To: **Quinault Indian Nation**

From: **Natural Systems Design and Saturna Watershed Sciences**
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Date: June 3, 2022

Re: Critical Review of the December 2021 Chehalis FRE Vegetation Management Plan

EXECUTIVE SUMMARY

At the request of the Quinault Indian Nation, a qualified technical team of forest ecologists, forest hydrologists, wetland ecologists, and geologists from Natural Systems Design (NSD) and Saturna Watershed Sciences (Saturna) reviewed the 2021 *Vegetation Management Plan, Chehalis River Basin Flood Damage Reduction Project* (VMP) submitted by the Chehalis River Basin Flood Control Zone District (FCZD) in December 2021. The team also reviewed related documents prepared by the FCZD and its consultants to support the proposed Flood Retention Expandable (FRE) facility and Airport Levee Improvement project (proposed project). The proposed project is being reviewed for construction authorization under the National Environmental Policy Act (NEPA) and the State Environmental Policy Act (SEPA) by the U.S. Army Corps of Engineers (Corps) and Washington State Department of Ecology (Ecology), respectively.

The team reviewed the 2021 VMP and utilized the information regarding technical issues, errors, and omissions previously prepared and summarized by NSD and Saturna in technical memos prepared in 2020 during the public comment periods for the SEPA and NEPA Draft Environmental Impact Statements (DEISs). The 2021 VMP provides an update to the earlier *Conceptual Vegetation Management Plan* (FCZD 2020), itself an expansion upon the *Technical Memorandum on Proposed Flood Retention Facility Pre-Construction Vegetation Management Plan* submitted by Anchor QEA, LLC, in 2016.

Particular attention was paid to the interconnected nature of the vegetation, hydrologic, geologic, and climate changes analyses presented in these documents. **The team focused on the assertion in the VMP that the approach proposed would lessen the significant impacts acknowledged in the SEPA and NEPA DEIS's to vegetation community integrity, geomorphic hillslope processes, aquatic habitat, and treaty-protected resources.**

The FCZD's VMP is an important document in that the approach it proposes of harvesting, planting and adaptively managing the vegetation within the proposed FRE facility reservoir directly and significantly determines the nature, scale, and severity of impacts to the reservoir's hillslope and riparian vegetation communities and thus to the aquatic habitat and species of the upper Chehalis River.

The team concluded that the following critical assumptions, omissions, and errors are present in the VMP and supporting SEPA and NEPA DEISs and associated discipline reports, resulting in a **gross underestimation of the scale, risk, and uncertainties of the approach articulated in the VMP and thus, the potential for unmitigable impacts to riparian, aquatic, and wetland resources:**

1. The VMP obfuscates the feasibility of implementing the approach it proposes by failing to acknowledge the complexities of redesignation and regulatory requirements under the Forest Practices Act for conversion of Weyerhaeuser commercial timber lands to lands in which the river's riparian zone and adjacent steep slopes can be converted to the FRE reservoir and periodically harvested as proposed in the VMP.
2. The VMP, and the NEPA and SEPA DEISs on which it is based, underestimate the frequency of peak flows that would trigger operation of the FRE facility under current conditions and therefore underestimates all impacts associated with frequency, magnitude, and duration of the operation of the FRE facility and reservoir inundation.
3. The VMP, and the NEPA and SEPA DEISs on which it is based, fails to include (NEPA), and fails to appropriately account (SEPA), for the ways in which climate change is altering precipitation patterns, intensity, and frequency of triggering flows, and thus similarly underestimated the frequency, magnitude, and duration of operation of the FRE facility and reservoir inundation on which the VMP is based.
4. The VMP offers an 'advance planting' approach that is based on a faulty analog of the Mud Mountain Dam reservoir, and which fails to account for soil moisture and slope conditions and is thus infeasible and fails to avoid or minimize the significant impacts associated with periodic inundation of 808 acres of currently functional riparian, wetland, and upland vegetation in the proposed reservoir area.
5. The VMP fails to include both reservoir vegetation root cohesion and associated hillslope stability analyses, necessary to assess the feasibility of the proposed 'advance planting' approach and the proposed 'adaptive management' approach of continuously assessing and replanting areas of vegetation establishment failure within the proposed reservoir.
6. Given the flawed assumptions of the VMP, it fails to recognize the pernicious effect of landslides, erosion and mass wasting throughout the reservoir due to loss of hillslope root cohesion and the inability to establish and sustain deep-rooted trees both initially before the first inundation event and after repeated inundation events.
7. The VMP proposes to regularly remove trees over 6 inches in diameter every 7-10 years within frequently flooded areas of the reservoir. This plan will maintain the lowest root cohesion and maximize slope instability throughout the lifetime of the project.
8. The VMP fails to acknowledge or provide any provision for response to the likelihood of substantial vegetation mortality, particularly adjacent to the river channel, following over 30 days of submergence under 200 feet of water.
9. The VMP fails to minimize or offer a viable strategy to mitigate the consequent significant impacts on water quality within the Chehalis River, particular increases in water temperature due to the loss of channel shade throughout the riparian zone of the proposed reservoir. The VMP also fails to present a viable strategy to reduce significant water quality impacts through the introduction of vast quantities of fine sediment input into the river as a result of the loss of root cohesion, slope instability, and landslides.
10. Given that the VMP is fundamentally flawed, but that the assumed success of the VMP is the basis for the assumptions that underlie the additional water quality modeling, the assertion of reduced effects on water quality from increased vegetation height and shading is unsupported.

Together, these flawed assumptions and analyses result in a gross overestimation of the feasibility of lessening significant impacts to vegetation, water quality, and aquatic habitat and species. The VMP similarly grossly underestimates the operational impacts of the proposed FRE facility, including the scale, intensity, and frequency of significant impacts to water quality, hillslope stability, fine sediment delivery and transport, instream aquatic habitat, and very existence of unique salmonid populations in the upper Chehalis River. **The**

approach proposed in the VMP presents a scenario of irreparable systemic damage to the upper Chehalis River and its ecosystems.

