint

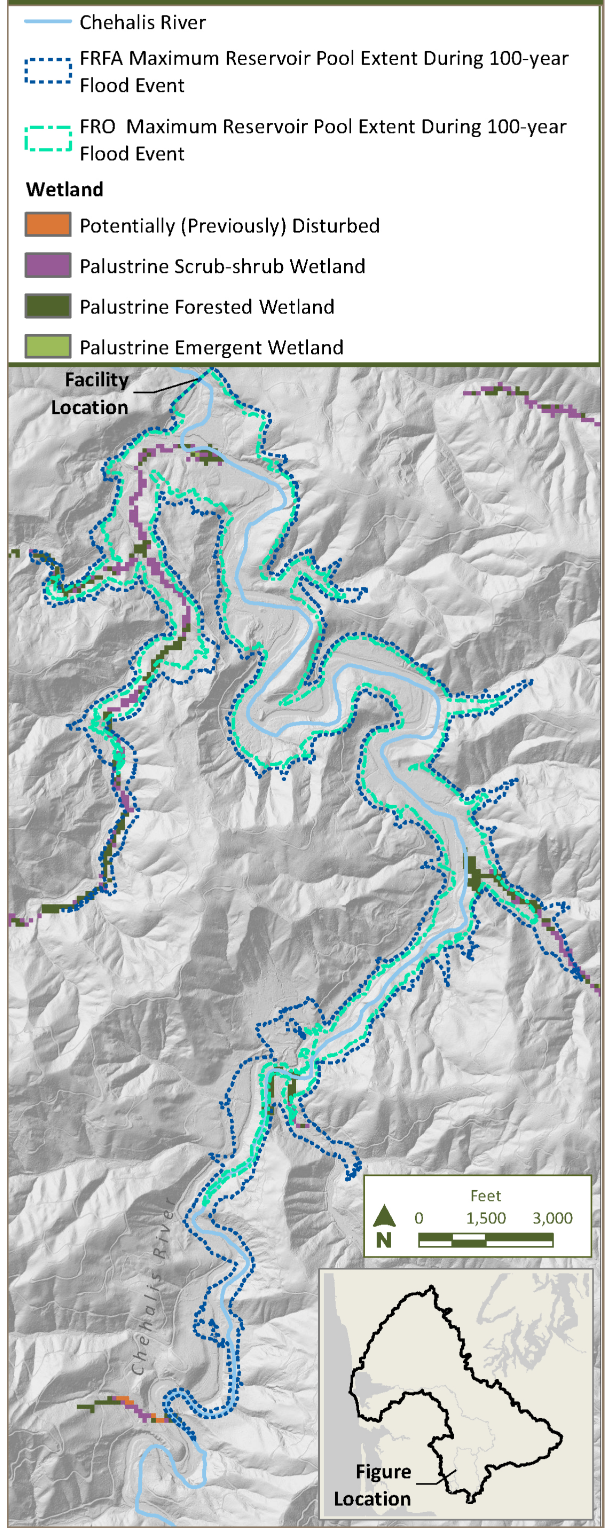


Table 4.2-4
Wetland Areas Mapped Within the Flood Retention Facility Reservoir Footprint

WETLAND TYPE	AREA (ACRES)			
	FRO FACILITY		FRFA FACILITY	
	FLOOD POOL TOTAL	CONSERVATION POOL	FLOOD POOL	TOTAL FOR FRFA RESERVOIR
Palustrine forested wetland	36	35	13	48
Palustrine scrub-shrub wetland	31	31	9	40
Palustrine emergent wetland	1	1	0	1
Total	**68**	**67**	**22**	**89**

Note: Several wetland seeps (springs, pools, or other wet places where groundwater naturally comes to the surface) could also be affected, including at least 10 seeps that are known to support amphibian species (e.g., Columbia torrent salamander, western red-back salamander, Dunn's salamander; Tyson and Hayes 2016). These seep areas are too small to be captured by the 2011 *Modeled Wetlands Inventory*, which does not capture wetlands that are less than 1 acre in size (Ecology 2016d).
Source: Ecology 2011b

4.2.3.2.2 Vegetation

Permanent impacts on vegetation include the removal of existing vegetation in the footprint of the dam, ranging in extent from 6 acres (FRO facility) to 9 acres (FRFA facility), for construction. This vegetation would not be expected to grow back or be replanted because these areas would be occupied by structures, access roads, and other features required for dam operations.

In addition to removal of vegetation for the dam, tree clearing and vegetation removal would occur within the reservoir area, with the details of the removal approach and mechanisms to reduce the extent of clearing provided in the Pre-construction Vegetation Management Plan (part of the Reservoir Operations and Management Plan). This plan would be designed to retain (and allow for the future establishment of) various vegetation community types in specific zones based on the expected duration of inundation during flood retention operations, while allowing some of the harvestable timber to be removed from the reservoir footprint.

The extent of vegetation removal completed prior to dam operation, and the expected post-construction vegetation community for each of these zones, is described in more detail in Appendix J.

The potential adverse impacts of the FRO reservoir area on vegetation include the following changes in vegetation communities:

- Selective harvesting of up to 405 acres of mixed coniferous/deciduous forested riparian areas, which would convert the area to forests dominated by deciduous riparian shrubland

- Periodic inundation of up to 306 acres of coniferous forest dominated by Douglas fir, which would transition to a mixed deciduous/coniferous forest dominated by such species as red alder, western red cedar, and big-leaf maple

The potential adverse impacts of the FRFA reservoir on vegetation include the following changes in vegetation communities:

- Permanent loss of 711 acres from forested upland, riparian, and wetland plant communities
- Selective harvesting of up to 178 acres of mixed coniferous/deciduous forested riparian areas, which would convert the area to forests dominated by deciduous riparian shrubland
- Periodic inundation of up to 262 acres of coniferous forest dominated by Douglas fir, which would transition over time to a mixed deciduous/coniferous forest dominated by such species as red alder, western red cedar, and big-leaf maple

Removal of vegetation from existing riparian areas along the Chehalis River channel and tributary streams in the reservoir footprint could alter or eliminate many of the important riparian functions (Knutson and Naef 1997) provided by these areas, including habitat corridors for wildlife, water and sediment filtration, shading and thermoregulation of instream water, and reduction in ecosystem complexity. These impacts could subsequently affect fish and wildlife, and change the types of habitat available in this area over the long term (see Section 4.2.4).

Both the FRO and FRFA facility types would modify seasonal peak flows in the Chehalis River and reduce the extent of major floods in areas downstream. These changes could reduce the transport of water and nutrients to the outer edges of the Chehalis River floodplain, which could in turn affect the growth and survivorship of vegetation in those areas. Potential results include a gradual change in vegetation composition in these locations. Such changes in plant community composition could modify the types of habitat available in these areas, and affect the fish and wildlife currently using them (see Section 4.2.4).

The reduction in flood extents downstream of the dam would also reduce the episodic disturbance of downstream riparian areas and wetlands by major or larger floods. This could result in a reduction in the occurrence of major channel avulsions and large-scale channel migrations, allowing the adjacent riparian forest to become more mature as the occurrence of periodic disturbance decreases. In addition to these changes, a reduction in the downstream flooding extents could also limit the establishment of invasive species that are spread by flood flows, as certain areas of the floodplain would receive floodwaters less frequently.

4.2.3.3 Mitigation

Some potential impacts on wetlands and vegetation could be addressed through avoidance and minimization measures, including avoiding wetlands during construction access and staging efforts, locating construction access and supporting infrastructure routes to avoid wetlands and minimize stream crossings, and restoring vegetation in temporarily disturbed areas.

The potential compensatory mitigation measures to address unavoidable significant adverse impacts on wetlands from the Flood Retention Facility would be designed to address loss of wetland habitat and ensure no net loss of ecological function. Potential compensatory mitigation for long-term impacts on wetlands could include the following:

- Creating wetlands around the perimeter of the FRO flood pool or FRFA conservation pool
- Restoring previously disturbed wetlands in the floodplain downstream of the dam
- Reconnecting off-channel wetlands to the Chehalis River and floodplain downstream of the dam
- Purchasing credits from an approved wetland mitigation bank in the same watershed

Potential compensatory mitigation measures to address unavoidable adverse impacts on vegetation from the Flood Retention Facility would be designed to address loss or conversion of riparian habitat and replace the functions and values lost from the removal and/or modification of vegetation. A Post-construction Vegetation Management Plan (part of the Reservoir Operations and Management Plan) would be developed and implemented to regularly inspect shoreline erosion, landslides, invasive species, and other conditions that could affect riparian functions along the perimeter of the FRFA conservation pool and tributaries that feed into the reservoir. Corrective measures such as replanting with native, flood-tolerant species could be implemented in problem areas.

Wetland Mitigation Guidance

For action elements that are anticipated to have long-term, significant, or unavoidable impacts on wetlands, compensatory mitigation measures would be developed during project-level design and environmental review to ensure no net loss of ecological function. To achieve this, the goals of the mitigation would be based on the following guidelines from the joint Ecology, USACE, and USEPA document *Wetland Mitigation in Washington State – Part 1*:

- Replace wetland impacts with the same or higher category of wetland
- Provide equal or greater area of wetlands through re-establishment or creation
- Locate mitigation in areas where compensation could contribute to ecosystem functioning
- Clearly identify how the compensation actions would replace the functions lost or provide measureable gains in other functions that are important in the area

Additional compensatory mitigation for long-term impacts on vegetation could include the following:

- Purchasing and preserving adjacent and off-site areas of forestlands within the same watershed
- Replanting harvested areas with native vegetation
- Restoring and enhancing downstream riparian areas by removing invasive species and replanting with native trees and shrubs
- Using flow controls or irrigation and strategic removal of non-native or invasive plant species to stimulate recruitment of valued pioneer riparian trees such as cottonwoods (Poff et al. 1997)

4.2.4 Fish and Wildlife

4.2.4.1 Short-term Impacts

4.2.4.1.1 Fish

Potential short-term impacts related to construction would primarily be from diversion of the Chehalis River around the construction site, and would include the risk of impaired water quality due to construction activities (including the risk of increased turbidity, hazardous materials spills, and low pH runoff), delays or blockages to upstream migrating adult salmon and steelhead with effects on population productivity and subsequent adult returns, and disturbance of habitat in the streambed and riparian areas.

Construction of the dam would require in-water work, diversion of the river, and construction of access roads. These short-term impacts would occur over 2 to 3 years. Direct impacts on fish would occur by injury, mortality, or inhibition of normal behavior like migration, spawning, foraging, and rearing in the same time and place as the construction activity. Effects from direct impacts are outlined in Table 4.1-1 and include gill and skin injuries, impaired foraging or predator avoidance, acutely toxic conditions due to concrete or hazardous spills, trauma from injurious noise levels, and stranding or obstruction of fish passage.

Construction of the Flood Retention Facility could temporarily cause the following indirect impacts on fish:

- Filling of course gravel with fine sediment, which would cause a temporary disruption to spawning and rearing
- Temporary, localized interruption of recharge or discharge of hyporheic zones that could provide cooler, more oxygenated water and food for fish
- Removal of upland and riparian vegetation that typically provides shade and food, and prevents erosion, from in and around the Flood Retention Facility footprint

4.2.4.1.2 Wildlife

Short-term impacts on wildlife would result from construction activities that are either site-specific (e.g., clearing of vegetation from construction access and staging areas) or transient (e.g., construction-and equipment-generated noise). Potential short-term impacts on wildlife related to construction activities are described in Table 4.1-1. Of the listed activities, the following are expected to have the greatest effects on wildlife:

- Removal and disturbance of upland, riparian, and wetland vegetation communities
- Diversion of the Chehalis River around the construction site and the dewatering of in-channel work areas
- Excavation and fill placement in upland work areas
- Disturbance to wildlife caused by construction noise, equipment and vehicle usage, and human presence

Construction of the Flood Retention Facility would require the disturbance of a variety of vegetation communities, including mixed upland forestland and riparian areas (see Section 4.2.3), which are currently providing habitat for native wildlife species that use these areas to breed, forage, rest, and overwinter. Activities required for selective tree removal in the reservoir footprint (e.g., access road construction, logging equipment usage) as part of the proposed Pre-construction Vegetation Management Plan (see Appendix J) could also affect wetlands and several seeps that are reported to support amphibians (Hayes et al. 2015c, 2015d).

Vegetation removal activities in construction areas would degrade or eliminate habitat and could directly injure or kill wildlife that are unable to relocate to avoid the disturbance (e.g., amphibians, reptiles, small mammals). If land clearing takes place during the spring and early summer when most birds nest, eggs and nestlings of tree- and ground-nesting birds could be lost or nests could be abandoned. More mobile species (e.g., young and adult birds, medium and large mammals) would be displaced to adjacent habitat during land-clearing activities. Wildlife displaced from construction sites would move to nearby habitats where they could be competing with resident wildlife, especially if nesting and food resources are already limited. The resulting changes in the local species composition would affect a variety of species in the food web that occupy these habitats, including species that prey on amphibians and other aquatic species. Since human disturbance from logging currently occurs in portions of the Flood Retention Facility site, some level of habituation by wildlife to noise and human activity has potentially occurred. Certain wildlife (e.g., various types of birds, raptors, coyote, raccoon) could adapt to and continue to use areas disturbed by construction activities.

Diversion of the Chehalis River through the temporary river bypass tunnel and dewatering of in-channel work areas would likely kill any aquatic species using those areas for breeding, foraging, or overwintering at the time of diversion and dewatering. Such impacts would primarily affect amphibians that use instream areas for these purposes (e.g., coastal giant salamander, coastal tailed frog, Columbia torrent salamander), as well as those amphibians that use the stream margin and associated stillwater areas (e.g., Pacific treefrog, northern red-legged frog, rough-skinned newt, and western toad; Hayes et al. 2015c, 2015d). Aquatic wildlife using areas upstream and downstream of the construction site could also be injured or killed by the increased water velocity and turbidity present in and around the temporary river bypass tunnel.

Excavation and fill placement in upland areas would adversely affect terrestrial wildlife with limited capacity to flee the disturbance area (e.g., terrestrial amphibians, reptiles, some small mammals), particularly burrowing mammals like moles, voles, and shrews. Such activities would likely cause direct mortality or injury to these species and temporarily or permanently eliminate their habitat.

In regard to more transient construction disturbances such as increased noise levels and vehicle usage, some wildlife species would adapt to these disruptions (e.g., birds and mammals that are habituated to human disturbance), and some species would successfully relocate to other suitable habitat (e.g., larger mammals, birds). Some less mobile wildlife species (e.g., small mammals, amphibians, reptiles) would be unsuccessful in adapting or relocating, and their ability to find adequate shelter and foraging and breeding habitat would be constrained.

Although many of these impacts would be of relatively short duration, and habitat for some types of wildlife would be re-established in many of these areas following construction, there would be temporal delays in restoring habitat function and quality to pre-action conditions.

4.2.4.2 Long-term Impacts

The potential adverse impacts on fish and wildlife were determined by evaluating how the physical changes in the environment described in the water resources, geology and geomorphology, and wetlands and vegetation sections (see Sections 4.2.1, 4.2.2, and 4.2.3) would affect the quality of habitat, behavior, and survival. Research was carried out in the Chehalis River from 2013 to 2016 to characterize existing distributions and behavior of fish and wildlife in the areas of the mainstem Chehalis River affected by the Flood Retention Facility, including the following studies:

- *Upper Chehalis Instream Fish Study 2015* (Winkowski 2015)
- *Riverscape Surveys of In-stream Fish Assemblages and Habitat in the Chehalis River* (Zimmerman and Winkowski 2016)
- *2016 Chehalis ASRP Egg Mass Surveys in Off-Channel Habitat: 3rd Progress Report for Post-Feasibility Efforts* (Hayes et al. 2016a)
- *2016 Chehalis ASRP Instream Amphibian Survey Report: 3rd Progress Report for Post-Feasibility Efforts* (Hayes et al. 2016b)
- *2016 Chehalis ASRP Stream-Associated Amphibian Survey: 3rd Progress Report* (Hayes et al. 2016c)
- *Waterfowl and Waterbird Abundance and Use of Aquatic Off-Channel Habitats in the Chehalis Floodplain: Preliminary Report* (Evenson et al. 2016)
- *Upper Chehalis Salmonid Spawner Abundance and Distribution, 2013-2015 Interim Report* (Ashcraft et al. 2016)

- *Summer habitat and movements of juvenile anadromous salmonids in a coastal river in Washington State* (Winkowski and Zimmerman, in prep)
- *Behavior and movements of adult spring Chinook salmon* (Oncorhynchus tshawytscha) *in the Chehalis River Basin, southwestern Washington, 2015* (Liedtke et al. 2016)

In order to estimate the change in fish populations with a dam, the potential changes in fish habitat quality were modeled using the EDT model (ICF 2016), and fish passage efficiency and survival through the dam were estimated for various fish passage scenarios (Garello 2016a).

4.2.4.2.1 Fish

The potential adverse impacts on fish are primarily related to the following changes in physical attributes of the environment created by the Flood Retention Facility:

- Periodic or permanent inundation of the area upstream of the dam
- Introduction of an obstacle or complete barrier to fish migration from dam infrastructure
- Reduction in the magnitude of high-flow events downstream of the dam, with a decrease in temperatures downstream for the FRFA facility only

Anticipated adverse impacts of the Flood Retention Facility on fish would be significant for fish populations in the Chehalis Basin. Adverse impacts would primarily affect fish in the mainstem Chehalis River above and immediately below the dam; however, the impact could cause changes to fish population levels that are observable at a Basin-wide scale, particularly for migratory fish such as salmon and steelhead. Adverse impacts would occur due to changes in habitat functions and reduced access to habitat from the following:

- Loss of habitat function within the reach of the Chehalis River inundated upstream of the dam for cool, swift-water associated fish species, including loss of spawning habitat and food supplied to the river from the riparian corridor and vegetation
- Partial reduction in fish survival and potential interruptions to migration due to passage impediments, including salmon and lamprey spawning migrations
- For the FRFA, exposure of juvenile salmonids that use the permanent reservoir for rearing to predators that may thrive in the reservoir
- Changes to fish habitat-forming processes and water quality downstream of the dam

The potential long-term benefits to some species of fish are primarily related to the following changes in physical attributes of the environment created by the FRFA facility:

- Creation of reservoir habitat that some species and life stages that currently exist in the area could utilize for rearing or foraging, such as coho salmon, steelhead, largescale sucker, mountain whitefish, or sculpin; however, uses in the summer may be limited due to high water temperatures

- Increased habitat area and capacity for native salmonid and non-salmonid species associated with flow augmentation and temperature reduction downstream of the FRFA facility

This section provides a summary of the effects to fish during operation of the Flood Retention Facility. Additional detailed information is provided in Appendix H.

The effects of dams on aquatic systems in the Pacific Northwest have been widely studied, with the literature generally showing far-reaching negative impacts for aquatic systems. These impacts are particularly notable for salmonids, affecting habitat quality, upstream and downstream survival, and migration. In addition, headwater areas like the upper Chehalis River are important holding and rearing areas for salmon across the Pacific Northwest, and the construction of dams in Puget Sound rivers has led to multiple extirpations of spring-run Chinook salmon populations (Beechie et al. 2006). The dams proposed for the upper Chehalis River are uniquely designed for the purpose of flood retention and fish passage, with added measures intended to reduce the adverse impacts on fish. It is important to evaluate the impacts of the proposed dams in context with historical impacts of existing dams throughout the Pacific Northwest; however, because of the unique design of the FRO and FRFA dams and flood control operations being proposed, it is equally important to evaluate the impacts of each dam type on fish independent from the known effects of other dams.

Construction of the Flood Retention Facility would occur over 2 to 3 years and would thus affect multiple year-classes of fish that spawn in the area of construction, potentially reducing survival of eggs and juveniles in the vicinity of the Flood Retention Facility site. Fish attempting to migrate upstream of the dam site to spawn could also be affected if adequate fish passage is not provided around the site during construction. Short-term impacts during the 2- to 3-year construction period could become a long-term impact as reduced egg and juvenile survival in a given year would lead to reduced abundance in subsequent generations. For instance, reduced salmon and steelhead egg survival in a given year could result in fewer adult salmon and steelhead returning to the upper Chehalis Basin 2 to 4 years later.

The construction of new roads to access the dam structure for maintenance activities has the potential to increase the amount of impervious surface adjacent to the Chehalis River and runoff carrying fine sediment. High levels of fine suspended sediment in the water could cause a direct impact on fish by causing gill abrasions, which is a hazard to fish health. In addition, there could be an indirect impact on fish because sedimentation slows the delivery of oxygenated water through spawning substrate to incubating eggs, and high turbidity interferes with vision, impairing foraging and predator avoidance behaviors.

Overall, both the FRO and FRFA facility types would create a significant adverse impact on fish survival, migration, and the area of habitat available for spawning and rearing, specifically for species that use the stream reaches just above and below the dam. The impact on fish resources would result from loss of habitat functions and reduced survival or access to spawning grounds in the vicinity of the Flood Retention Facility. The magnitude of the impact on the total Chehalis Basin population of a given species would vary depending on the abundance and distribution of each species in other tributaries to the Chehalis River, including those that would be largely unaffected by the dam.

The free-flowing reach of the Chehalis River upstream of the dam would be converted to a lake-type habitat—either temporarily in the case of the FRO facility (up to 32 days), or permanently in the case of the FRFA facility. Many species that migrate, spawn, and rear in the dam footprint and reservoir area have adapted to cool, fast-flowing stream conditions and would be adversely affected by inundation, whether temporary or permanent. With current conditions, major floods can adversely affect fish in these areas due to high-velocity flow that can displace fish and scour redds, causing impacts that can last several generations. Flood retention with a dam would cause inundation that would similarly displace fish from the stream channel and suffocate redds, but may additionally interrupt normal behaviors (e.g., foraging, migration, spawning), and could reduce survival of resident fish species and immobile life stages for longer periods of time than occurs during an uncontrolled flood under existing conditions. Changes to flow and inundation areas could cause localized modifications to hyporheic flows, a habitat feature that can supply cool groundwater in otherwise warm rivers, including the Chehalis River (Liedtke et al. 2016), as well as act as a site for nutrient cycling, a source of DO, and a source of food for fish (Boulton et al. 1998; Stanford and Ward 1988). Modifications to hyporheic flow could also affect critical spawning habitat for salmon that seek areas of hyporheic exchange for building redds (Geist et al. 2002).

Loss of habitat function would occur due to removal of trees with either the FRO or FRFA facility, as described in Section 4.2.3, which would permanently eliminate the riparian buffer zone and reduce food and nutrient inputs that directly and indirectly feed fish (Allan et al. 2003). With the FRO reservoir, shading by riparian trees would be reduced or eliminated around stream reaches that flow through the reservoir footprint, resulting in an increase of water temperatures in the summer of up to 5°C for some areas compared to current conditions (e.g., Crim Creek, an area with a narrow stream channel that is currently well shaded) that would persist to areas downstream of the FRO dam. Water temperatures in the reach immediately below the FRO dam—where summer water temperatures already exceed optimal limits for salmon and other cool-water fish species—are predicted to increase in summer by approximately 2 to 3°C (Beschta 1997). Impacts of the FRO facility on water temperature would be negligible below the confluence with the South Fork Chehalis River.

The supply of large wood to the river channel from the stretch of river that flows through the inundation footprint would be eliminated with an FRFA facility during both non-flood and flood operations. For the FRO facility, large wood would be trapped during flood operations (see Section 4.2.2.2.2). Large wood is necessary to maintain fish habitat-forming processes, such as the creation of pools and side-channel habitat. Some impacts on riparian zone function in the inundation footprint could be minimized with a Pre-construction Vegetation Management Plan that would prevent total loss of riparian vegetation and riparian area function for fish through selective clearing; however, adequate shading is not likely to minimize the impact on water temperature, and large wood would not be recruited to the stream channel.

Changes in water quality in the reservoir, as discussed in Section 4.2.1.2.1 (turbidity, temperature, and DO), would create a significant adverse impact on fish. A small risk exists for MeHg to accumulate in the food web due to the conversion of atmospheric Hg to its toxic form, MeHg, by bacteria that thrive in summer reservoir conditions. In the permanent FRFA reservoir, water would heat and stratify during the summer months, exceeding the core summer salmonid habitat criterion (of 16°C), and the temperature range for optimal growth of juvenile salmon (10 to 15°C; McCullough 1999) in the upper elevations (shallower depths) of the reservoir. Immediately upstream of the FRFA dam, water temperatures may reach approximately 20 to 25°C in July and August—depending on meteorological conditions—which would be stressful, increase risk of disease outbreak, and would be detrimental to growth of juvenile salmon because their ability to feed cannot meet their metabolic requirements at these temperatures. Warmer waters in the FRFA reservoir would also hold lower DO; however, reductions in DO are not expected to reach levels considered lethal for juvenile salmon near the surface. In addition, decaying vegetation and lack of mixing could contribute to low DO levels deep in the reservoir, causing fish to avoid seeking refuge at depth.

Reduced water quality in shallower layers of the reservoir could force juvenile salmon to seek thermal refugia in deeper water, limiting their foraging opportunities and reducing the effectiveness of juvenile fish collection facilities, or could cause them to emigrate from the reservoir early in the summer, eliminating any benefit of the reservoir for rearing. Warmer reservoir temperatures are also known to exacerbate predator feeding (e.g., northern pikeminnow that are currently found downstream of the proposed dam site) on juvenile salmonids (Peterson and Kitchell 2001). Invasive predators (e.g., smallmouth or largemouth bass) are not anticipated because these species are located farther downstream at this time.

Mobilization of fine sediment would occur in hydrologically dynamic areas of both the FRO and FRFA reservoir, causing increased turbidity in the reservoir and areas downstream of the dam. Turbidity could affect fish directly by causing gill abrasion and impairing vision. Frequent disturbance of the substrate would alter food webs that support fish by resetting the standing crop of algae and aquatic invertebrates that feed fish (Power 2006). Sediment deposition would create the greatest impact on benthic species and immobile life stages. Fine sediments could reduce incubation survival for fish that use the riverbed for spawning, and change habitat use for species that rely on larger bed materials. In particular, incubating salmon embryos in redds require a constant flow of oxygenated water through the gravel and would suffocate if inundated under still, deep water or if they become covered in newly deposited sediment.

The dam presents a barrier to upstream and downstream juvenile and adult fish movement, impairing the fish's ability to forage, find refuge, and, in some cases, complete its life cycle, presenting a significant adverse impact on fish. The potential impact of a barrier would be greatest for highly migratory species that migrate to the sea to complete their life cycles (e.g., salmon, steelhead, Pacific lamprey). Passage through tunnels with the FRO dam presents the least impact on migratory species because these would be designed to mimic the natural gradient of the river channel. Therefore, when water is not being impounded, the FRO dam may only present a minor adverse impact on passage for adult and juvenile fish migrating upstream and downstream. With the FRFA dam, and when tunnels in the FRO dam are closed for flood retention, engineered structures and mechanisms for the passage of juvenile and adult fish through or around either dam would be provided. Final fish passage designs have not been determined, and passage success would vary considerably depending on the method of passage. Fish passage facilities would be designed according to state and federal fish passage engineering criteria to allow fish to safely pass the dam and access spawning and rearing area above the dam.

Pacific lamprey are found in the mainstem Chehalis River below the proposed dam site (USFWS 2011) and occupied every sub-basin sampled in the Chehalis Basin in a recent study, including major tributaries of the Chehalis River that would not be affected by the proposed dam and reservoir, including the Newaukum, Skookumchuck, and Black rivers (Jolley et al. 2016). Considerations to accommodate adult lamprey passage through the outlet tunnels in the FRO dam and around the FRFA dam are being incorporated into the designs, because adult lamprey have difficulty ascending fish passageways designed strictly for salmon (Garello 2016b).

Overall, adult and juvenile lamprey passage through the FRO dam is expected to be high (from 95% to 96%), and higher than passage through the FRFA dam (adult passage estimates range from 40% to 60%; juvenile downstream passage estimates range from 0.3% to 0.6%). While upstream and downstream passage and survival rates for lamprey and salmonids would be reduced from current levels, there is uncertainty with how well the facilities would perform for lamprey, especially the facilities designed to pass fish around the FRFA dam. The fish passage facilities associated with the FRFA dam could nearly eliminate downstream passage for lamprey. Over the long term, the challenge of passing lamprey downstream around the FRFA dam could prevent lamprey from migrating to the ocean, leading to local reductions in the population, and possibly the elimination of lamprey upstream of the dam. Based on the available information, construction of the FRO dam would not significantly affect passage of lamprey, but it is unknown how changes in the reservoir area would affect lamprey. Construction of the FRFA dam would have a significant effect on the upper mainstem population of lamprey in the Chehalis Basin. Because lamprey abundance has not been as broadly quantified as salmon abundance, the magnitude of the impact that the loss of lamprey upstream of the FRFA dam presents to the whole Chehalis Basin population remains uncertain. However, the Basin-wide population is not expected to be eliminated with either dam type, based on the conclusion by Jolley et al. (2016) that a robust population of Pacific lamprey is currently present in the Chehalis Basin.

The anticipated total survival (a combination of fish performance and survival) through each type of fish passage facility for groups of species is summarized in Table 4.2-5. For the FRO dam, passage through the tunnel outlets is expected to be high for all species and life stages. When water is impounded behind the FRO dam, passage through the trap and transport facility is expected to be average or high, depending on the species and life stage. For the FRFA dam, passage facilities for fish migrating upstream are expected to perform well for adult salmonids and average for adult lamprey and juvenile salmonids. Passage of juvenile lamprey migrating downstream is expected to be extremely poor and could result in Pacific lamprey being eliminated from the upper Chehalis River.

Table 4.2-5
Anticipated Fish Passage Survival Through the Dam and Fish Passage Structures

		TYPE OF FACILITY AND PASSAGE STRUCTURE			
		FRO	FRFA		FRO OR FRFA
SPECIES		TUNNELS	LADDER	JUVENILE PASSAGE FACILITIES	TRAP AND TRANSPORT
Anadromous salmon and steelhead	Adult upstream	94% – 96%	79%		91%
	Juvenile upstream	59% – 79%			54%
	Juvenile downstream	85% – 95%		64%	
Lamprey	Adult upstream	96%	54%		54%
	Juvenile downstream	95%		<1%	

Note: Ranges are based on differing passage survival depending on species.

Though inundation or blockages to fish passage could be temporary, a loss of productivity for several weeks in a single year due to temporary inundation or blockage of fish passage would lead to reduced productivity in the subsequent generation. For salmon, the operation of the FRO facility could impair a single group of spawners, and reduce the productivity of their offspring 2 to 4 years later. In this way, the impact of a single flood could become protracted and cause fewer adult salmon and steelhead to return to the upper Chehalis Basin in future years.

There would be a reduction in fish habitat downstream of the dam to RM 62 (downstream of the Skookumchuck River confluence) during major floods due to impaired geomorphic processes, including reduced transport of coarse sediment (reduced by 25% to 50%) and wood transport (see Section 4.2.2). Mitigating effects of a Pre-construction Vegetation Management Plan, and the ability of the FRO dam to pass sediment and wood during most flows, would reduce the change to habitat function downstream of the FRO dam compared to the year-round change in flow and retention of sediment and wood with the FRFA dam (see Section 4.2.2.2.2). Changes to geomorphic processes downstream of the dam would result in a significant adverse impact on the formation of fish habitat.

Flood control operations would reduce floodplain inundation by 10% (4,480 acres), eliminating some connections between the Chehalis River and off-channel or floodplain areas during and after floods that are large enough to trigger flood retention. Floodplain areas that are ephemerally connected to the mainstem Chehalis River can be important rearing and holding habitat for fish, and a reduction in the floodplain's inundated area would be a minor impact on fish habitat function.