Given the multiple areas of uncertainty, the scale of area affected, and the sensitivity of the riparian and aquatic resources, the approach articulated in the VMP poses a high degree of uncertainty and an unacceptable risk of significant, systemic, and irreparably damaging impacts to the Chehalis River riparian and aquatic ecosystems. We conclude the VMP is poorly thought through and technically and logistically infeasible. As such, **the VMP <u>cannot</u> lessen or mitigate the significant impacts to waters of the U.S., wetlands, riparian and aquatic habitats, or fisheries resources acknowledged in the NEPA and SEPA DEISs.**

PURPOSE AND UNDERSTANDING

A Flood Retention Expandable (FRE) facility and airport levee improvements have been proposed by the Chehalis River Basin Flood Control Zone District (FCZD, Applicant) as the preferred alternative to accomplish flood damage reduction on the Chehalis River, Washington. The stated purpose of the FRE facility would be to store water in the upper watershed to alleviate flood damage to developed areas of the lower floodplain near the towns of Centralia and Chehalis. The FRE facility and airport levee improvements are being reviewed under the National Environmental Policy Act (NEPA) and the State Environmental Policy Act (SEPA) by the U.S. Army Corps of Engineers (Corps) and the Washington State Department of Ecology (Ecology), respectively. As part of that review process, the Corps and Ecology have requested the FCZD provide additional analyses and supporting documentation to inform regulatory decision making.

The incorporation of a science-based vegetation management plan for the FRE facility reservoir is critical to a credible analysis of potential impacts and determination of project impact uncertainties. The analysis of reservoir vegetation community effects due to operation of the FRE facility depends on the hydrology of the system, and particularly on the frequency and magnitude of flooding events that would trigger operation of the FRE facility, the magnitude and duration of the inundation of the FRE facility reservoir, and the treatment of the reservoir hillslopes before, during, and after inundation events.

The VMP was prepared in response to the Corps request that the FCZD address means to avoid, minimize, or mitigate potential impacts to terrestrial and aquatic resources as a result of the operation and management of the proposed FRE facility and its reservoir. Ecology similarly requested the FCZD provide a more detailed vegetation management plan than was previously prepared. The VMP was therefore prepared by the FCZD in response to the Corps and Ecology's requests and to inform preparation of the SEPA and NEPA Final Environmental Impact Statements (FEISs). The VMP provides an update to the earlier *Conceptual Vegetation Management Plan* (FCZD 2020), itself an expansion upon the *Technical Memorandum on Proposed Flood Retention Facility Pre-Construction Vegetation Management Plan* submitted by Anchor QEA, LLC, in 2016.

Our review finds there are multiple flaws with the VMP centering on assumptions of duration and frequency of reservoir inundation and related consideration of climate change effects, vegetation submergence tolerance, effect of loss of vegetation root cohesion on reservoir hillslope stability, the feasibility of the reservoir harvest and 'advance planting', and the role of the VMP in the consequent cascade of ecosystem impacts that will result from the FRE facility operation and reservoir formation. Furthermore, the additional water quality modeling that was performed asserts that the impacts of the FRE on water temperature will be less than the impacts that were presented in the DEIS, but the foundation of the additional modeling is the assumed success of the VMP. Given the flaws in the VMP, in combination with additional flawed assumptions underlying the water quality modeling approach, the conclusion of less severe water temperature impacts than those presented in the DEISs is unsupported.

We present our analysis supporting these conclusions and the implications for considering the VMP as an 'impact reduction/mitigation' approach for the proposed FRE facility in 11 sections:

1. Inability to Meet Forest Practices Requirements for Riparian Function Restoration
2. Continued Reliance on Flawed Hydrologic Analysis
3. Flawed Approach to Characterizing Impacts and Impact Reduction
4. Flawed Approach to Converting Existing Vegetation Communities

5. Flawed Application of 'Hydrologic Tolerance' of Native Trees and Shrubs
6. Flawed Application of Mud Mountain Dam as Analogous System
7. Failure to Consider Vegetation Root Cohesion and Hillslope Stability
8. Failure to Consider Hydraulic Stability During Reservoir Operation
9. Failure of VMP to Reduce Impacts to Water Quality
10. Failure to Mitigate the Cascade of Ecosystem Effects
11. Need for Risk Assessment Based Decision-Making Given Uncertainty

ANALYSIS

To understand and assess how inundation frequency and duration, reservoir drawdown, vegetation root cohesion, and hillslope stability were considered in the VMP, NSD reviewed the relevant information in the NEPA and SEPA DEISs. NSD also reviewed the following previously completed technical review documents which are specifically incorporated herein by reference:

1. Cascade of FRE Facility Ecosystem Effects Technical Memo (SEPA Cascade of Ecosystem Effects Technical Memo) (NSD 2020a)
2. Hydrology Technical Memo 1: Observed and Predicted Flows Relative to FRE Facility Operation (SEPA Hydrology Technical Memo 1) (NSD 2020b)
3. Hydrology Technical Memo 2: Hydrology and Climate Change Technical Analyses Review (SEPA Hydrology 2 Technical Memo) (NSD 2020c)
4. Critical Review of Proposed Chehalis River Basin Flood Damage Reduction Project NEPA DEIS: Addendum to Cascade of FRE Ecosystems Effects Technical Memo (NEPA Ecosystems Addendum) (NSD 2020d)
5. Critical Review of Proposed Chehalis River Basin Flood Damage Reduction Project NEPA DEIS: Climate Change Impacts (NEPA Climate Change memo) (NSD 2020e)
6. Earth Discipline Report–Geology Technical Analyses Review (SEPA Geology Technical Memo) (NSD and Saturna Watershed Sciences 2020a)
7. Critical Review of Proposed Chehalis River Basin Flood Damage Reduction Project NEPA DEIS: Geology Discipline Report Review (NEPA Geology Addendum) (NSD and Saturna Watershed Sciences 2020b)
8. Water Temperature Model Sensitivity Analysis, Chehalis River Basin Flood Damage Reduction Project, Chehalis River Basin Flood Control Zone District, August 2021.
9. Level II Habitat Survey & Wetland Identification: Howard Hanson Dam and Mud Mountain Dam, King and Pierce Counties, Washington. U.S. Army Corps of Engineers, Engineer Research and Development Center (ERDC) Environmental Laboratory. July 2019.

These documents provide the basis for evaluation of design, impacts, and revegetation design. Additional peer-reviewed science literature, regulations, and government agency guidelines were also referenced as indicated.

FINDINGS

Obfuscation Regarding Forest Practices Act Re-Designation

The previous November 2020 Conceptual VMP stated that the WDNR would "*need to issue a Forest Practices Permit per the Washington State Forest Practices Rules (Title 222 Washington Administrative Code [WAC]) in order for the FCZD to conduct selective tree harvest and long-term vegetation management during Project construction and operations. WDNR would approve the VMP as part of the Forest Practices Permit issuance*" (CVMP Section 2 page 3). The development of the proposed quarries and improvements to the road network would also be subject to Forest Practices Act Rules. The CVMP further stated that selective tree harvesting would deviate from the Forest Practices Act Rules and thus an Alternate Plan would need to be developed to meet the provisions of the Forest Practices Act and WDNR would need to approve the ultimate VMP as part of their Forest Practices Permit Issuance (CVMP Section 2.3.3.1 page 5).

Forest Practices Act Rules require an alternate plan to "*protect aquatic resources and related habitat to achieve restoration of riparian function; and the maintenance of these resources once they are restored*" (WAC 22-12-040). Realistically, the VMP proposal to harvest non 'flood tolerant' trees within the Riparian Management Zone of the Chehalis River and associated tributaries in the reservoir inundation area and the likelihood of slope instability and slope failure (as described in detail herein), is completely contrary to the requirements for a Forest Practices Permit alternate plan. Protection of aquatic resources and related habitat to achieve the required restoration and maintenance of riparian function is unattainable with the approach proposed in the VMP. The loss of riparian forest area and critically important functions including but not limited to stream shading, stream bank stability, woody debris sources, sediment filtering and nutrients and leaf litter fall will be irreplaceable.

The VMP is virtually silent on the Forest Practices Act. The VMP does not address the feasibility of meeting the requirements of the Forest Practices Act, nor the potential for an alternate plan or WDNR approval of the VMP. It states only that "*The area within the temporary reservoir will be redesignated from commercial forest land to a non-commercial status and will not continue to be regulated under the WDNR Forest Practices Act.*" (VMP Section 6.4, page 6-2) No explanation of the process or feasibility (including any opportunity for public comment) of the redesignation to non-commercial status is presented. The supposition that WDNR will redesignate 808 acres of productive commercial forest lands presupposes a regulatory outcome and through that omission obfuscates the feasibility of implementing the VMP.

Continued Reliance on Flawed Hydrologic Analysis

The comments submitted on the NEPA and SEPA DEIs, as presented in the critical review summary memos cited above, identified multiple flaws with the hydrologic analysis. These flaws include:

- Underestimation of the frequency of peak flows that would trigger dam closure and thus underestimation of the frequency and duration of operation of the FRE facility.
  - This underestimation compounds as an underestimation of the frequency at which the reservoir forms and the duration of inundation to which the reservoir's slopes and conifer forests, and the deciduous riparian zone of the river would be repeatedly subjected.
- Failure to appropriately include climate change projections in projecting reservoir inundation frequency, magnitude, and duration (*SEPA Hydrology Technical Memo 2*) (NSD 2020c).

- The NEPA DEIS analysis of flood frequency effectively ignores climate change and therefore does not reflect best available science.
- NEPA DEIS relies on the assumption that current conditions are representative of future conditions and the assertion that future uncertainty justifies ignoring robust projections, both of which stands in contrast to a large body of scientific literature.
    - Peer-reviewed scientific studies in the Pacific Northwest region, as well as in the Chehalis Basin, indicate the frequency and magnitude of peak river flows will increase over the next 100 years (Hamlet et al. 2013; Mauger et al. 2016; Warner et al. 2015; Hamlet and Lettenmaier 2007; Elsner et al. 2010).
- Climate change impacts on flooding are projected to occur in the coming decades, with increases in peak flows modeled for the 2040s (inclusive of 2030-2059; Hamlet et al. 2013), 2050s (inclusive of 2040-2069; Mauger et al. 2016), and beyond.
- Climate change impacts are relevant to the analysis period of 2030 to 2080 for quantifying impacts that are based on the frequency and duration of operation of the FRE facility and for assessing whether the FRE facility will meet proposed project's purpose and need related to the amount and duration of potential flood reduction benefits.
    - Numerous studies for western Washington have indicated increases in peak flows as early as the 2020s (inclusive of 2010-2039; Elsner et al. 2010, Mantua, et al. 2010), which would affect the frequency and/or magnitude of flood events that occur during the proposed construction period of 2025-2030 and thus potentially affect the construction site and the reservoir hillslopes during the harvest of trees within the debris management zone slated to occur as part of construction.
- While the SEPA DEIS presented a climate change scenario, it also failed to adequately consider several aspects, including underestimation of the frequency of peak flows that will trigger FRE operation under both current and future climate conditions.

The NEPA DEIS assumes that the FRE facility will be operated at a frequency of once every 7 years. In contrast, the SEPA DEIS analysis reported a frequency of once every 5 years by mid-century and once every 4 years by late-century because of incorporating climate change. NSD's previous analysis of the SEPA DEIS estimates that the frequency would be once in every 1.8 and 1.4 years under the mid- and late-century climate change scenarios used by Ecology in the SEPA DEIS (see *SEPA Hydrology Technical Memo 2* (2020c)).

Previous analysis of the SEPA DEIS details the multitude of ways that the nature, scale, and intensity of upstream and downstream impacts are underestimated when the frequency and duration of FRE operation are underestimated (see SEPA Hydrology Technical Memo 1 (NSD 2020b), and SEPA Cascade of Ecosystem Effects Technical Memo (2020a)), including:

- Underestimation of the increases in the frequency and magnitude of landslides and hillslope erosion, and therefore sediment delivery,
- Underestimation of impacts to channel morphology, sediment transport, vegetation, and aquatic habitat within the reservoir area and downstream of the reservoir, and
- Underestimation of the impacts to the formation and maintenance of floodplain wetlands and the recharge of groundwater.

The lack of/issues with climate change analyses utilized in the NEPA and SEPA DEISs compounds the flawed hydrologic analyses of current conditions, and results in more extreme underestimates of all impacts related to the frequency and duration of the operation of the FRE facility, which is perpetuated in the VMP. For example, the SEPA and NEPA DEISs and the VMP fail to note that multiple back-to-back atmospheric river storms are common to the Pacific Northwest (*NEPA Climate Change memo*, NSD 2020e and *SEPA Hydrology 2 Technical Memo*, NSD 2020c). Multiple events will increase the duration of reservoir inundation and result in multiple sequential partial drawdowns and refilling of the reservoir, compounding the submergence impacts on reservoir vegetation and slope stability. These repeated drawdowns would cause vegetation mortality, slope instability and sediment mobilization into the foreseeable future initiating a cascade of landscape-scale impacts to the reservoir hillslopes, as well as both riparian and aquatic ecosystems in the reservoir and downstream of the FRE facility.

Furthermore, the NEPA DEIS analyses fail to account for the ways in which impacts from the operation of the FRE facility, such as reduced groundwater recharge and storage downstream of the FRE, will reduce summer streamflow and increase summer stream temperatures beyond what is projected to occur from the warming climate. These aspects will be further amplified by the loss of vegetation from the slopes of the reservoir and riparian zone of the river with the approach proposed in the VMP, as described in detail below.