Flow augmentation and releases of cool water from the FRFA reservoir are anticipated to provide downstream benefits to native fish species including Pacific lamprey, mountain whitefish, largescale sucker, speckled dace (discussed later in this section) and adult spring-run Chinook salmon that require cool-water refugia during peak summer water temperatures. A positive response of spring-run Chinook salmon reflects the potential effect of cooler summer water on pre-spawning survival, improved juvenile rearing, and potential for earlier spawning. This assumes that spring-run Chinook salmon would respond by expanding their distribution into the reach of the mainstem Chehalis River between Elk Creek and the Flood Retention Facility site, as they have not been observed using this stretch of river previously in summer (Zimmerman and Winkowski 2016). Whether adult spring-run Chinook salmon would respond behaviorally to modulating temperature and flow from the FRFA facility is unknown and represents a key uncertainty (see Appendix K). In spring and summer months, water temperatures would be reduced by as much as 10°C in the reach immediately below the dam with effects diminishing farther downstream to RM 65 (approximately the confluence with the Skookumchuck River). Below RM 65, negligible differences in cool-water habitat from baseline conditions would occur, mainly due to the influence of large tributaries. The predicted impact of the FRO and FRFA facilities on salmon productivity was quantified using habitat modeling (EDT; ICF 2016). The modeled current habitat potential for the Chehalis Basin to support each salmon species is depicted as the number of potential spawners, alongside average estimated total run size and escapement since 1987 shown in Table 4.2-6 (further details on salmon run size can be found in Table 3.4-4 in Section 3.4.1.1.4).

Table 4.2-6
Baseline Potential Salmonid Abundance in the Chehalis Basin

SPECIES	EDT HABITAT POTENTIAL SPAWNERS	ESTIMATED TOTAL RUN ABUNDANCE	ESTIMATED ESCAPEMENT
Coho salmon	40,642	60,096	43,222
Fall-run Chinook salmon	25,844	25,500	12,100
Fall/winter-run chum salmon	190,550	36,300	21,900
Spring-run Chinook salmon	2,146	2,300	2,200
Winter-run steelhead	6,800	12,800	10,700

Source: ICF 2016

Three dam scenarios were modeled using EDT to account for the changes in habitat that could occur with inundation, barriers to fish passage, and reduction in downstream habitat-building processes: the FRFA, and two FRO scenarios. Two scenarios were modeled for the FRO dam to provide a range of results that reflects the uncertainty around the effects of habitat degradation upstream of the dam. The FRO 50 scenario predicts degradation in 50% of the spawning habitat in the inundation area, whereas the FRO 100 predicts degradation in 100% of spawning habitat in the inundation area, with no differences in all other habitat characteristics upstream and downstream of the dam for the FRO. The degradation is modeled by converting reaches from pool and riffle habitat with high value for salmon spawning to glide habitat which holds little spawning value. The effect of an FRO 50 scenario could represent a more likely scenario because habitat would be disturbed only when floods are retained, approximately once every 7 years on average, and a Pre-construction Vegetation Management Plan would prevent total loss of riparian vegetation and riparian area function for fish. Though inundation associated with an FRO facility is anticipated to occur infrequently, a precise projection of the highest extent of impacts on upstream habitat degradation is difficult to predict given uncertainties related to the extent of potential water temperature increases, reduction of food and nutrient inputs from riparian habitat loss and fine sediment deposition, spawning gravel changes in the reach between retention events, channel widening, mass wasting sediment input, and other factors. Therefore, it is appropriate to evaluate both 50% and 100% upstream habitat loss, to capture the range of potential outcomes. The modeled impact of each Flood Retention Facility type on the whole Chehalis Basin population of salmon and steelhead is summarized in Table 4.2-7 and Figure 4.2-8 (ICF 2016).

All of the three dam scenarios modeled would reduce the overall abundance of all salmon and steelhead populations in the Chehalis Basin from less than 1% to 4% depending on the species. An FRFA dam would have a larger adverse impact on coho and fall-run Chinook salmon, whereas the FRO dam would have a larger adverse impact on spring-run Chinook salmon, winter/fall-run chum salmon, and winter-run steelhead.

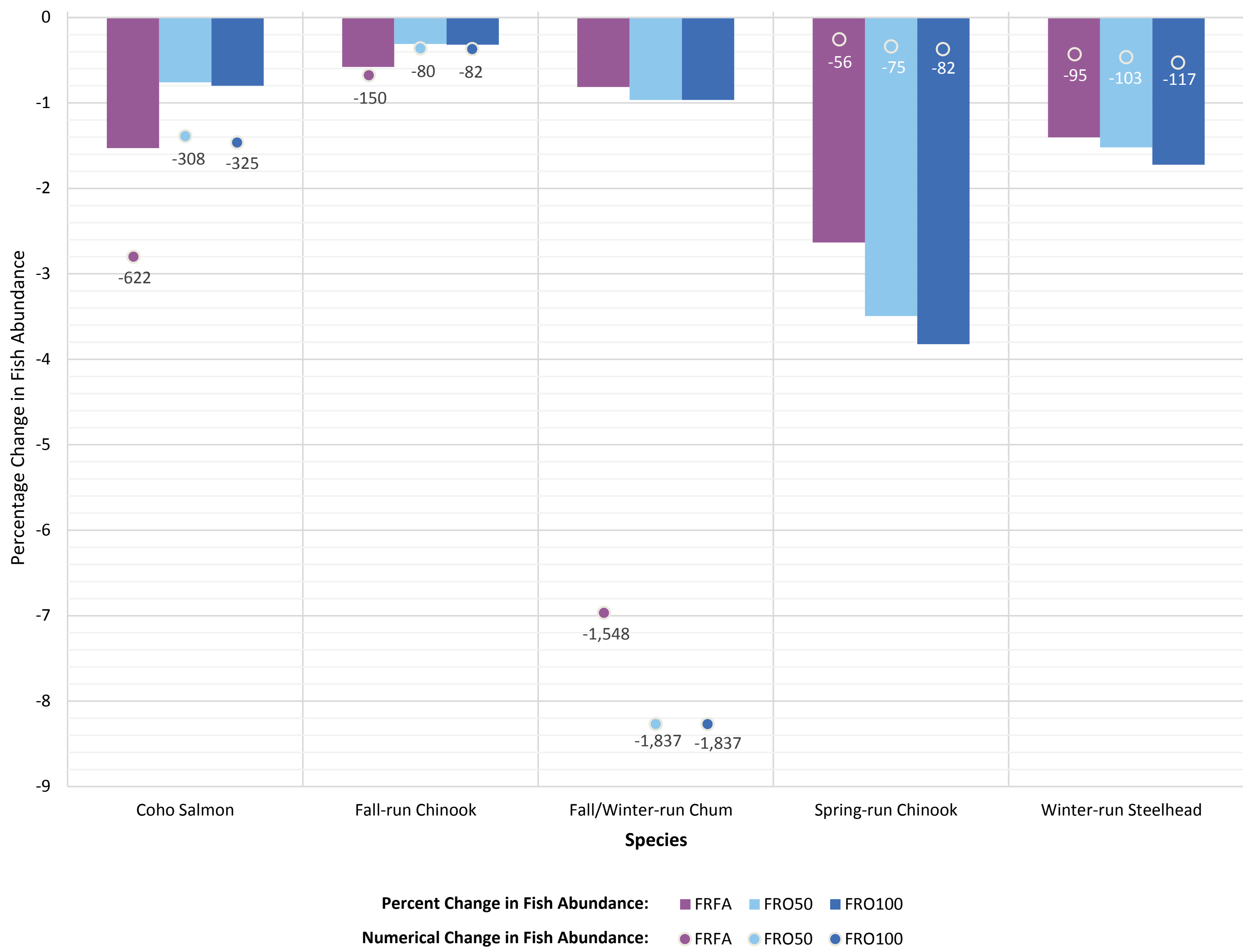
Table 4.2-7
Potential Response in Salmonid Abundance to Habitat Change in the Chehalis Basin from Flood Retention Facility Types

SPECIES (CURRENT HABITAT POTENTIAL)	CHANGE FROM CURRENT CONDITION IN NUMBER OF FISH (%)		
	FRFA	FRO 50	FRO 100
Coho salmon (40,642)	-622 (-2%)	-308 (-1%)	-325 (-1%)
Fall-run Chinook salmon (25,844)	-150 (-1%)	-80 (<-1%)	-82 (<-1%)
Winter/fall-run chum salmon (190,550)	-1,548 (-1%)	-1,837 (-1%)	-1,837 (-1%)
Spring-run Chinook salmon (2,146)	-56 (-3%)*	-75 (-3%)	-82 (-4%)
Winter-run steelhead (6,800)	-95 (-1%)	-103 (-2%)	-117 (-2%)

Note:
* = With response to flow augmentation and temperature reduction; without response to increased flow and cooler water, effect downstream of dam similar to FRO 100
The behavioral response of adult spring-run Chinook salmon in the Chehalis River to modulating temperature and flow from the FRFA facility is unknown and represents a key uncertainty described in more detail below and in Appendix K.
Source: ICF 2016

Figure 4.2-8

Potential Response in Salmonid Abundance to Habitat Change in the Chehalis Basin from Flood Retention Facility Types



Source: ICF 2016

The combination of adverse impacts upstream of the FRFA dam and beneficial effects of flow augmentation and temperature reduction downstream of the FRFA dam is expected to reduce the Chehalis Basin population abundance of salmon by 1% to 3%, depending on species (see Table 4.2-7 and Figure 4.2-8). The cumulative change to Chehalis Basin spring-run Chinook salmon populations is predicted to be negative; however, the abundance of spring-run Chinook salmon spawners using areas just below the dam is predicted to increase (impacts in the area just below the dam are discussed further below). The strong positive response of spring-run Chinook salmon modeled was due to the reduction in water temperature during the summer, and reflects the potential effect of cooler summer water on pre-spawning survival, improved juvenile rearing, and expansion of earlier spawning life histories. This assumes that spring-run Chinook salmon would hold over summer and spawn in the mainstem Chehalis River between Elk Creek and the Flood Retention Facility site prior to spawning in the fall in the same area. Whether adult spring-run Chinook salmon would respond behaviorally to modulating temperature and flow from the FRFA facility is unknown and represents a key uncertainty. An alternative view is that during summer, prior to spawning, adult spring-run Chinook salmon have adapted to the Chehalis River by holding in cool-water refugia—either in areas with cold groundwater inputs farther downstream than the area that would be most affected by an FRFA dam, or by moving upstream quickly to cool headwaters—and that the area modified by increased flow and decreased temperature with an FRFA dam would provide little habitat value for pre-spawn holding, spawning, or rearing. If this view is correct, the cool-water releases from an FRFA dam may have no effect on fish populations downstream of the dam. If the benefits of flow augmentation and temperature reduction do not accrue as anticipated, the total Chehalis Basin spring-run Chinook salmon population would experience reductions at least on the scale of the FRO 100 scenario, and perhaps greater due to the added loss of habitat upstream of the dam. More information is included in Appendix K.

At the Basin-wide scale, both FRO facility habitat scenarios considered would have negative effects on all salmonid species, resulting in population declines ranging from about <-1% for fall-run Chinook salmon under FRO 50 and FRO 100, to -4% for spring-run Chinook salmon under FRO 100, presenting a significant adverse impact on salmon (see Table 4.2-7 and Figure 4.2-8).

When considering impacts on salmonid species at a local scale within individual sub-basins, the impacts of both dam facilities attenuate moving downstream (see Figure 4.2-9). Changes in abundance would occur in other tributary sub-basin populations because those fish migrate through, and are affected by, changes occurring in the mainstem Chehalis River downstream of the FRO facility. This includes spawning populations in Elk Creek, the South Fork Chehalis, and the Newaukum, Skookumchuck, and Black rivers. Model results indicate impacts on subpopulations using the mainstem Chehalis River up to the confluence with the Skookumchuck River. Chum salmon would be affected in areas below the confluence with Elk Creek because chum are not present upstream of Elk Creek. Impacts on populations in the lowest reaches and tributaries of the Chehalis River were not detected.

Changes to habitat in the river segments upstream of the dam facilities and immediately downstream to the confluence of the mainstem Chehalis River with Elk Creek are shown in Table 4.2-8. The number of salmon spawning in the upper Chehalis River upstream of the FRO facility would be reduced by 18% to 49% under the FRO 50 scenario, and 29% to 55% under the FRO 100 scenario, depending on the species (see Table 4.2-8 and Figure 4.2-9). Changes in habitat between the FRO facility and the confluence of the mainstem Chehalis River with Elk Creek would result in declines in the subpopulations that use this reach to spawn, ranging from a loss of 17% of the fall-run Chinook salmon population to a loss of 58% of the spring-run Chinook salmon population (see Table 4.2-8 and Figure 4.2-9). Declines in subpopulations downstream of Elk Creek would be smaller (0% to 17%), except for spring-run Chinook salmon that could spawn in the mainstem from the confluence of the South Fork Chehalis River to the confluence with Elk Creek, which could see a decline of 36% (see Figure 4.2-9). With an FRFA facility, major declines in salmon subpopulations currently spawning above the dam site would occur due to the replacement of stream habitat with a reservoir (see Table 4.2-8 and Figure 4.2-9). The majority of fall-run Chinook salmon (98%), spring-run Chinook salmon (97%), and half the winter-run steelhead (50%) would be lost upstream of the dam. Coho salmon in this reach would experience a 23% loss. Immediately downstream of the FRFA facility to the confluence with Elk Creek, spring-run Chinook salmon abundance could increase (67%), but other species spawning in this reach would decline (losses of 28% to 62%, depending on species). Impacts in the lower portion of the Chehalis River were either not detected or were minor and positive for spring-run Chinook salmon (see Figure 4.2-9). If spring-run Chinook salmon do not respond as modeled to flow and temperature modulation, the change in abundance modeled for spring-run Chinook salmon would be similar to that predicted for the FRO facility, since adverse impacts of downstream changes to habitat-forming processes would be similar.