Flawed Approach to Characterizing Impacts and Impact Reduction

These flawed analyses underlie the suppositions presented about how the landforms and vegetation communities will be affected by the frequency and duration of both FRE operation and reservoir inundation and of the rate and duration of reservoir drawdown.

Specifically, the VMP purports to reduce water quality impacts of FRE operation and reservoir formation (particularly elevated temperatures inconsistent with viable salmonid spawning and rearing habitats) by strategic harvest of all trees other than willows and black cottonwood within the 122 acres of the Debris Management Evacuation Area and by pre-operational in-planting in the 281 combined acres of the Debris Management Evacuation Area and the Final Reservoir Evacuation Area in the years prior to the first FRE operation and reservoir formation. The premise articulated in the VMP for this approach is:

1. The ‘inundation tolerant’ tree and shrub species observed within the reservoir zone of the Mud Mountain Dam are indicative of the species and conditions which will be experienced at the proposed FRE facility. Those tree and shrub species can be planted within both the currently periodically flooded riparian zone of the river and the surrounding coniferous forest slopes currently managed by Weyerhaeuser for commercial timber harvest.
2. The planted tree and shrub species will successfully establish in advance of the inundation and submergence of the first FRE operation event.
3. The pre-operational in-planting will create conditions in which the planted species will grow in stature in advance of the first FRE operation event, such that they will be poised to provide shade to the river channel and thus reduce water quality and habitat impacts once non-tolerant vegetation have succumbed to reservoir inundation and submergence.

The premise of the VMP is that this approach of harvest and pre-operational in-planting with ‘inundation tolerant’ species will effectively reduce the significant water quality and habitat impacts acknowledged in the NEPA and SEPA DEISs from the destruction of the complex wetland and riparian vegetation communities and the upland forests on the slopes surrounding the river. Thus, reducing, in theory, the significant impacts to the suite of salmonids, lamprey, amphibians, and other species within the river which the DEISs acknowledge would occur due to the loss of forested shade, loss of aquatic foodweb support, and consequent impacts to water temperature, dissolved oxygen, sediment, and habitat quality.

However, as detailed below, since the proposed approach of harvest and pre-operational in-planting with 'inundation tolerant' species is fundamentally flawed, the assumptions that underlie the additional water quality modeling so too are fundamentally flawed. Further, the VMP fails to account for the increases in the frequency and magnitude of landslides and hillslope erosion within the reservoir. The VMP therefore fails to consider the condition of the soils and degree of soil stability into which the VMP purports to establish 'inundation tolerant' vegetation. the consequent likelihood of repeated cycles of mortality and regrowth throughout the reservoir are not considered. Therefore, the VMP assertion of reduced impacts to water temperature and aquatic habitat and species from the assumed conversion to taller 'flood tolerant' vegetation communities capable of providing functional shade to the channel is also unsupported.

Water quality modeling is presented to demonstrate that the impacts to water temperature are less severe than those previously presented in the NEPA and SEPA DEISs; however, the water quality modeling is entirely based on two flawed assumptions: (1) the VMP will be successful in growing and maintaining mature vegetation within all zones of the reservoir, and (2) there will be zero periods of mortality or re-growth during which vegetation is not maintained at its assumed mature height. As described in detail below, both assumptions are fundamentally flawed, and therefore the assertion of reduced water temperature impacts is unsupported.

Flawed Approach to Converting Existing Vegetation Communities

The fatal flaws in the inundation frequency and duration analysis are compounded by a fundamentally flawed understanding of the physical landscape and existing vegetation communities present in the proposed reservoir area. The VMP presents the following 10 land cover classifications mapped in the FRE facility reservoir area (Figure 1):

1. Wetlands
2. Open Water/Sand Bar
3. Terrestrial Bare Ground/Roads
4. Herbaceous/grass
5. Deciduous Riparian Shrubland
6. Deciduous Riparian Forest with Some Conifers
7. Mixed Coniferous/Deciduous Transitional Forest
8. Coniferous Forest
9. Logged–replanted 0-5 years
10. Logged–replanted 5-15+ years