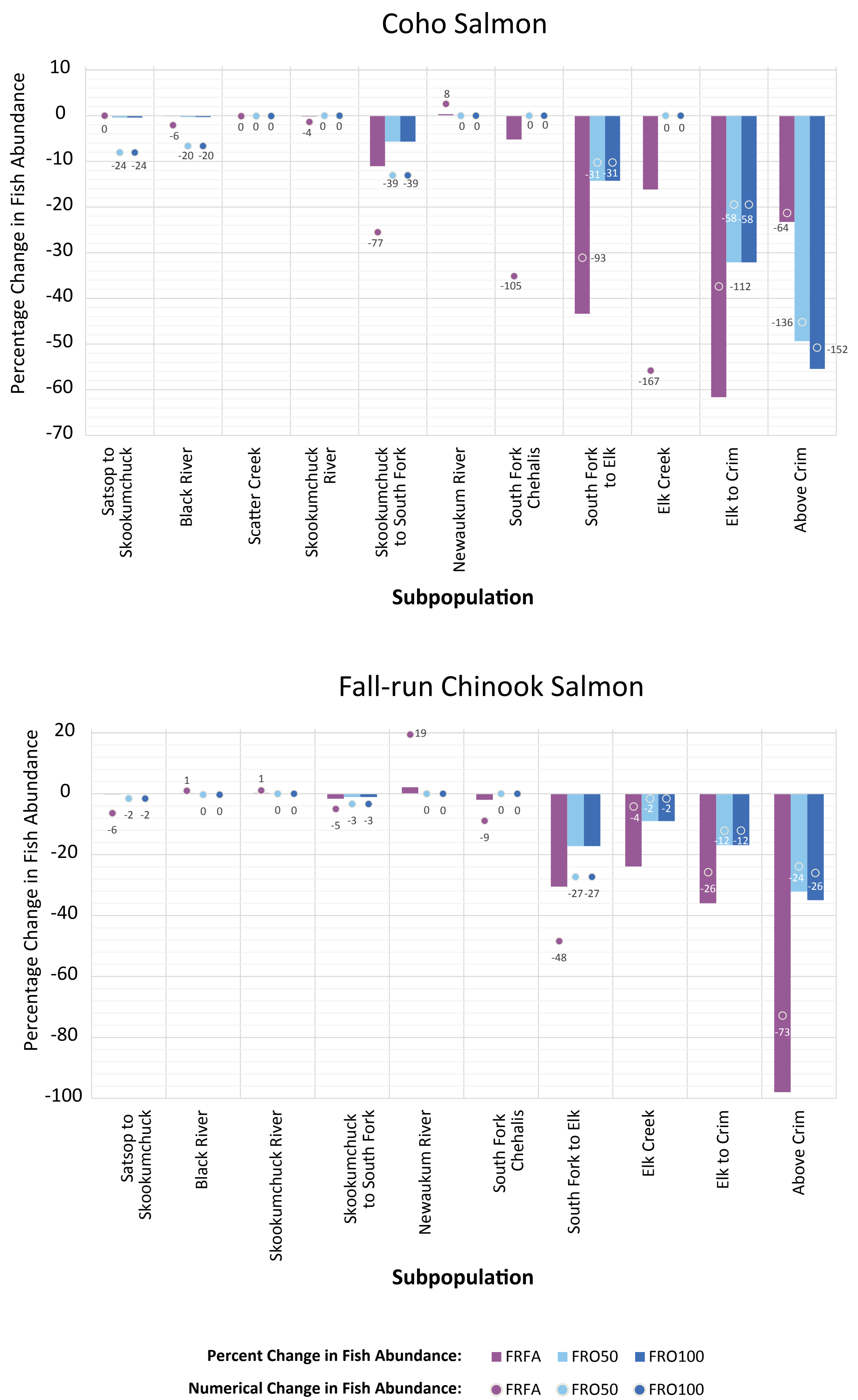
Table 4.2-8
Potential Response in Salmonid Abundance to Habitat Change in Upper Chehalis Sub-populations from Flood Retention Facility Types

SPECIES	SUB-POPULATION (CURRENT HABITAT POTENTIAL)	CHANGE FROM CURRENT CONDITION IN NUMBER OF FISH (%)		
		FRFA	FRO 50	FRO 100
Coho salmon	Upstream of Crim Creek (dam site; 275)	-64 (-23%)	-136 (-49%)	-152 (-55%)
	Crim Creek to Elk Creek (182)	-112 (-62%)	-58 (-32%)	-58 (-32%)
Fall-run Chinook salmon	Upstream of Crim Creek (dam site; 74)	-73 (-98%)	-24; -32%	-26 (-35%)
	Crim Creek to Elk Creek (72)	-26 (-36%)	-12; -17%	-12 (-17%)
Fall/winter-run chum salmon	Upstream of Crim Creek (dam site; 0)	N/A	N/A	N/A
	Crim Creek to Elk Creek (0)	N/A	N/A	N/A
Spring-run Chinook salmon	Upstream of Crim Creek (dam site; 61)	-59 (-97%)	-11 (-18%)	-18 (-29%)
	Crim Creek to Elk Creek (56)	38 (67%)	-33 (-58%)	-33 (-58%)
Winter-run steelhead	Upstream of Crim Creek (dam site; 171)	-85 (-50%)	-74 (-44%)	-88 (-52%)
	Crim Creek to Elk Creek (18)	-5 (-28%)	-5 (-25%)	-5 (-25%)

Note: N/A is used where the percentage change cannot be calculated from an initial population of zero.
Source: ICF 2016

Figure 4.2-9a

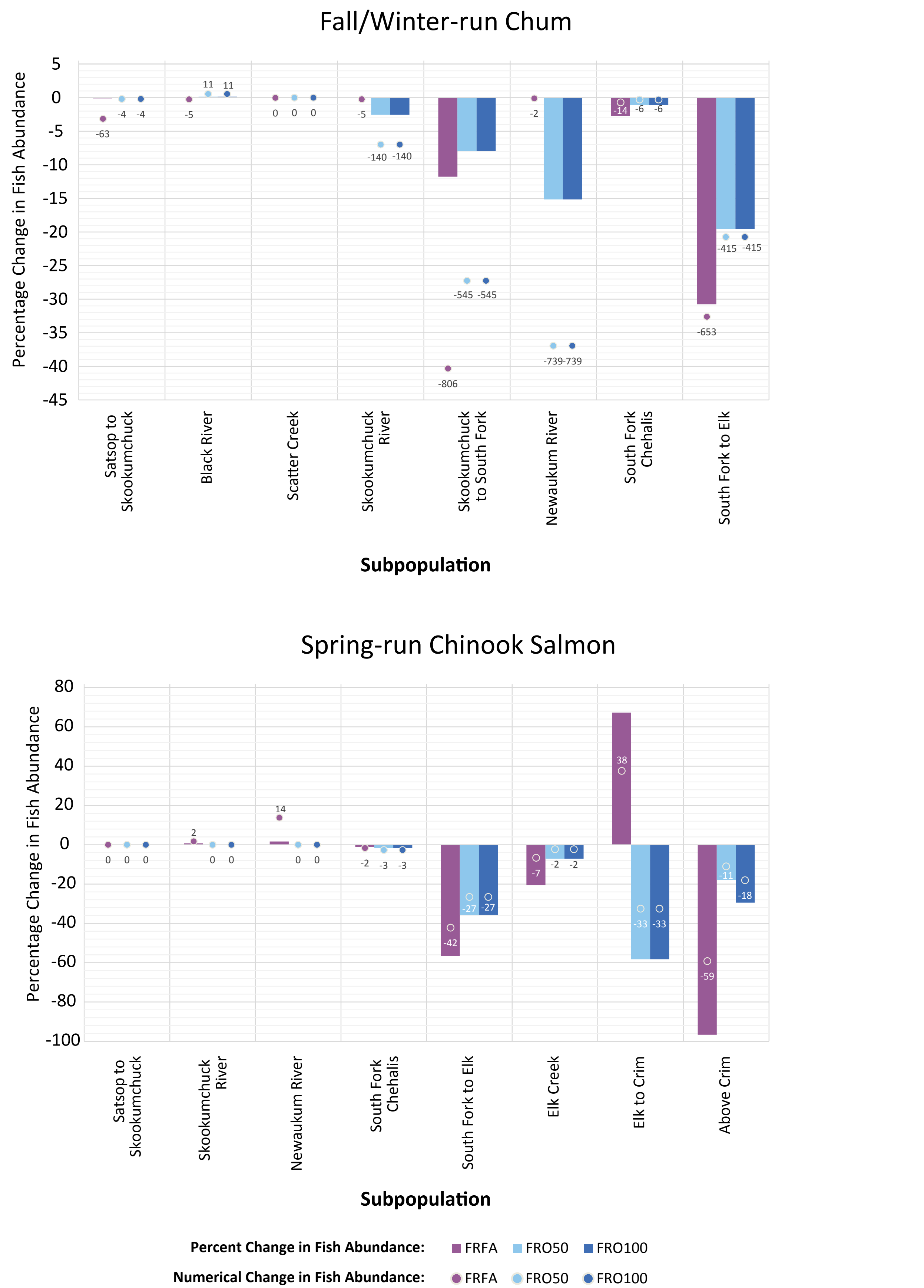
Potential Response in Salmonid Abundance to Habitat Change in Upper Chehalis Sub-populations from Flood Retention Facility Types



Source: ICF 2016

Figure 4.2-9b

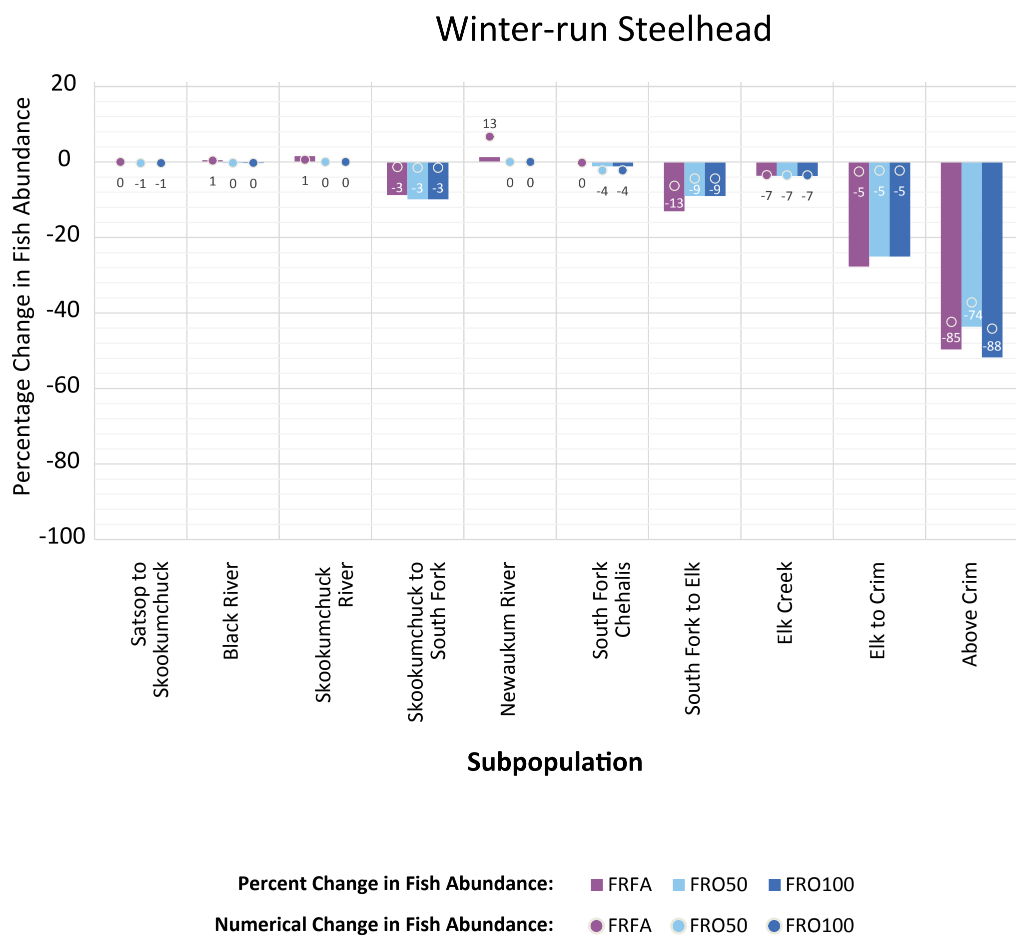
Potential Response in Salmonid Abundance to Habitat Change in Upper Chehalis Sub-populations from Flood Retention Facility Types



Source: ICF 2016

Figure 4.2-9c

Potential Response in Salmonid Abundance to Habitat Change in Upper Chehalis Sub-populations from Flood Retention Facility Types



Source: ICF 2016

The response of non-salmonid fishes to an FRFA facility was estimated by evaluating the change in usable instream habitat area available to different species based on changes in flow and temperature that would occur with an FRFA dam from May through September (Beecher 2015; PSU 2016). Habitat area for spawning and rearing life stages (where relevant and data is available) of four native fish species (Pacific lamprey, mountain whitefish, speckled dace, and largescale sucker) and two non-native predator species (largemouth bass and smallmouth bass) were evaluated. The monthly averages of change in Weighted Usable Area (WUA), a measure of habitat area, were summed to provide a single index of change in WUA for each species and life stage (see Table 4.2-9). In general, the native fish species evaluated would respond positively to summer water releases from an FRFA dam, which would increase flow and decrease summer water temperature. The responses could be greatest in the reach just downstream of the dam (Pe Ell to Elk Creek), with the responses attenuating downstream corresponding to attenuation of the change in flow and temperature resulting from the FRFA dam.

Table 4.2-9
Cumulative Monthly Change in Instream Habitat Area (Weighted Usable Area) in Summer with Augmented Flow and Reduced Temperature Water Released from the FRFA Facility

SPECIES	LIFE STAGE	PE ELL TO ELK CREEK	ELK CREEK TO SOUTH FORK	SOUTH FORK TO NEWAUKUM	NEWAUKUM TO SKOOKUM-CHUCK	SKOOKUM-CHUCK TO BLACK	BLACK TO PORTER
Pacific lamprey	Rearing	28%	-11%	4%	5%	2%	-1%
	Spawning	24%	18%	14%	2%	3%	5%
Mountain whitefish	Spawning	43%	26%	23%	7%	4%	6%
Speckled dace	Rearing	28%	8%	9%	7%	1%	-1%
Largescale sucker	Rearing	18%	8%	8%	4%	2%	0%
	Spawning	34%	27%	59%	9%	26%	29%
Largemouth bass	Rearing	N/A[2]	N/A[2]	-17%	-1%	-1%	-3%
	Spawning	N/A[2]	N/A[2]	-43%	-10%	-5%	-7%
Smallmouth bass	Rearing	N/A[2]	N/A[2]	-9%	-1%	-1%	-2%
	Spawning	N/A[2]	N/A[2]	0%	46%	0%	0%

Notes:
Data are the sum of the monthly averages of the change in WUA from May through September.
N/A indicates the species was not recorded in that reach at any life stage.
Source: Beecher 2015

The non-native predator species evaluated have only been observed as far upstream as the confluence with the South Fork Chehalis River (Hughes and Herlihy 2012; Zimmerman and Winkowski 2016). However, downstream of the South Fork Chehalis River, the habitat available for non-native species could be reduced in summer, with the effect attenuating farther downstream. One exception could occur with an increase in smallmouth bass spawning habitat in the reach between the confluences of the mainstem Chehalis River with the Newaukum and Skookumchuck rivers (see Table 4.2-9), influenced largely by changes to conditions in June (data by month not shown). It is important to note that other metrics such as substrate type or habitat structure that would be affected by an FRFA dam were not considered in this approach, and these other habitat metrics may have as much influence on species distributions as flow and temperature. Data are not available to construct a similar analysis of change in habitat during fall and winter months for these fish species when flow would be reduced by flood retention. Further evaluation would be necessary to accurately predict species responses to all of the changes in habitat that could accrue. Overall, these data suggest the FRFA dam would cause an increase in habitat for native fish species, with a reduction in habitat for non-native predators, representing a benefit to native fish downstream of the dam.

Reduction in instream habitat that would occur upstream of an FRFA facility has the potential to suppress populations of state or federally sensitive, candidate, or listed species. Pacific lamprey and Olympic mudminnow are species that could be affected by a Flood Retention Facility and are listed as state species of concern, priority species, and species of greatest conservation need. Additionally, riffle and reticulate sculpin are state species of concern. Pacific lamprey, riffle sculpin, and reticulate sculpin have been observed in the potential dam and reservoir footprint (Winkowski 2015), and like salmon, prefer fast-moving streams, with well-aerated gravel to spawn and rear as larvae. The installation of an FRFA facility would eliminate this type of habitat in the footprint of the conservation pool. Reticulate sculpin could inhabit the shallow areas of a permanent reservoir because they can tolerate warmer temperatures (greater than 20°C) and silty habitat. Pacific lamprey, riffle sculpin, and reticulate sculpin are likely widespread across the Chehalis Basin, though their distribution has not been extensively studied. Olympic mudminnow occur in slow-moving, off-channel habitat in floodplain areas in the middle and lower Chehalis River floodplain many river miles downstream of the potential dam and downstream of the area affected by flow and temperature modulation by the FRFA facility (Hayes et al. 2016a). The impact of a dam in the upper Chehalis Basin on Olympic mudminnow would be minor, as the majority of Olympic mudminnow habitat would not be affected, however flood retention could prevent inundation of relatively small areas of Olympic mudminnow off-channel habitat. No Chehalis River salmon or steelhead populations are currently listed as threatened or endangered under the ESA, and none have been designated as ESUs or main population groups under an ESU, as is commonly done for species in need of recovery. Nonetheless, any degradation in Chehalis River salmon population abundance, productivity, diversity, and spatial structure could lead to listing of the species if the population is no longer found to be viable (McElhany et al. 2000).

4.2.4.2.2 Wildlife

Anticipated adverse impacts on wildlife that would result from the construction and operation of the Flood Retention Facility are primarily related to the removal and disturbance of habitat and habitat functions over time, including potential loss of amphibian breeding habitat. The potential impacts on wildlife are similar for the FRO facility and FRFA facility, but vary in magnitude due to the larger footprint of the FRFA reservoir and the fact that a significant portion of the habitat would be converted to open water within the FRFA permanent reservoir pool. The adverse impacts described in this section range from minor to significant because different classes of wildlife species have a variety of habitat needs and home ranges, with different vulnerabilities and potential responses to the disturbance and conversion of habitat features.

Adverse impacts on wildlife would primarily be driven by the following changes in the physical environment created by the construction and operation of the Flood Retention Facility:

- Loss, conversion, and fragmentation of wetland and vegetation communities that function as wildlife habitat as a result of selective clearing and inundation in the dam and reservoir footprint
- Changes to wildlife habitat-forming processes downstream of the dam due to the streamflow management and vegetation community modification

Each of these changes would modify habitat that is currently used by a variety of wildlife to breed, forage, rest, and overwinter, including invertebrates, amphibians, reptiles, and multiple species of mammals and birds. Changing or eliminating existing habitat characteristics and functions would create conditions that reduce the quality of habitat available for existing species, thereby affecting the ability of wildlife to occupy the modified habitat. As a result, the diversity and composition of species that occupy affected habitats would change as some existing species adapt to and occupy the modified habitat, those that are unable to adapt or compete in the changed habitat perish or leave, and new species that were not there previously (e.g., invasive species) become established.

Potential adverse impacts on habitat conditions and functions in the Flood Retention Facility footprint include the loss, conversion, and fragmentation of wetland and vegetation communities that function as wildlife habitat (see Section 4.2.3). The loss, conversion, and fragmentation of such communities would occur during both construction and operation of the facility through selective clearing and periodic to permanent inundation, respectively.

Impacts on wetland and vegetation habitat would affect wildlife currently using these areas and change the types and functions of available habitat over the long term. Potential impacts on wildlife vary depending on the type of activity and the different classes of wildlife species that occupy these habitats. The clearing of vegetation to construct the dam structures and their supporting infrastructure (e.g., access roads, utility corridors) would cause a direct loss of wildlife habitat, and would cause varying degrees of habitat fragmentation based on the width and orientation of the clearing as well as the wildlife species affected.

Conversion of forested upland, riparian, and wetland habitats to those dominated by herbaceous and shrubby vegetation would result in the loss of habitats used by some wildlife species in the reservoir footprints, and could represent a gain of habitat for other wildlife species. For example, loss of riparian cover would impair habitat conditions for many amphibians, especially by reducing adequate surface moisture and appropriate temperature conditions for terrestrial stages of stream-associated amphibians, such as the state-candidate species Van Dyke's salamander (Hallock and McAllister 2005). Conversely, the more brushy vegetation that would likely replace several of the forested riparian zones in the reservoir footprint could provide additional foraging habitat for deer, elk, and birds of prey (Link 2004). In the FRFA reservoir area, the conversion from upland forest and wetlands to an inundated reservoir would remove and convert habitat used by terrestrial and semi-aquatic wildlife species; however, species that utilize open-water habitat (e.g., waterfowl and osprey) would benefit from the changes in habitat types. Disturbances to habitats of native species provide opportunities for the invasion of non-native wildlife species (e.g., European starling and American bullfrog) that could prey on or out-compete native wildlife species for resources (Knutson and Naef 1997).

The loss of trees from the riparian zone in the reservoir footprint by either selective removal under the proposed Pre-construction Vegetation Management Plan or by flood-induced mortality would directly remove nesting, denning, and feeding habitat used by wildlife including birds, mammals, amphibians, and other animals. Tree removal from these areas would also adversely affect many of the riparian functions being performed by these areas including water filtration and purification, stream channel stability, nutrient dynamics, stream shading (i.e., thermoregulation), and wood recruitment. Increased sediments entering the stream system from runoff and streambank erosion could lead to filling of interstitial spaces in stream substrates that are used by amphibians for breeding and foraging (Leonard et al. 1993). Reduction in the amount of leaf litter, organic material, and other nutrient inputs that support species at the base of the food chain would reduce foraging for aquatic and semi-aquatic wildlife species. Reduction in the amount and variety of woody material entering the system would also affect nutrient cycles and limit instream habitat-forming processes that support stream-associated amphibians. Riparian woody material is a habitat feature used by terrestrial amphibians, like the state-candidate species Van Dyke's salamander, for breeding and foraging. Instream woody material is used by stream-breeding amphibians like the Columbia torrent salamander for breeding and refuge. In addition to these impacts, conversion or removal of riparian areas would reduce, eliminate, or fragment habitat and travel corridors for wildlife including amphibians, reptiles, birds, and various mammals.

Generally, wildlife such as songbirds, raptors, and various classes of mammals are more adaptable to changes in habitat features. These wildlife groups are also able to disperse more easily to adjacent areas with suitable habitat conditions. Given that the proposed Flood Retention Facility would be located in a basin dominated by managed forestland, similar forest habitats are abundant and accessible in the area. Semi-aquatic wildlife species such as amphibians, North American beaver, and western pond turtle, however, rely on specific aquatic habitat features to breed, forage, and overwinter, and would be much more vulnerable to the localized impacts on wetlands and the conversion of riparian vegetation communities. Such species would not be able to adapt to significant changes in aquatic habitat and are unlikely to disperse successfully to other suitable habitats. Some amphibians could also face increased predation within modified habitats as a result of changes in the availability or quality of cover (e.g., vegetation, leaf litter, woody material), as well as a potential increase in the number of predators (e.g., fish, reptiles, small and medium-sized mammals, birds, other amphibians) in the area due to displacement from adjacent modified habitats.

In addition to vegetation removal and modification, inundation of the reservoir would cause adverse impacts on wildlife and wildlife habitat in the stream reach within the boundaries of the inundation area. Though flooding would be infrequent and temporary in both the FRO reservoir and flood storage portion of the FRFA reservoir that is located above the conservation pool, the flooded area would be relatively large (see Table 4.2-1 in Section 4.2.1.2.2). During floods, river flows would be retained in the reservoir, with filling and draining of the reservoir lasting up to 32 days. Inundation of riparian habitat used by amphibians and other wildlife species would directly displace animals or result in mortality for species unable to disperse or relocate to other suitable habitats (Knutson and Naef 1997). Increased deposition of sediment upstream of the dam would negatively affect water quality, as well as breeding and foraging habitat for stream invertebrates and stream-associated amphibians. Temporary inundation and sedimentation of the stream channel would alter its structure from pools and riffles to an eroded channel through sediment, and would replace stable aquatic habitat with dynamic habitat, removing instream habitat preferred by aquatic amphibians.

Permanent inundation of up to 1,264 acres for the FRFA reservoir would convert stream and riparian habitats to a pool (lacustrine) habitat for which many stream-dwelling wildlife species, especially native amphibians, are not well adapted, presenting a loss of functional habitat for these species and a substantial adverse impact on aquatic wildlife. Most wildlife species would not adapt to the changes from stream, riparian, and terrestrial habitats to a lacustrine habitat, forcing these species to attempt to relocate to other suitable habitat (Knutson and Naef 1997). Some species would successfully relocate to other suitable habitat and some species would be unsuccessful in relocating to other habitats and would perish (Knutson and Naef 1997).

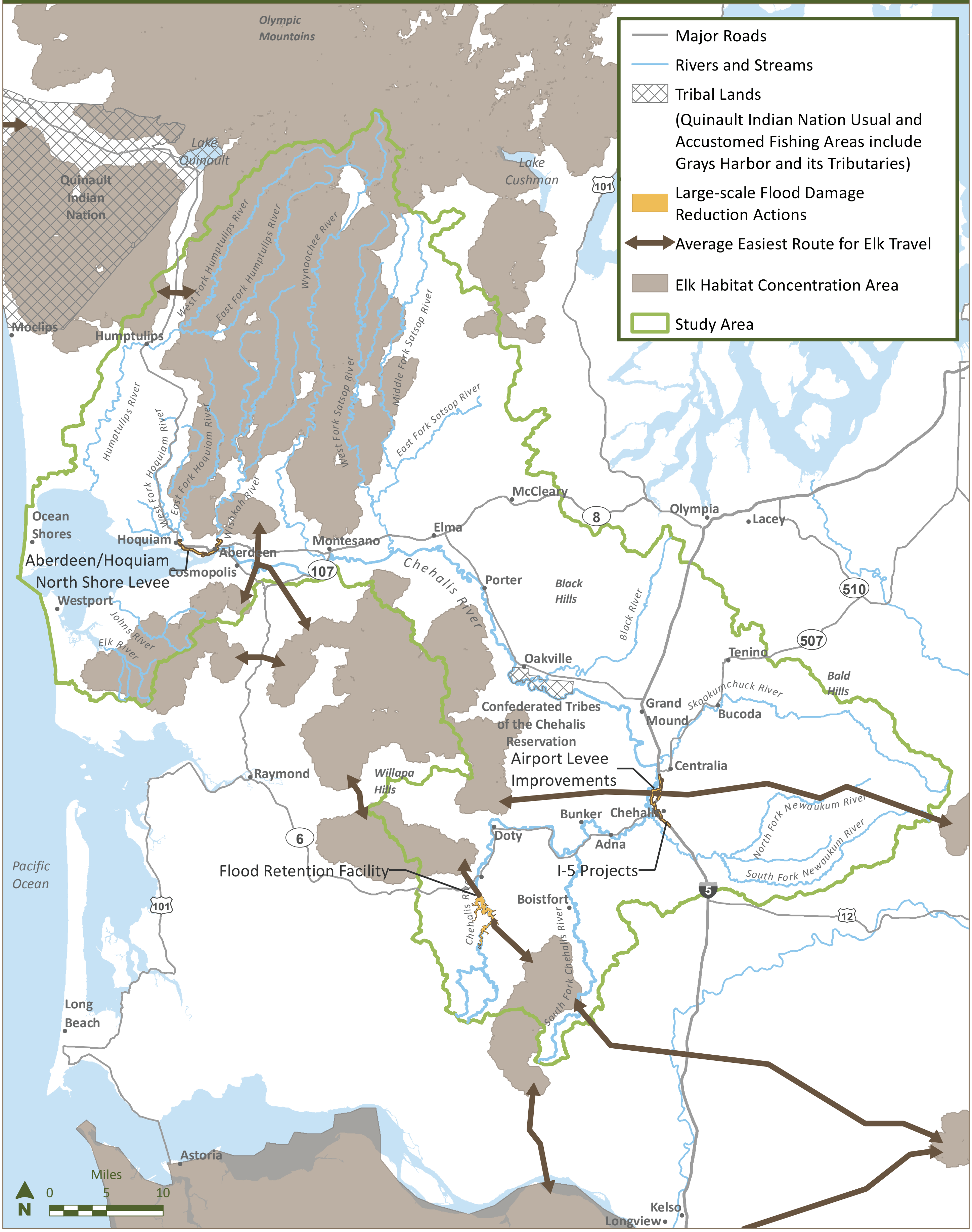
Specific species that would be adversely affected by temporary (FRO reservoir) and permanent (FRFA reservoir) water retention include western toad and western pond turtle. Breeding habitat for western toad in the Chehalis Basin is concentrated in the mainstem Chehalis River and larger tributaries within the proposed reservoir footprint (Hayes et al. 2016b). Temporary inundation of these areas by the FRO reservoir during flood retention and permanent inundation in the FRFA reservoir conservation pool would eliminate this habitat, potentially contributing to the extirpation of western toad from this portion of the Chehalis Basin. Although western toad are known to breed in stillwater reservoirs, the potential for this to occur in the FRFA conservation pool is uncertain due to the magnitude and timing of water fluctuations in the reservoir due to dam operations. Western pond turtle, a state-endangered species that is potentially present in the Chehalis Basin, would also be affected by the direct loss of potential breeding habitat from the conversion of stream habitat to reservoir habitat (ASEPTC 2014c). Such losses would contribute to the local extirpation of that species.

As discussed in Section 4.2.4.2.1, conversion of stream and riparian habitats to a pool habitat under the FRFA would also result in the loss of salmon spawning habitat within the reach of the Chehalis River upstream of the dam. Salmon provide nutrients to a wide range of wildlife species that directly prey on live spawners, scavenge the carcasses of dead fish, or prey upon salmon eggs and juveniles after spawning. The range of mammal species that feed on salmon includes bears, weasels, shrews, and potentially deer, squirrels, and mice. Avian predators and scavengers include eagles, hawks, gulls, crows, and some songbirds (Willson and Halupka 1995). The nutrients from spawners also benefit wildlife by fertilizing riparian and aquatic plant species which, in turn, provide food or cover for aquatic and terrestrial animal species (Schindler et al. 2003). Decreases in salmon abundance resulting from lost freshwater habitat will, therefore, have an adverse impact on wildlife species that either feed on or otherwise benefit from salmon-derived nutrients. The significance of the adverse impact on wildlife is proportional to the decrease in abundance and is also expected to be most intense in areas where salmon spawning is substantially reduced or prevented, such as the reservoir footprint.

Replacing vegetated habitat with reservoirs of standing water could alter or restrict the migratory routes of elk, deer, and other large, migratory, terrestrial species. Elk require large areas to meet migratory needs and often move long distances on a seasonal basis. Important habitat patches for elk known as HCAs exist within the Chehalis Basin and in the surrounding geographic area to the north and south of the proposed reservoir footprints (see Figure 4.2-10). Landscape connectivity between the HCAs—that is, migratory routes that are not significantly altered by human infrastructure—are necessary for migration of elk and other species. Migratory elk would seek paths between HCAs that require the least energy expenditure by the animals (i.e., least cost paths). The Flood Retention Facility would not directly affect acreage within an HCA; however, both footprints appear to overlap one of these paths of least energy expenditure and could force animals to travel around the area, expending more energy and presenting a moderate impact on the species (WHCWG 2010; see Figure 4.2-10).

Figure 4.2-10

Terrestrial Species Connectivity



Changes to the way floodwaters move through the system both upstream and downstream of the dam would also disrupt many of the existing physical, chemical, and biotic processes of riparian areas, reducing or eliminating many of the important functions provided by the riparian zone (Knutson and Naef 1997). Downstream of the dam, flood control would cause a reduction in the magnitude of peak floods, which would translate to reductions in habitat-forming processes, especially those that are driven by major floods. While flooding of the magnitude that would trigger flood retention would be infrequent, it is the largest floods that have the greatest ability to shape habitat for aquatic and semi-aquatic species and wildlife species that use the riparian areas and the floodplain. Habitat-building processes downstream would also be affected by the retention of much of the sediment and LWM load by the Flood Retention Facility.

Downstream of the dam, reduced flooding would reduce stream and riparian habitat-shaping processes. Wetlands and periodically inundated areas that serve as functional floodplain habitat for semi-aquatic species, such as amphibians and waterfowl, would also be reduced. These adverse impacts range from minor to moderate given the size of the entire Chehalis Basin relative to the change in the extent of flooding.

Flood control with the FRFA dam would allow for the modulation of flows downstream of the dam year-round, with the intention of providing higher base flows and cooler water during the summer months to improve downstream habitat. The potential effects of these higher flows and cooler water temperatures on stream breeding and stream-associated terrestrial amphibians is variable. An increase in low summer instream flows downstream of the FRFA dam could benefit certain amphibian species by providing sufficient water levels in off-channel habitats that dry up under existing conditions. Although many amphibian species could also benefit from cooler stream temperatures, such changes could interfere with the seasonal environmental cues (e.g., increased water temperature, decreased flow and water depth) used by these species to trigger the initiation of metamorphic processes. An increase in summer base flows and reduction in temperatures has the potential to delay or eliminate breeding habitat for the instream-breeding western toad, which appears to prefer warm, shallow, open water areas in the stream channel for breeding (Hayes et al. 2016b). To evaluate this potential, the change in usable downstream habitat for western toad based on the proposed changes in flow and temperature that would occur with an FRFA dam was modeled for the six consecutive river reaches below the proposed dam. The results of this modeling effort indicate that there would be no change in the area of usable habitat for western toad in the river reach immediately below the proposed dam, but a reduction in area of usable habitat for all subsequent reaches. Overall, although flows from the FRFA dam could be regulated to maximize available instream habitat for salmon below the dam, targeted flows could conflict with those that are optimal for amphibians (ASEPTC 2014c).