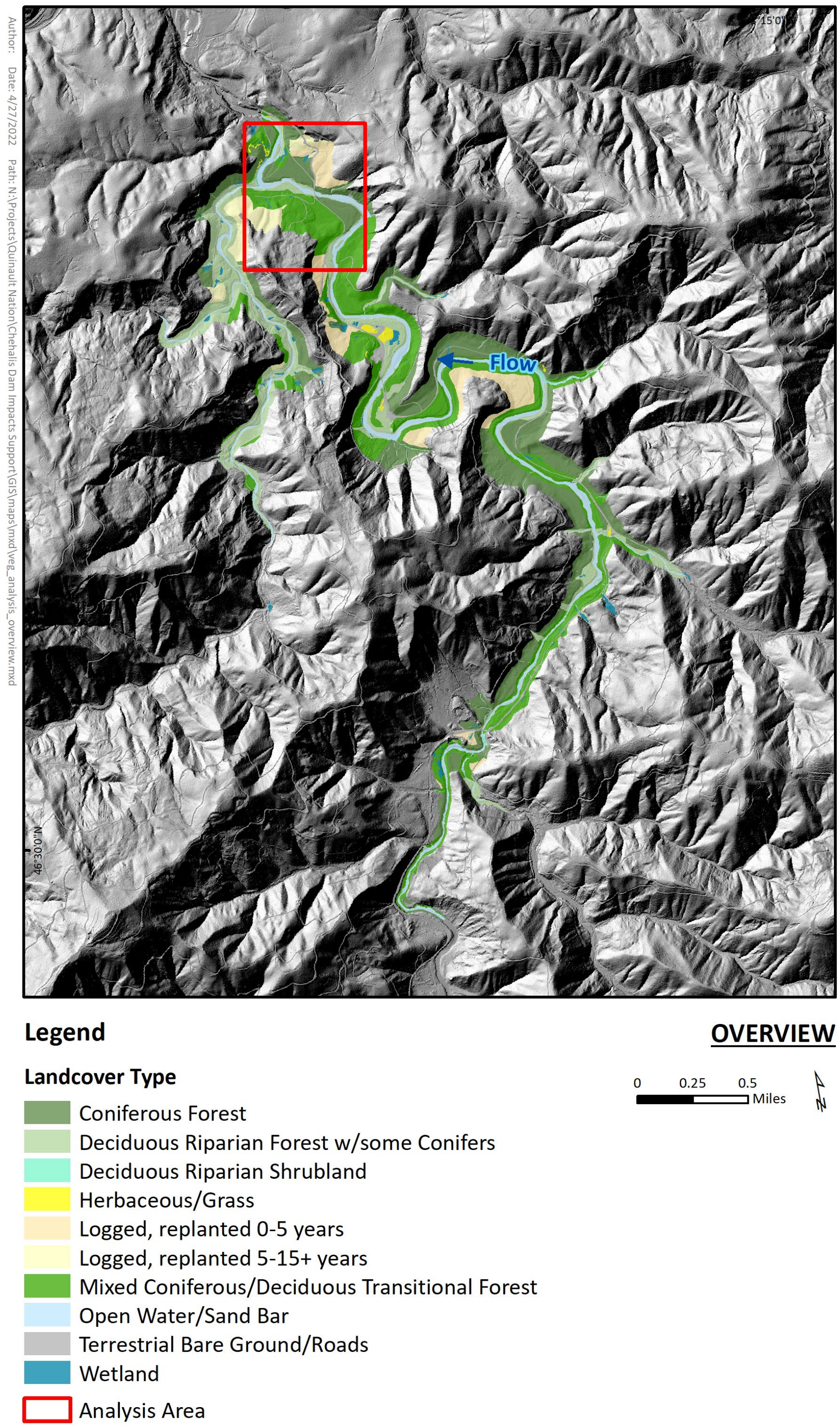


Figure 1. Landcovers mapped within the reservoir area as presented in the VMP. Example area analyzed herein outlined in red box. Note the predominantly south-north orientation of the reservoir. This orientation maximizes solar radiation and water temperatures in the river, minimizing the influence of riparian shade. This differs substantially from the east-west orientation of Mud Mountain Dam reservoir.

The VMP describes the forested plant communities as:

- Mixed Coniferous Transitional Forest – dominated by Douglas fir (*Pseudotsuga menziesii*), red alder (*Alnus rubra*) and big leaf maple (*Acer macrophyllum*) trees.
- Deciduous Riparian Forest with some Conifers – dominated by red alder, western red cedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), black cottonwood (*Populus balsamifera*), cascara (*Frangula purshiana*), willows (*Salix* spp.), and big leaf maple trees, with red elderberry (*Sambucus racemosa*) and snowberry (*Symphoricarpos albus*).
- Coniferous Forest – dominated by Douglas fir trees (currently managed for timber harvest by Weyerhaeuser).
- Logged, replanted 0-5 years – sun tolerant grasses and forbs, Douglas-fir seedings
- Logged, replanted 5-15 years – Douglas fir saplings

A portion of the proposed reservoir just upstream of the FRE facility was selected to illustrate the VMP actions. Figures 2 through 4 illustrate the existing landcover and soil drainage classes mapped in this example area. The example cross section extends from river left (A) to river right (A') in Figures 2 through 5.

Both the *Mixed Coniferous Transitional Forest* and *Deciduous Riparian Forest with some Conifers* plant communities have well developed overstory and understory vegetation. *Coniferous Forest* dominated by Douglas fir would have a well-developed tree stratum and dense canopy with poorly developed understory vegetation (Figure 2). This community is adapted to generally dry upland soil conditions on the well-drained hillslopes surrounding the river channel and riparian zone. The *Logged and Replanted* communities have variable degrees of vegetative cover depending on the length of time since replanting, but generally poorly developed overstory and understory vegetation on dry well drained soils (Figure 3).

The VMP proposes to convert the Debris Management Evacuation Treatment Area and the Final Evacuation Treatment Area (Figure 4) from Coniferous Forest, Transitional Forest, and Logged/replanted slopes to a 'revegetated community of flood tolerant' shrubs and trees in the first few years of the construction schedule (I.e., in advance of the first activation of the proposed FRE facility and formation of the reservoir) (Figures 4 and 5). The Riparian Area Treatment would be applied within 200 feet of the Chehalis River and Type S streams (I.e., Crim Creek) and within 75 to 150 feet of smaller tributaries depending on their mapped WDNR stream type. The VMP also proposes to install 'flood tolerant' species in the Final Evacuation Treatment Area on the hillslopes with well-drained upland soils (I.e., Bunker loam, Katula cobbly loam, Lytell silt loam and Winston loam) (Figure 3, NRCS Soil Mapper 2020).

Planting flood tolerant species on slide-prone hillslopes with well drained soils and existing forest and shrub cover is fatally flawed (Figure 5). The VMP fails to consider the dry, well drained soils of these areas, as well as the density of existing plants and shade of the existing conifer dominated forest vegetation. Further, the proposed spacing/density (VMP Section 6. 4, page 6-4) is an aggressive planting design given plants are, in theory, to be inter-planted within existing forested and shrub vegetation. For example, the proposed spacing for the Riparian Treatment Area is for all shrubs to be planted 3-5 feet on-center and Pacific willow trees 6-10 feet on-center (VMP Section 6. 4, page 6-4). It is difficult to see just how this density of planting design will be accomplished within existing forested and shrub communities as described in the VMP. There will simply not be enough room to plant at these densities let alone having these wet soil-adapted species survive both sustained inundation, submergence and the predominantly dry upland conditions that occur between reservoir filling events.