4.2.4.3 Mitigation

4.2.4.3.1 Fish

A range of possible mitigation measures for short-term impacts on fish are described in Table 4.1-1. However, instream work would be unavoidable and large in scale, and limiting work to times of the year when sensitive species are absent would not be possible. Year-round construction for 2 to 3 years would be required. Avoidance and minimization to reduce short-term direct impacts on fish could include construction of a temporary river bypass tunnel to pass water and fish downstream during the construction period. A trap-and-haul strategy would be implemented to provide upstream fish passage and maintain fish survival around the Flood Retention Facility construction site.

Some potential long-term impacts on fish would be addressed through avoidance and minimization measures, including provision of fish passage around the dam, minimum instream flows released from the dam during flood retention periods, and release of cool water from the FRFA facility during late spring to early fall. New infrastructure such as roads and power lines could be planned to minimize the number of stream crossings that require permanent removal of intact riparian habitat. Compensatory mitigation would be required for loss of fish habitat and fish habitat function, and reduced fish population performance above and below the dam. Examples of compensatory mitigation could include fish habitat restoration, protection, or acquisition of land that presents an opportunity for in-kind compensation for fish habitat lost.

Consistent with state mitigation policy (WDFW mitigation policy POL-M5002), mitigation for unavoidable adverse impacts on fish would include continued collection of baseline data and detailed implementation plans based on identified population performance standards or goals for fish populations, fish passage, and life history diversity, including maintenance of recreational and harvest opportunities. Compensatory mitigation would be described in the Reservoir Operations and Management Plan, including an adaptive management plan for fish species affected by the Flood Retention Facility that includes regular monitoring and evaluation of fish passage and population performance (e.g., monitoring fish abundance, habitat processes upstream and downstream of the dam site) to ensure population viability goals are met. Compensatory mitigation measures would be developed during project-level design and permitting to address the loss of fish habitat and function. Adaptive management plans would include corrective actions to be taken if mitigation developments do not meet goals and objectives. A Flood Retention Facility may cause adverse impacts that cannot be fully mitigated by the compensatory actions described here.

4.2.4.3.2 Wildlife

Potential mitigation measures to reduce short-term impacts on wildlife and wildlife habitat from construction of the Flood Retention Facility are described in Table 4.1-1.

Some potential long-term impacts on wildlife could be addressed through avoidance and minimization measures, including developing and implementing a Post-construction Vegetation Management Plan (see Section 4.2.3.3) to address the loss of loss of forestland upstream of the dam. Compensatory mitigation measures would be developed during project-level design and environmental review that would create or improve wetland, wetland buffer, and riparian habitat conditions that support a variety of native wildlife species.

4.2.5 Tribal Resources

The health and productivity of the entire Chehalis Basin affects the treaty fisheries and the non-treaty Chehalis Tribe fishery on the Chehalis Tribe reservation. The upper and middle Chehalis River and its tributaries contain valuable habitat for spawning and rearing salmonids.

Impacts on tribal resources could occur during or following construction, if tribal members could no longer access a resource or if the resource was diminished. The following potential impacts were considered:

- Access to treaty reserved usual and accustomed fishing areas, including Grays Harbor and the Chehalis River
- Access to treaty-reserved usual and accustomed areas for hunting and gathering on open and unclaimed lands
- Access to culturally significant areas for gathering of plant material or other related activities
- Injury and mortality of fish and wildlife and their habitats, and plants that are identified as a tribal resource; these impacts are detailed in Section 4.2.4 and are included in this section by reference

Indirect impacts on tribal resources could occur as a result of the impacts on water resources, geology and geomorphology, wetlands and vegetation, and fish and wildlife detailed in Sections 4.2.1 through 4.2.4.

> **Tribal Resources**
>
> Tribal resources refer to the rights and interests of Indian tribes within the Chehalis Basin to various natural resources, including those associated with a tribe's sovereignty and/or federally reserved treaty rights. These resources include plants, wildlife, fish, and shellfish. Tribal resources also include rights and interests in cultural, historic, spiritual, and archaeologic places and artifacts, including graves and Indian human remains. Impacts on treaty-reserved rights cannot be mitigated without consent of an affected treaty tribe. Discussion or consideration of mitigation for impacts on treaty rights resulting from any of the actions evaluated in this EIS would require consent by the Quinault Indian Nation. Additional information on tribal rights is found in Section 2.4.1

4.2.5.1 Short- and Long-term Impacts

The potential impacts on tribal resources that would occur during construction of the Flood Retention Facility are related to the temporary disruption of access to areas for gathering resources associated with a tribe's sovereignty or formal treaty rights. These construction-related impacts could occur near construction activities associated with the dam, reservoir area, haul roads, and other components of the Flood Retention Facility. Potential impacts could include reduced or limited access to plants, fish, or wildlife used for commercial, subsistence, and ceremonial purposes. For example, members of the Quinault Indian Nation and the Chehalis Tribe can harvest Pacific lamprey found in the area of the Flood Retention Facility. Access to this resource would be affected during the 2- to 3-year construction period.

Additional construction-related impacts on tribal resources are associated with loss or take of natural resources protected by tribal treaty for fishing, hunting, and gathering. As described in Section 4.2.3, direct impacts on fish or wildlife could occur during construction (including injury or mortality), as well as activities resulting in indirect impacts through habitat pathways such as sediment released into the river or construction noise-affecting behavior. Construction-related impacts would affect fish use within the immediate area of construction and habitat upstream, which would affect productivity and abundance of fish species in the area.

Additional input from the Quinault Indian Nation, Chehalis Tribe, and other potentially affected tribes will help to characterize existing tribal resources and use of the area for fishing, hunting, and gathering, and confirm the nature of potential impacts from construction-related activities. Additional coordination with affected tribes to address specific impacts on tribal resources would continue during project-level environmental review, and as part of continued government-to-government consultations.

The potential long-term impacts on tribal resources consider impacts on fishing, hunting, gathering, and other traditional cultural activities following construction. As described in Section 4.2.4.2.1, impacts on fish and fish habitat during construction that occurs over a 2- to 3-year period could become a long-term impact because reduced egg and juvenile survival in a given year would lead to reduced abundance in the subsequent generations.

Long-term impacts from the Flood Retention Facility could affect tribal resources in the following ways:

- Restricted or reduced access of tribal members to tribal resources
- Altered vegetation in the riparian and flood-affected areas due to periodic inundation, which could affect tribal fisheries
- Loss of fish habitat function within the reach of the Chehalis River inundated upstream of the dam for cool, swift water-associated fish species, including loss of salmon-spawning habitat
- Diminishment in the number of fish that would otherwise be available for tribal harvest, as well as wildlife and plants that are identified as a tribal resource

Additional potential impacts on fish and wildlife and vegetation that may directly or indirectly affect tribal resources are described in Sections 4.2.4.2 and 4.2.3.2.3, respectively. Several potential impacts have been identified, with the extent of impacts pending additional coordination with tribes and continued government-to-government consultations. Potential long-term impacts could occur to tribal resources on tribal lands, within usual and accustomed fishing areas, or other areas used for hunting and gathering. As noted by the Quinault Indian Nation, adverse impacts that impede the ability to exercise treaty rights, such as impaired access to resources or actions that harm resources directly or indirectly by affecting the habitat on which they are dependent, constitutes the take of a property right that has been guaranteed to tribes (Sharp 2016a, 2016b).

Construction of the Flood Retention Facility would occur over 2 to 3 years and, thus, could affect multiple years of salmon and steelhead adults returning to spawn in the area of construction and upstream of the construction site, as well as juveniles in the vicinity of the Flood Retention Facility site. In-water construction activities could also reduce adult passage to the upper watershed for spawning or could affect habitat, thereby affecting survival of eggs or juveniles. Together these impacts would result in fewer adult salmon and steelhead returning to the Chehalis Basin and upper watershed in future years, and would result in fewer salmon and steelhead available for harvest by tribal fishers in the lower Chehalis River. Long-term impacts on fish habitat associated with construction and operation of the Flood Retention Facility could result in a reduction in the abundance of chum salmon, Chinook salmon, coho salmon, and winter-run steelhead returning to the Chehalis Basin as predicted through habitat modeling presented in Section 4.2.4.

The Flood Retention Facility would reduce the available area for fish spawning, rearing, and migration, and would reduce upstream habitat for fish. Over the longer term, the Flood Retention Facility could affect fish population productivity and population life history diversity—both measures of population resiliency (McElhany et al. 2000). These impacts could result in greater sensitivity of the populations to variability in environmental conditions, affecting freshwater and marine survival and year-to-year variability in number of adults returning to the Chehalis Basin. Modeling is currently underway to evaluate whether sediment supply from the area above the Flood Retention Facility would result in a measurable decrease in beach sediment contribution to the Pacific Ocean (Watershed GeoDynamics and Anchor QEA 2016).

The Flood Retention Facility would be located in an area that could be used by tribal hunters and would affect access to this area. The Flood Retention Facility would affect habitat potentially used by wildlife. The dam and reservoir would remove the availability of these areas for the collection of plants and the harvesting of deer and elk by tribal hunters and gatherers.

4.2.5.2 Mitigation

The mitigation associated with potential impacts on tribal resources would be addressed directly with Quinault Indian Nation and Chehalis Tribe tribal leadership during project-level environmental review and continued government-to-government consultations.

Some potential long-term impacts on tribal fish resources could be addressed through avoidance and minimization measures developed in consultation with tribes. These may include the provision of fish passage around the dam during construction and operation, noise attenuation measures during construction, minimum instream flow release from the dam during operation, and release of cool water during operation of the FRFA facility in late spring to early fall.

Potential compensatory mitigation measures developed in consultation with tribes could include, but are not limited to, the following:

- Coordinating with tribal leaders and managers on the timing and location of construction activities that could affect tribal access
  - Coordination could result in adjustments to the timing of construction activities to avoid periods when use is the highest or provisions to provide an access point around the construction site and proposed Flood Retention Facility
- Identifying areas with significant tribal resources and coordinating with the tribes regarding access points to these areas during and after construction

Compensatory mitigation could be required for loss of fish habitat and fish habitat function, and reduced fish population performance above and below the Flood Retention Facility. Compensatory mitigation would be developed in consultation with tribes and may include fish habitat restoration, protection, or acquisition of land that presents an opportunity for in-kind compensation for fish habitat lost. Mitigation of impacts on treaty rights is subject to consideration and agreement by the Quinault Indian Nation.

4.2.6 Air Quality

4.2.6.1 Short-term Impacts

The potential short-term impacts on air quality that would occur during construction are described in Table 4.1-1. Emissions and dust would increase during the 2- to 3-year construction period, and clearing activities early in construction would cause the most increases in dust. These temporary impacts would occur in an isolated area with no permanent residents, so increased dust would not affect people. Increased dust and emissions would be localized and are not expected to violate air quality standards.

4.2.6.2 Long-term Impacts

The Flood Retention Facility would result in minor adverse impacts on air quality due to windblown particulate matter (e.g., dust). The cleared area of the FRO reservoir and FRFA reservoir flood storage pool could be a source of dust when not inundated. The dust would be limited to the dry season and during relatively high winds. Impacts would be temporary and would not affect overall regional air quality. The Flood Retention Facility would not generate emissions, and would therefore not affect air quality.

4.2.6.3 Mitigation

Potential mitigation measures to reduce short-term impacts on air quality are described in Table 4.1-1. No long-term impacts on air quality are anticipated, so no mitigation is proposed.

4.2.7 Climate Change

The evaluation of impacts related to climate change is considered from two perspectives, based on Ecology guidance (Ecology 2011c), and is as follows:

- Adverse impacts that contribute to the effects of climate change (e.g., new sources of GHG emissions)
- Adverse impacts of climate change on the proposed action element (e.g., increased sea levels, reduced snowpack, changes in water availability, changes in streamflow timing, increased forest fires, more extreme precipitation events and flooding)

Ecology's guidance (Ecology 2011c) is used for clarifying the level of analysis as follows:

- Actions that are expected to annually produce an average estimate of at least 10,000, but less than 25,000 MT carbon dioxide equivalent (CO_2e), should at least qualitatively disclose the GHG emissions caused by the action
- Actions that are expected to produce an average of 25,000 or more MT CO_2e each year should include a quantitative disclosure of GHG emissions

4.2.7.1 Short-term Impacts

4.2.7.1.1 Effects of the Flood Retention Facility Contributing to Climate Change

The potential short-term impacts that could contribute to climate change would occur during construction of the Flood Retention Facility and include additional GHG emissions from construction equipment and truck shipments of materials to and from the dam site, such as construction materials, excavated materials, cement (including GHG emissions from cement production processes), and vegetation removal. Concrete aggregate would be mined within the facility area and an on-site concrete batch plant would produce concrete at the Flood Retention Facility site. Construction of the FRFA facility would generate greater GHG emissions (270,000 MT CO_2e) than construction of the FRO facility (166,000 MT CO_2e). These effects would be above the threshold of significance established by Ecology, but would be temporary and not sustained over time.

4.2.7.1.2 Effects of Climate Change on the Flood Retention Facility

No short-term impacts of climate change on the Flood Retention Facility are anticipated during construction.

4.2.7.2 Long-term Impacts

4.2.7.2.1 Effects of the Flood Retention Facility Contributing to Climate Change

The potential adverse impacts of the Flood Retention Facility contributing to climate change would occur as a result of the permanent loss of vegetation within the Flood Retention Facility footprint, which reduces carbon sequestration (i.e., carbon storage). The loss of carbon sequestration decreases CO_2 capture, which increases the concentration of GHGs in the atmosphere. The GHG emission equivalents from lost carbon storage due to vegetation loss for both types of dams (see Section 4.2.3.2) are above the threshold of significance for evaluation of impacts (207 acres of deforestation and/or 25,000 MT CO_2e) for the Flood Retention Facility (Ecology 2011c). These effects are considered a moderate adverse impact in the immediate vicinity of the Flood Retention Facility due to the sustained impact over time of GHG emission equivalents in excess of the Ecology threshold for significance for impact evaluation. However, on a Basin-wide scale, the loss of vegetation for the dam facility represents a small percentage loss of vegetation across the watershed, which includes more than 830,000 acres of forestland.

Table 4.2-10 provides information on the loss of vegetation associated with the Flood Retention Facility, along with the corresponding annual GHG emission equivalents.

Table 4.2-10
Vegetation Loss and GHG Emission Equivalents

CATEGORY	FRO FACILITY	FRFA FACILITY
Vegetation loss in acres		
Facility footprint	6	9
Conversion of forestland to shrubland in reservoir area	405	178
Conservation pool	0	711
Total acres	**411**	**889**
GHG emission equivalents[1]	**49,731 MT CO_2e/year**	**107,569 MT CO_2e/year**

Note:
1. Based on Ecology's SEPA GHG Calculation Tool (Ecology 2011c, Attachment 2)

4.2.7.2.2 Effects of Climate Change on the Flood Retention Facility

The CIG has studied the potential effect of climate change on peak flows in the Chehalis Basin (CIG 2016). The predicted change in peak flows derived from the CIG study are listed in Table 4.2-11 (Karpack 2016a).

Table 4.2-11
Percentage Change to Chehalis Basin Peak Flows for Climate Change Conditions

EVENT	PERCENT CHANGE
2-year	+16%
10-year	+35%
20-year	+45%
100-year	+66%
500-year	+94%

The results of the CIG study were used in hydrologic modeling to estimate the effectiveness of the Flood Retention Facility in reducing peak flows under climate change conditions (Anchor QEA 2016c). The modeling found a beneficial effect of reducing flood damage in the Chehalis River Basin from the reduction in peak flows from the Flood Retention Facility under climate change conditions. Table 4.2-12 presents a comparison of peak flows for a 100-year flood, under existing and climate change conditions with the Flood Retention Facility, at Doty and at Grand Mound.

Table 4.2-12
Peak Flows During 100-year Flood Under Existing and Climate Change Conditions

	AT DAM LOCATION		AT DOTY			AT GRAND MOUND		
	EXISTING PEAK FLOW WITHOUT DAM (cfs)	PEAK FLOW WITH DAM (cfs)	PEAK FLOW WITHOUT DAM (cfs)	PEAK FLOW WITH DAM (cfs)	PERCENT DIFFERENCE	PEAK FLOW WITHOUT DAM (cfs)	PEAK FLOW WITH DAM (cfs)	PERCENT DIFFERENCE
Existing	24,200	300	36,700	12,800	-65%	75,100	62,900	-16%
With Climate Change	40,200	300	60,900	21,000	-66%	137,900	108,600	-21%

Sources: Anchor QEA 2016b; Karpack 2016b

It is predicted that the Flood Retention Facility will reduce peak flows downstream of the dam under future climate change conditions. Both the peak flow reduction and percentage reduction will be greater than under existing conditions, indicating the Flood Retention Facility could help reduce flood damage in the Chehalis River floodplain resulting from climate change. Detailed floodplain modeling of climate change conditions was not available at the time this EIS was published. The EDT model developed for the Chehalis Basin (ICF 2016) was used to predict how fish species would respond to habitat modifications resulting from climate change, both with and without the Flood Retention Facility (see Section 4.1.3 for information on forecasting climate change). The model determined that climate change would have the greatest impact on spring-run Chinook salmon and least impact on winter- and fall-run chum salmon (ASEPTC 2014c). A Flood Retention Facility would further reduce salmon abundance up to 4% on a Basin-wide scale, depending on the species. Table 4.2-13 and Figure 4.2-11 present these results for the Flood Retention Facility as a percentage increase or decrease compared to the results under current conditions with climate change.

Table 4.2-13
Potential Response in Salmonid Abundance to Habitat Change in the Chehalis Basin from Climate Change and Flood Retention Facility Types

SPECIES (CURRENT HABITAT POTENTIAL)	CHANGE FROM CURRENT CONDITION IN NUMBER OF FISH (%)			
	WITH CLIMATE CHANGE ONLY	WITH CLIMATE CHANGE AND FRFA	WITH CLIMATE CHANGE AND FR0 50	WITH CLIMATE CHANGE AND FR0 100
Coho salmon (40,642)	-22,390 (-55%)	-22,447 (-55%)	-22,560 (-56%)	-22,566 (-56%)
Fall-run Chinook salmon (25,844)	-6,969 (-27%)	-6,994 (-27%)	-7,048 (-27%)	-7,048 (-27%)
Winter/fall-run chum salmon (190,550)	-8,270 (-4%)	-9,528 (-5%)	-9,204 (-5%)	-9,204 (-5%)
Spring-run Chinook salmon (2,146)	-1,869 (-87%)	-1,897 (-88%)	-1,954 (-91%)	-1,954 (-91%)
Winter-run steelhead (6,800)	-3,741 (-55%)	-3,732 (-55%)	-3,793 (-56%)	-3,799 (-56%)

Source: ICF 2016

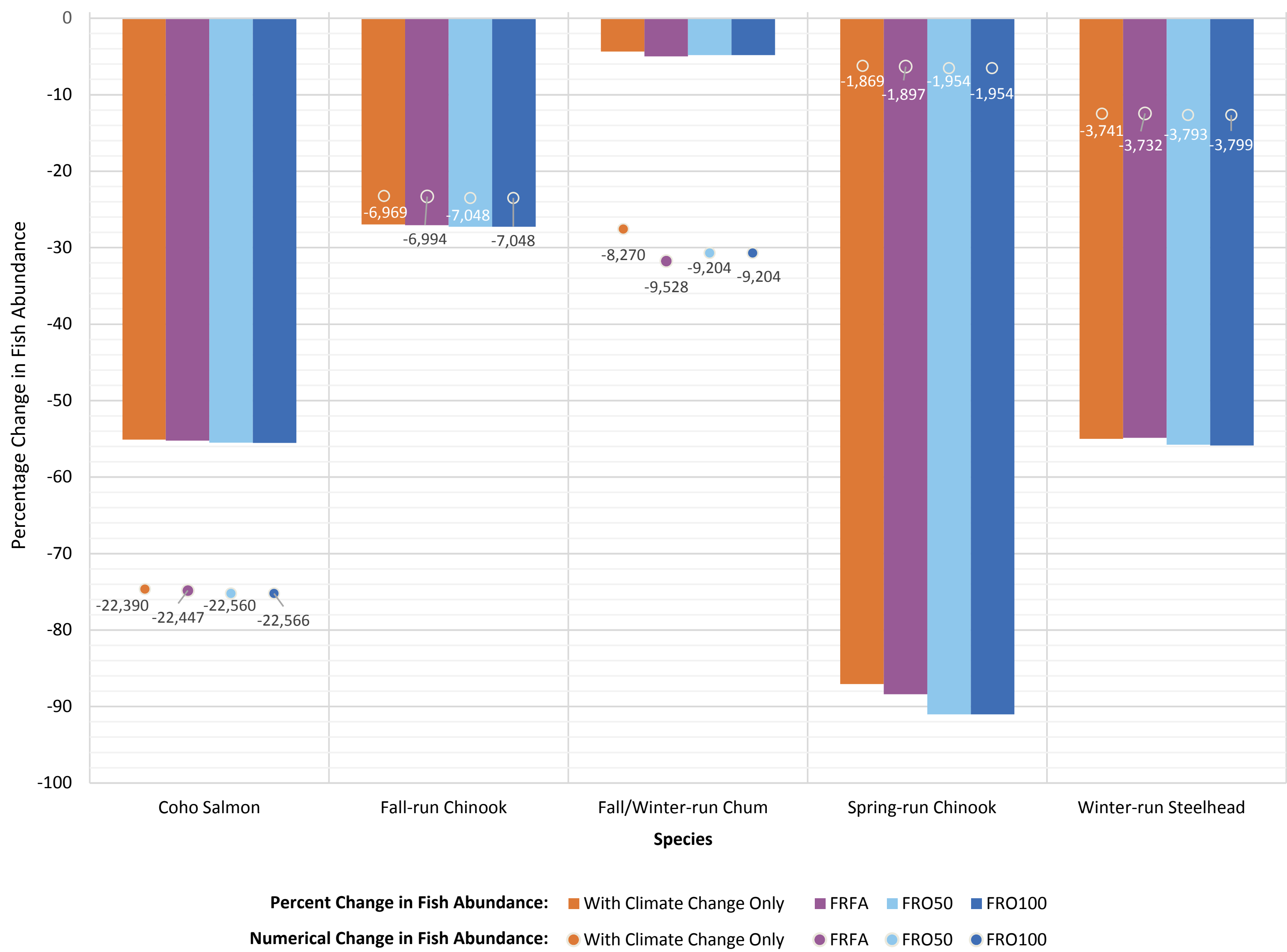
The Flood Retention Facility could worsen the adverse effects of climate change on some salmonid species, including winter/fall-run chum salmon and spring-run Chinook salmon. The FRO facility would have greater detrimental adverse impacts on the spring-run Chinook salmon population than the FRFA facility. Modeling results indicate that little or no change in populations of other salmonid populations are predicted with climate change and construction of a Flood Retention Facility.

As discussed in Section 4.2.4.2.2, decreases in salmon abundance resulting from lost freshwater habitat would have an adverse impact on wildlife species that either feed on or otherwise benefit from salmon-derived nutrients. This adverse impact would likely be most intense in areas where salmon spawning is substantially reduced or prevented, such as the reservoir footprint.

Climate change may also impact vegetation and riparian habitat upstream of the dam, as reservoir inundation patterns change with increased duration and amount of floodwater retention. Unlike the impacts associated with the immediate reservoir inundation following dam construction, the increases in these periods of inundation would likely be gradual, and the potential impacts on fish and wildlife or vegetation would be difficult to predict, but less than the initial impact after dam construction.

Figure 4.2-11

Potential Response in Salmonid Abundance to Habitat Change in the Chehalis Basin from Climate Change and Flood Retention Facility Types



Source: ICF 2016

4.2.7.3 Mitigation

4.2.7.3.1 Mitigation to Address Effects of the Flood Retention Facility Contributing to Climate Change

Potential long-term adverse impacts on climate conditions from operation of the Flood Retention Facility are associated with the loss of carbon sequestration resulting from vegetation removal. These effects could be addressed through avoidance and minimization measures, including implementing the Reservoir Operations and Management Plan, which includes vegetation management efforts to minimize increased GHG emissions (from the loss of carbon storage/vegetation removal).

The potential compensatory mitigation measures to address unavoidable adverse impacts from the operation of the Flood Retention Facility could include conservation of existing forestland to address loss of carbon storage and sequestration and increased GHG emissions.

4.2.7.3.2 Mitigation to Address Effects of Climate Change on the Flood Retention Facility

As described earlier, some of the potential long-term impacts of climate change on the Flood Retention Facility that could occur from increased intensity and frequency of storms would be mitigated by the design of the facility. Other avoidance and minimization efforts include implementation of the Reservoir Operations and Management Plan that would provide for adaptive management of dam operations to address downstream flooding. Adaptive management of the FRFA facility would also include management for instream flow and temperatures to minimize impacts on fish, in addition to downstream flooding.

4.2.8 Visual Quality

4.2.8.1 Short-term Impacts

The potential short-term impacts on visual quality that would occur during construction are described in Table 4.1-1. In addition, construction activities would substantially alter the appearance of the area near the Flood Retention Facility. Because the site is on private land, public access and views of the area are limited to Weyerhaeuser workers and occasional recreational users. Access to the area would likely be restricted during construction, further limiting the number of people exposed to construction impacts.

4.2.8.2 Long-term Impacts

Although few people would view the site of the Flood Retention Facility because of limited access, the FRO facility would result in a significant adverse impact due to the change in visual quality of the area (see Figures 4.2-12 and 4.2-13). Clearing of vegetation at the dam and reservoir sites would permanently remove forestland, as described in Section 4.2.3. The FRO dam would be approximately 226 feet high and 1,220 feet long, and would therefore be visible from adjacent hillsides. Where a free-flowing river previously existed, the FRO facility would introduce a large concrete structure with an ancillary “wing” and storage reservoir. This would greatly contrast with the existing landscape.

During floods, the FRO facility would store water and inundate 5.3 miles (on average) behind the dam (maximum area of 778 acres), creating views of open water in the foreground. Following floods, the slow release of water from the dam would leave visible mud, silt, and other residue on the edges of the storage area. During times when water is not being stored, the Chehalis River would be visible in its channel, but the riparian vegetation would be changed with the removal of trees in the reservoir area (see Section 4.2.3).

The potential adverse impacts on visual quality of the FRFA facility would be similar to the FRO facility, except the FRFA dam would be 41 feet lower (185 feet) and 1,250 feet longer (2,470 feet), and the area behind the FRFA dam would be inundated most of the year rather than just during major floods (see Figures 4.2-14 and 4.2-15). The permanent reservoir would extend up to 7.6 miles (maximum area of 1,264 acres). When reservoir water levels are high, the area behind the FRFA dam would be inundated with water, creating views of open water in the foreground. When reservoir water levels are low, the drawdown would expose areas of deciduous shrubland on the edges of the reservoir area.

4.2.8.3 Mitigation

In addition to those described in Table 4.1-1, short-term mitigation measures could include locating temporary construction access roads, staging areas, and stockpile sites within previously disturbed areas.

Long-term mitigation measures could include integrating design techniques for minimizing visual impacts, including repeating elements of form, line, color, and texture into the design and alignment of facilities. These measures could slightly reduce the visual quality impacts, but the impacts would still be significant.

Figure 4.2-12

Rendering of Existing Conditions at Potential Facility and Flood Retention Site

Figure 4.2-13

Rendering of FRO Facility (100-year Flood Stage)

Figure 4.2-14

Rendering of FRFA Facility (Permanent Reservoir)

Figure 4.2-15

Rendering of FRFA Facility (100-year Flood Stage)

4.2.9 Noise

4.2.9.1 Short-term Impacts

This section uses standard information about noise levels from typical construction equipment to present a generalized, qualitative discussion of short-term changes in noise during construction. Construction and blasting noise is exempt from regulation if conducted between 7:00 a.m. and 10:00 p.m. (daytime hours) per WAC 173-60-050. In addition, noise created by traffic (including heavy construction vehicles) on public roads is exempt from regulation under WAC 173-60-050. Therefore, there are no applicable standards to determine the significance of short-term noise impacts from construction activities. Section 4.2.4 discusses noise impacts on fish and wildlife.

The potential short-term impacts related to noise that would occur during construction are described in Table 4.1-1. Heavy equipment and construction activities associated with the Flood Retention Facility would cause short-term noise impacts. Table 4.2-14 shows noise levels of typical construction equipment at 50 feet from the source of the noise.

Table 4.2-14
Sound Levels of Common Sources and Noise Environments

CONSTRUCTION EQUIPMENT TYPES	EXAMPLES	ACTUAL MEASURED AVERAGE L_{max} AT 50 FEET (dB)
Earth moving	Compactor	83
	Front-end loader	79
	Backhoe	78
	Tractor	84
	Grader	89
	Paver	77
Materials handling	Concrete mixer truck	79
	Concrete pump truck	81
	Crane	81
Stationary	Pumps	81
	Compressor	78
	Generator	81
Hauling	Dump truck	76
Impact equipment	Pile driver	110
Impact tools	Jackhammer	81
	Rock drill	81
	Pneumatic tools	85

Note: L_{max} is the maximum value of a noise level that occurs during a single event.
Source: Reherman et al. 2006

Depending on the type of construction activity, peak noise levels from the equipment shown in Table 4.2-14 would range from 76 to 110 dBA at 50 feet from the source. Damage to hearing occurs with noise levels above 85 dBA. However, noise levels decrease with distance from the source at a rate of approximately 6 to 7.5 dBA per doubled distance. For example, noise levels from construction equipment would range from approximately 57 to 98 dBA at a distance of 200 feet; from 51 to 92 dBA at 400 feet; and from 45 to 86 dBA at 800 feet.

The location of the Flood Retention Facility is isolated, with the closest permanent residents several miles away. There are no sensitive noise receptors in the area. The area would be closed to recreational use during construction, so the only people in the area during construction would be construction workers.

Construction of the dam, as well as selective clearing of the reservoir area, would require heavy equipment and activities with high noise levels, including compactors, pile drivers, jackhammers, and rock drills. Some of this equipment would operate at noise levels high enough to cause hearing damage at very short distances (less than 50 feet), but the noise levels would dissipate to safe levels with distance. Construction would require blasting to excavate the rock footings of the dam. Blasting has an instantaneous noise level of 94 dBA at 50 feet. Blasting also causes air and ground vibrations that could be felt in surrounding areas. Because the Flood Retention Facility site is isolated and the area would be closed to recreational use during construction, few people or buildings would be exposed to the noise and vibration of blasting. Noise associated with the construction of the Flood Retention Facility would be major and would last for 2 to 3 years.

4.2.9.2 Long-term Impacts

The potential for adverse noise impacts is based on increased noise levels. Significant impacts would occur if projects generated noise that would conflict with local ordinances or increase noise levels by 5 dBA or greater at a sensitive land use. Neither the FRO or FRFA facility would generate noise, so there would be no adverse noise impacts.

4.2.9.3 Mitigation

Assuming the specifications for equipment meet the noise standards described in Table 4.1-1, no additional equipment mitigation for short-term impacts would be required. Construction workers at the site would wear hearing protectors to prevent hearing damage. A Blasting Noise Mitigation Plan would also be prepared.

No long-term impacts related to noise are anticipated, so no mitigation is required.