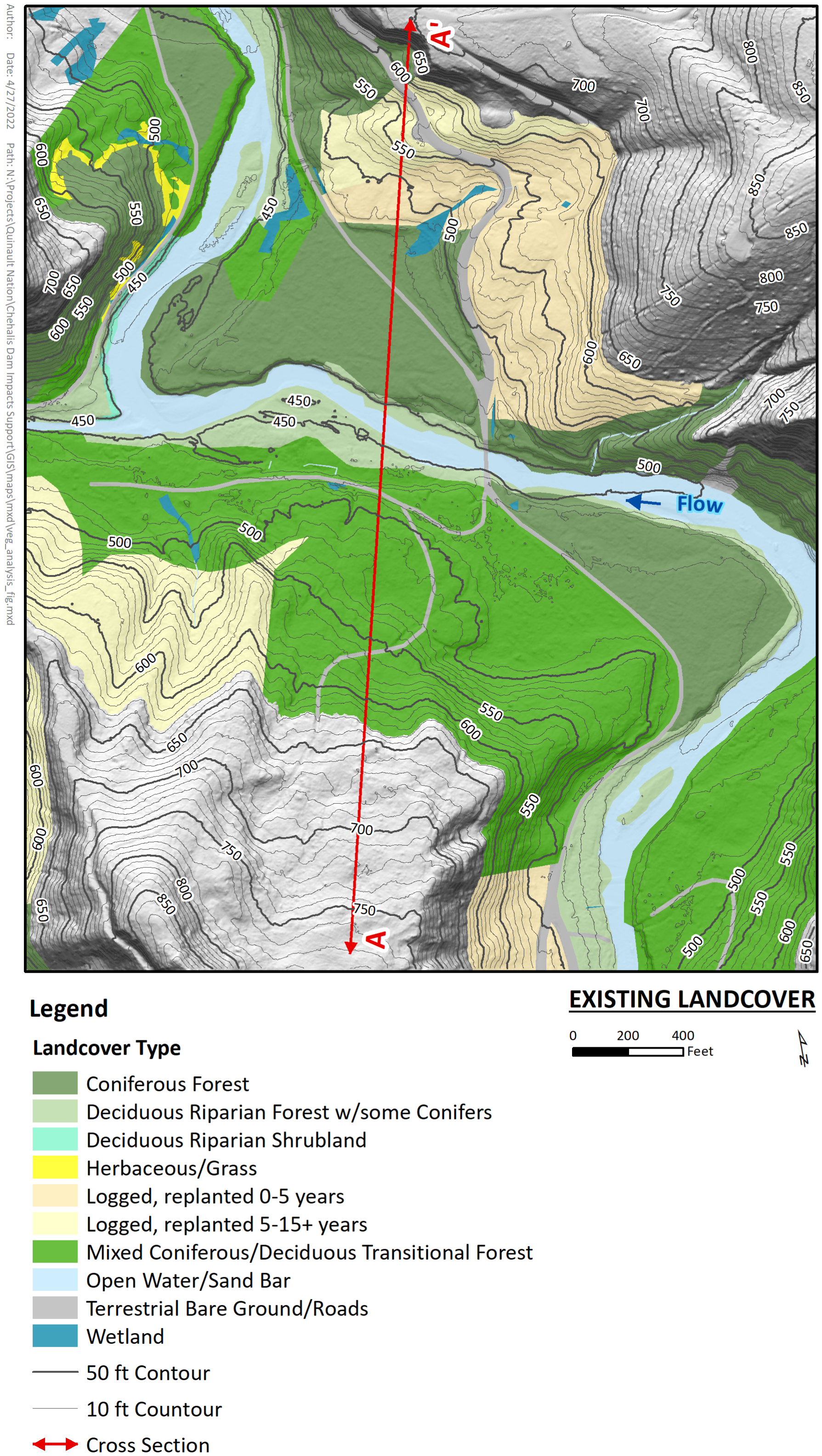


Figure 2. Landcovers mapped along cross section within an example portion of reservoir area upstream of proposed FRE facility.

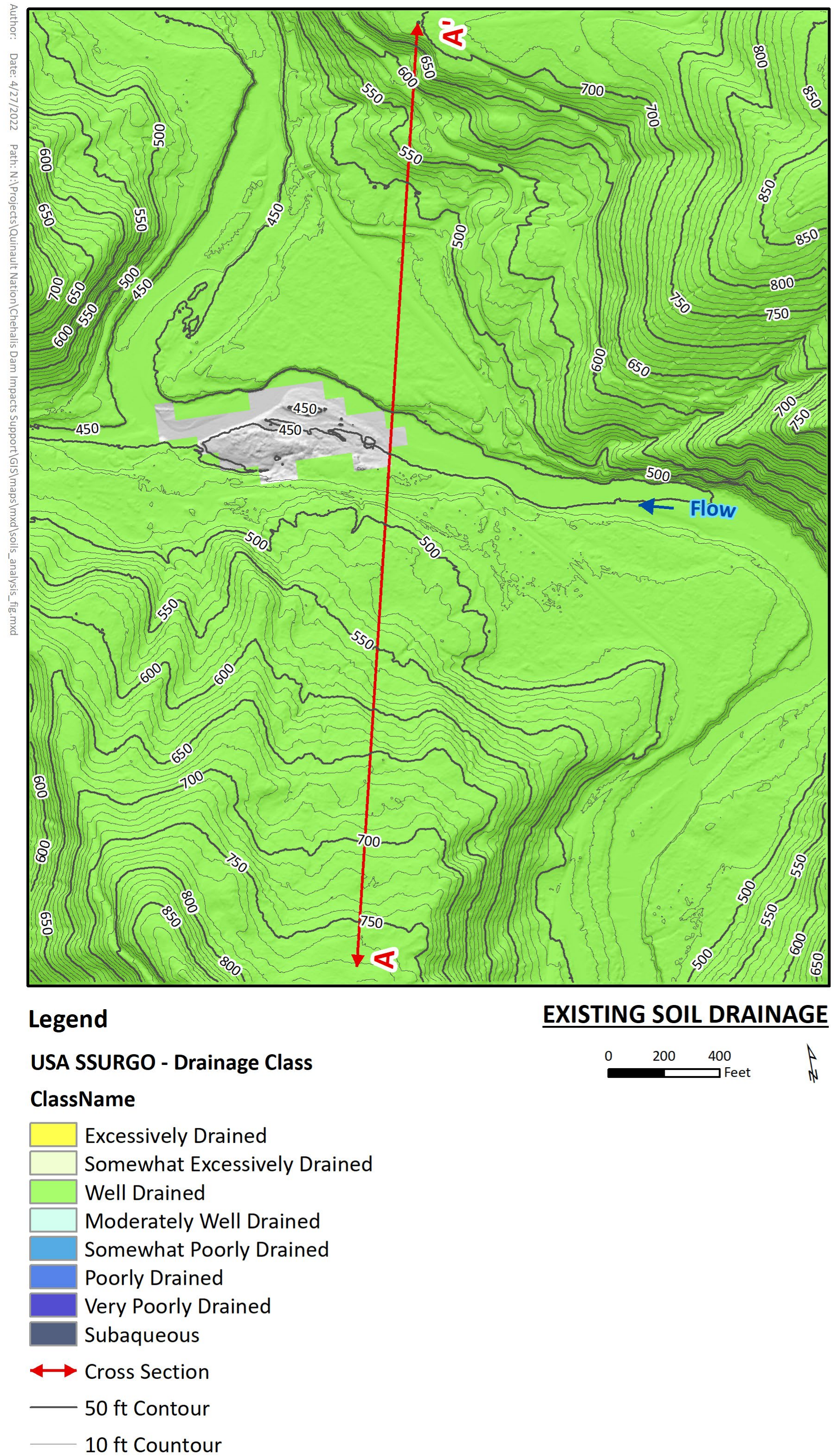


Figure 3. NRCS soil drainage mapping shows the entire area as well-drained soils.