4.2.10 Land Use

4.2.10.1 Short-term Impacts

The potential short-term impacts on land use would occur during construction, with land use conditions returning to pre-construction status following construction. Potential short-term impacts on land use during construction include limited access to forestland and the establishment of temporary worker housing. Potential temporary impacts to vegetation associated with construction activities are addressed in Table 4.1-1 and Section 4.2.3.1.

Limited access to commercial forestland in areas immediately adjacent to the construction site could affect forestry operations in this vicinity during construction. In addition, temporary housing could be required for workers during construction, which could affect land use within the vicinity of the construction site. The specific plans for site access and temporary worker housing would be determined during the project-level environmental review associated with more detailed project design and construction specifications.

4.2.10.2 Long-term Impacts

The potential adverse impacts on land use are similar for the FRO facility and FRFA facility and include the following:

- Conversion of managed forestland to a Flood Retention Facility
- Land use changes associated with reduced flood extents and frequency of major flooding

Following the initial clearing or selective harvesting of timber during construction, the area within the Flood Retention Facility would no longer be managed as commercial forestland. The property immediately surrounding the Flood Retention Facility would remain in use as commercial forestland, and the use of the Flood Retention Facility would be compatible with surrounding land uses. No other changes in land use, including new residential or community development, are anticipated within or adjacent to the reservoir area. Such development would not be consistent with the Chehalis Basin Strategy objectives to reduce flood damage and restore habitat for aquatic species. The conversion of managed forestland to a Flood Retention Facility is considered a minor adverse effect on land use, because a substantial amount of forestry operations on 830,000 acres of forestland would continue in the Chehalis Basin.

The extent and depth of major flooding would be reduced in the Chehalis River floodplain with construction of the Flood Retention Facility, which is anticipated to reduce crop damage on agricultural land. The reduction in flooding could result in changes in the types of agricultural crops grown in the upper Chehalis Basin. Currently, an estimated 13% of the crops grown in the Chehalis Basin are vegetable crops and the remainder are field crops (e.g., pasture or hay), which are more tolerant of flooding (EES and HDR 2014). With less inundation from major floods, it is possible that some agricultural lands could be converted from field crops to higher-value vegetable crops. A reduction in the extent of major floods would likely result in fewer livestock losses as compared to major floods in the past. Less severe flooding would also provide more areas of refuge from floodwaters for livestock.

A reduction in flooding of commercial, residential, industrial, and agricultural structures is also anticipated. Modeled results for the decreased area and extent of floodplain inundation and corresponding decrease in structures damaged by flooding have been developed for the combined alternatives and are described in Chapter 5. Corresponding potential increases in development in areas protected by the Flood Retention Facility and Airport Levee Improvements are also described in the impacts analysis for Alternative 1 in Chapter 5 and Appendix L.

4.2.10.3 Mitigation

For short-term impacts, no compensatory mitigation measures are proposed.

The potential long-term adverse impacts on land use that are anticipated with Flood Retention Facility implementation are minor and are associated with the conversion of forestland. These impacts could be minimized by implementing the Reservoir Operations and Management Plan, which would include provisions to ensure that operation of the Flood Retention Facility included coordination with adjacent landowners with respect to vegetation management and site access. The need for compensatory mitigation is not anticipated.

4.2.11 Recreation

4.2.11.1 Short-term Impacts

The potential short-term impacts on recreation that would occur during construction are described in Table 4.1-1. These impacts would disrupt recreational activities in the Flood Retention Facility area. Recreational access to the area would likely be restricted during the 2- to 3-year construction period. Permits to use the Pe Ell South Permit Area on Weyerhaeuser land would likely not be issued during this time. Recreational users in nearby areas would notice construction noise and dust. Construction noise and activities could be particularly disruptive to hunters in nearby areas because wildlife would leave the area during construction.

4.2.11.2 Long-term Impacts

The Flood Retention Facility would permanently change the recreational character of the immediate area. Large areas of forestland would be cleared as described in Section 4.2.3. For the FRO facility, the area behind the dam would be inundated and unavailable for recreational activities during major floods. For the FRFA facility, the area behind the dam would be permanently inundated and unavailable for recreational activities. It is expected that Weyerhaeuser would reopen the area to recreational use (e.g., hunting) following construction. Portions of the area that would be periodically or permanently inundated could be closed to hunting, but the conversion of forestland to deciduous riparian shrubland could increase hunting opportunities. These potential adverse impacts are considered minor because the loss of access to the reservoir area for hunting and camping would affect a small area compared to the rest of the recreation opportunities in the Chehalis Basin, and recreational access is already limited by the number of passes available from Weyerhaeuser.

The Flood Retention Facility would permanently foreclose use of this reach of the Chehalis River for whitewater rafters for health and safety reasons. The American Whitewater Association lists the reach as a Class III-IV whitewater area, but the area is not used heavily by rafters (O'Keefe 2016). This change to recreation use in the area is considered a moderate adverse impact because of the permanent loss of this reach of the Chehalis River for in-water recreation.

The Flood Retention Facility would reduce flood damage at parks and other recreational facilities throughout the Chehalis Basin during a 100-year flood, including in the area of Rainbow Falls State Park and the Willapa Hills Trail. Most of the benefits of flood damage reduction would occur at recreational facilities in the upper Chehalis Basin. The Flood Retention Facility would also reduce flood damage to agricultural properties, including those used for agritourism.

4.2.11.3 Mitigation

For short-term mitigation, the area would be closed for recreational use for safety reasons. No other mitigation measures would be implemented.

No mitigation is available for the long-term impacts from changes to in-water recreation and reduction of recreation opportunities within the reservoir area. Once construction is complete, the accessible areas for activities (e.g., hunting) are likely to be re-opened to permit use.

4.2.12 Historic and Cultural Preservation

4.2.12.1 Short- and Long-term Impacts

Potential short- and long-term impacts on historic and cultural resources include the following:

- Destruction, damage to, or alteration of a cultural resource
- Necessary removal of a cultural resource from its original location
- Changes to the use or physical features of a cultural resource
- Introduction of visual, atmospheric, or audible elements that diminish the integrity of the significant features of a cultural resource

The potential impacts on historic and cultural resources that could occur during construction include ground disturbance associated with new roads or access routes, building the dam, and creating the reservoir. Although no historic buildings or other cultural resources have been documented within the boundary of the Flood Retention Facility, there is a high to moderate potential for archaeological deposits to exist within the vicinity based on WSAPM.

The potential impacts on cultural resources are similar for the FRO facility and FRFA facility, but differ slightly, as the operational function of the reservoir varies between the facility types. Although the degree or severity of the impact would depend on the nature of cultural resources that would be disturbed, moderate to significant adverse impacts on cultural resources could occur due to the predicted archaeological potential. Potential impacts on tribal cultural resources or graves, Indian human remains, or traditional cultural properties would be determined in coordination with tribes, and government-to-government consultations.

For both facility types, the initial inundation and drawdown of the flood storage reservoir and subsequent reservoir inundation as needed for flood storage, would result in the following conditions with potential long-term impacts:

- Sedimentation of submerged resources
- Stream channel changes and erosion, or streambank changes and resulting erosion—both of which could expose, damage, destroy, and/or alter as-yet undocumented cultural resources
- Increased or changed vehicular and foot traffic patterns

4.2.12.2 Mitigation

Once potential project-specific impacts of the Flood Retention Facility on cultural resources have been identified, avoidance/minimization measures may be considered that alter design or construction methods to avoid or minimize these impacts. If impacts cannot be avoided, mitigation measures to address potential impacts on cultural resources would be determined during project-specific evaluations of the Flood Retention Facility, and would include consultation with DAHP, interested and affected tribes, as well as other consulting parties.

Addressing Potential Impacts on Cultural Resources

If the Flood Retention Facility is selected to move forward into project-specific SEPA and NEPA evaluations, studies would be performed to determine if cultural resources are present within the Area of Potential Effects, and whether the action would have unavoidable significant impacts on these resources. In the case of a NEPA evaluation, a significant cultural resource is defined as any cultural resource eligible for, or listed in, the National Register of Historic Places. In the case of a SEPA evaluation, a significant cultural resource is defined as any archaeological site, or any built environment site that is eligible for the Washington Heritage Register.

The cultural resources investigative studies would include background research, field investigations, and consultation with DAHP and affected tribes. If these studies determine that significant cultural resources (including potential traditional cultural properties and designated traditional cultural properties) would be affected, the project consultation process would be used to develop and identify appropriate methods for avoiding or minimizing and mitigating impacts on significant cultural resources. This process and could include the development of a memorandum of agreement or programmatic agreement outlining the steps that would be taken to address impacts.

The potential compensatory mitigation measures could include data recovery (scientific excavation and analysis) of the archaeological sites, archaeological monitoring during construction to ensure that no (previously unknown) cultural resources are affected, development and implementation of an Inadvertent Discovery Plan, ethnographic studies, Historic American Building Survey/Historic American Engineering Record documentation, and cultural resources identification trainings for construction personnel.

4.2.13 Transportation

4.2.13.1 Short-term Impacts

The potential short-term impacts on transportation that would occur during construction are described in Table 4.1-1. In addition, road access to the Flood Retention Facility site is limited, so construction traffic would be concentrated on SR 6 to Pe Ell and local roads leading to the site. Traffic delays would be likely on these roadways. Several miles of new temporary roads would be constructed to access the Flood Retention Facility and quarry sites.

4.2.13.2 Long-term Impacts

No adverse impacts on transportation are anticipated. The Flood Retention Facility would reduce the duration of closures of I-5 during a 100-year flood. The FRO facility would reduce flooding impacts on transportation systems in the Chehalis Basin, especially in the upper Chehalis Basin. According to modeling conducted for the Flood Retention Facility, the dam would reduce flooding of roadways in the upper Chehalis Basin near the Chehalis River during a 100-year flood by approximately 1 to 3 days, including roads in Fords Prairie, south Centralia, and parallel to SR 6. Flood depths in these areas would be reduced between 1 and 11 feet, and some portions of SR 6 between Doty and Adna would no longer be inundated during a 100-year flood. In the Chehalis and Centralia area, the Flood Retention Facility would reduce flood depths by 1 to 2 feet. The Flood Retention Facility would provide some flood protection for the Chehalis-Centralia Airport during smaller floods, allowing flights to continue, but the airport would continue to flood during some floods. The Flood Retention Facility would reduce flood depths by 7 feet at the Chehalis-Centralia Airport during a 100-year flood; it would also likely decrease the frequency of rail closures. These flood damage reductions would result in beneficial effects for transportation facilities.

The completed Flood Retention Facility would not increase traffic on local roadways. Vehicle trips to the dam would be limited trips for periodic maintenance. For the FRO facility, a bypass road for FR 1000, up to 6 miles long, would provide access when the FRO facility is in operation and FR 1000 is inundated. Inundation of FR 1000 may damage the roadway, requiring maintenance following operation of the FRO facility. For the FRFA facility, a 5-mile stretch of FR 1000 would be closed and a new 7-mile bypass road would be constructed outside the reservoir area, using either a new 7-mile road or a permanent detour using existing forest roads.

4.2.13.3 Mitigation

In addition to the short-term mitigation measures described in Table 4.1-1, specific measures to mitigate short-term traffic impacts would be developed in the design phase and could include obtaining necessary permits and developing transportation plans in coordination with WSDOT, local jurisdictions, Weyerhaeuser, and other property owners. Closure of the roads around the reservoir could be coordinated with Weyerhaeuser and other property owners, if necessary.

Any damage to forest roads caused by operation of the FRO facility would be repaired. No other adverse long-term impacts on transportation are anticipated, so no additional mitigation is required.

4.2.14 Public Services and Utilities

4.2.14.1 Short-term Impacts

The Flood Retention Facility would be located in a remote area that is accessible only by a private road. Construction of the Flood Retention Facility would not hinder the access to or operation of public services; therefore, no short-term impacts on public services are anticipated. However, construction would cause short-term impacts on utilities. A new low-voltage line would be necessary for construction and operation of the dam to power pumps, gates, instruments, and other facilities. Construction would include a new transformer and electrical right-of-way to transmit electricity from local transmission lines to the Flood Retention Facility. At this time, no alignment has been identified for the potential electrical right-of-way. Constructing the new transmission line is not expected to cause adverse impacts because no services or utilities would be disrupted.

4.2.14.2 Long-term Impacts

Adverse impacts of the Flood Retention Facility would be moderate because the reservoir would inundate Pe Ell's water supply located on Lester Creek. The small amount of electricity required for operation of the Flood Retention Facility would not affect electrical supplies. The Flood Retention Facility could require localized relocation of public utilities, resulting in minor adverse impacts.

The Flood Retention Facility would decrease the level and duration of flooding in portions of the Chehalis Basin during major floods, and therefore would reduce corresponding flood impacts on public services and utilities. Most of the benefits would occur in the Chehalis-Centralia area where public services and utilities are concentrated and where flood depths would be reduced from 1 to 2 feet during a 100-year flood. The Flood Retention Facility would reduce flooding of public services and utilities downstream of the Chehalis-Centralia area, but to a lesser extent.

4.2.14.3 Mitigation

To mitigate short-term impacts on utilities, the new electrical transmission lines would be sited according to industry best practices. Lewis County PUD provides electrical service in the area of the Flood Retention Facility. Through the permitting process, Lewis County PUD would determine how to design and place the new electrical infrastructure in a way that best avoids or minimizes impacts on exiting utilities. In addition, a Construction Sequence Plan would be developed to coordinate schedules for utility work to minimize service disruptions and provide ample advance notice when disruptions are unavoidable.

To mitigate for long-term impacts on Pe Ell's water supply, the intake could be relocated or a new water source could be provided.

4.2.15 Environmental Health and Safety

4.2.15.1 Short-term Impacts

The potential short-term impacts on environmental health and safety that would occur during construction are described in Table 4.1-1. In addition, construction traffic on local roadways could cause temporary delays to emergency response. However, construction traffic would be heading towards a more remote area on roads that are less traveled, decreasing the degree of impact. Limited emergency services are required in the remote area so disruptions would be minimal and impacts would be limited to the construction period. Construction is not likely to increase the need for emergency services.

4.2.15.2 Long-term Impacts

The Flood Retention Facility would reduce the severity of flooding in portions of the Chehalis Basin during a major flood, which would reduce the need for emergency response services in those areas. The Flood Retention Facility would also reduce the number of local roadways flooded during major floods, which would have positive impacts on emergency response and public safety within those road corridors. It could also reduce contamination of surface water by floodwaters and the release of hazardous materials, thereby reducing the potential for public exposure to hazardous materials and any health and safety effects. The Flood Retention Facility would not substantially reduce contamination of drinking water wells because most areas would continue to be inundated during a 100-year flood. Reducing the level of inundation would not prevent groundwater contamination. These potential impacts are considered beneficial because they would improve public health and safety. Overall, the Flood Retention Facility would reduce threats to public health and safety.

Over the life of the Flood Retention Facility, an earthquake on the CSZ could cause damage to the dam. If the dam sustained major damage while storing water, reservoir water could be released, causing catastrophic downstream flooding and resulting in endangered public safety. The dam would be designed to withstand shaking associated with an earthquake on the CSZ, reducing the risk of catastrophic failure. Although unlikely, the results of such an event would be considered an unavoidable significant adverse impact. Because the FRFA facility would store water continuously, there would be more potential for a failure to cause catastrophic downstream flooding compared to the FRO facility.

4.2.15.3 Mitigation

Potential measures to reduce short-term construction disruptions to environmental health and safety (e.g., encountering hazardous materials) could include coordinating construction with emergency services, scheduling construction to minimize impacts, and notifying the public of construction. Construction Traffic Control Plans would be developed to reduce impacts on emergency services and response and Worksite Safety Plans would be developed to provide emergency response for construction workers.

If the dam were to fail, emergency response would be executed in accordance with an Emergency Action Plan (EAP), as required by Ecology's Dam Safety Office. EAPs provide guidance for detecting the event, determining the emergency level, notifying the community, addressing the event, and reporting the event.