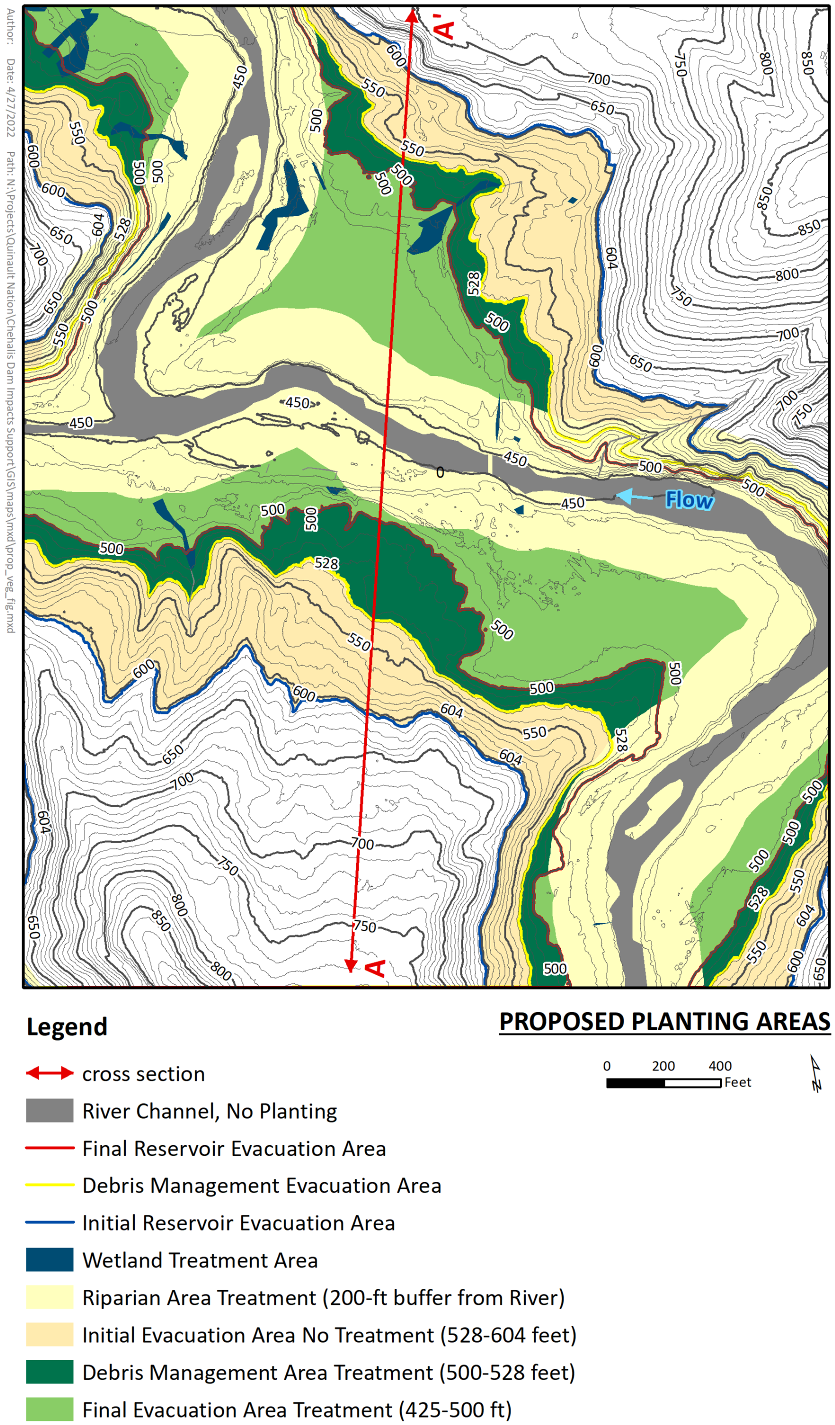


Figure 4. Proposed planting areas along cross section within an example portion of reservoir area upstream of proposed FRE facility.

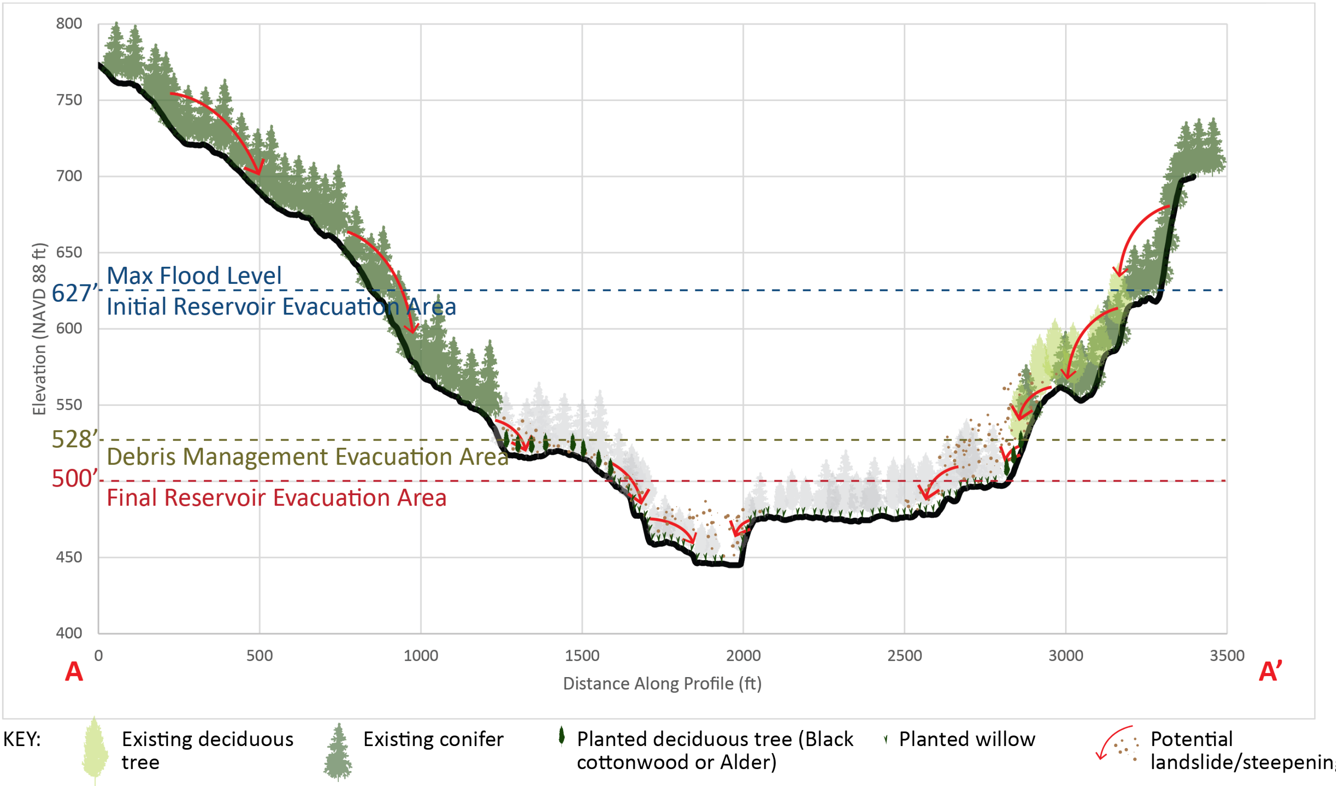


Figure 5. Proposed planting areas looking downstream along example cross section illustrating existing vegetation and proposed planting zones.

As detailed further below, **the approach of 'advance planting' vegetation adapted to periodically saturated soil conditions into dry coniferous forest and logged/replanted slopes with poor water holding capacity is completely unrealistic and fails to consider the requirements for sunlight, soil moisture, and space required for the proposed species to establish and thrive**. It is difficult to imagine how this vegetation conversion could succeed given the competition for space, light, moisture, and soil resources from the existing upland conditions and understory plant cover. Planting in advance of the first inundation from operating the FRE facility attempts to place species adapted to wetter and typically sunnier conditions into an environment of dry soils and shade and then unrealistically anticipates these plantings will not only survive but grow rapidly to a stature where they are poised to provide shade to the river channel once the first reservoir inundation event occurs.

Flawed Application of 'Hydrologic Tolerance' of Native Trees and Shrubs

Woody plant species have a range of natural tolerance to varying frequency, depth, and duration of periodic flood inundation and submergence (e.g., Kozlowski 1984, Whitlow and Harris 1979). As was true with the *Conceptual Vegetation Management Plan* (FCZD 2020) and the Anchor QEA 2016 *Technical Memorandum on Proposed Flood Retention Facility Pre-Construction Vegetation Management Plan*, the experimental and empirical studies cited in the VMP Table 5 (pages 4-10 through 4-13) present known flood tolerance estimates, many of which are subjective, or apply to tree seedlings only. The application of this literature on flood tolerance to tens to hundreds of feet of prolonged submergence is incorrect. The applicability of using established plant communities at Mud Mountain Dam to the conditions anticipated in the FRE facility reservoir is flawed, as detailed below.

The cited studies do not generally address the consequences of complete submergence of mature trees and shrubs for the extended duration anticipated in the FRE reservoir during flood events. The FRE facility reservoir inundation characteristics (e.g., repeated submergence depths of tens to hundreds of feet) is inconsistent with the tolerance levels and survival of the diversity of tree and shrub species prescribed by the VMP. The need to extrapolate predicted vegetation response from flood tolerance studies to the more extreme conditions of full submergence is acknowledged in the VMP:

> "*Although scientific literature generally reviews overall flood tolerance rather than full submergence (as will likely be experienced by vegetation in the Final Reservoir Evacuation Area during a major flood event), general flood tolerance and known survivability factors were used to extrapolate anticipated vegetation responses to inundation in the temporary reservoir footprint*." (Section 4.3.1, page 4-7)

The proposed suite of wetter adapted "flood tolerant" species proposed for advance planting is based on literature regarding tolerance to flooding in largely experimental conditions and observations of plant communities associated with the reservoir of the Corps-operated Mud Mountain Dam on the upper White River in the Puget Sound Ecoregion. Table 1 summarizes the VMP proposed planting plan by Treatment Area, elevation, and estimated inundation duration as presented in Section 4.2.2 of the VMP. We have added the Wetland Indicator Status for each species as established by the Corps for the National Wetland Plant List (NWPL) in the Mountains, Valleys, and Coast geographic region. The Wetland Indicator Status indicates species likelihood of occurring in wetlands, based on its perceived adaptation to soils with prolonged periods of saturation (I.e., hydric soils).

Table 1. VMP planting schedule with National Wetland Indicator Plant Status.

REPLANTING/TREATMENT AREA	SCIENTIFIC NAME	COMMON NAME	WETLAND INDICATOR STATUS[3]
Initial Reservoir Evacuation Area[1] (238 to 527 acres depending on flood event)	Limited interplanting following monitoring for mortality and stress is proposed. No specific species are proposed.		
Water Surface Elevation >528 feet			
Inundation duration 5.9 to 11.1 days			
Debris Management Area Treatment[1] (122 acres)	**Trees**		
Water Surface Elevation 528 feet to 500 feet	*Fraxinus latifolia*	Oregon ash	FACW
Inundation duration 20.2 to 25.2 days	*Populus balsamifera*	Black cottonwood	FAC
	Salix lasiandra	Pacific willow	FACW
	Shrubs		
	Cornus alba	Red-osier dogwood	FACW
	Lonicera involucrata	Twinberry	FAC
	Spiraea douglasii	Hardhack	FACW
	Rosa nutkana	Nootka rose	FAC
	Rubus spectabilis	Salmonberry	FAC
Riparian Treatment[2] (150 acres)	**Trees**		
Water Surface Elevation 528 feet to 500 feet in Debris Management Evacuation Area and 500 feet to 425 feet in Final Reservoir Evacuation Area	*Salix lasiandra*	Pacific willow	FACW

REPLANTING/TREATMENT AREA	SCIENTIFIC NAME	COMMON NAME	WETLAND INDICATOR STATUS[3]
Inundation duration 20.2 to 32.3 days depending on area	**Shrubs**		
	Cornus alba	Red-osier dogwood	FACW
	Salix exigua	Narrow-leaf willow	OBL
	Salix hookeriana	Hooker's willow	FACW
	Salix sitchensis	Sitka willow	FACW
	Spiraea douglasii	Hardhack	FACW
Wetland Mix[2] (4 acres)	**Trees**		
Water Surface Elevation 528 feet to 500 feet in Debris Management Evacuation Area and 500 feet to 425 feet in Final Reservoir Evacuation Area	*Alnus rubra*	Red alder	FAC
Inundation duration 20.2 to 32.3 days depending on area	*Salix lasiandra*	Pacific willow	FACW
	Shrubs		
	Cornus alba	Red-osier dogwood	FACW
	Rubus spectabilis	Salmonberry	FAC
	Salix sitchensis	Sitka willow	FACW
	Salix scouleriana	Scouler's willow	FAC
	Salix hookeriana	Hooker's willow	FACW
Final Evacuation Area Treatment[1] (159 acres)	**Trees**		
Water Surface Elevation 500 feet to 425 feet	*Salix lasiandra*	Pacific willow	FACW
Inundation duration 26.9 to 32.3 days	**Shrubs**		
	Cornus alba	Red-osier dogwood	FACW
	Salix exigua	Narrow-leaf willow	OBL
	Salix hookeriana	Hooker's willow	FACW
	Salix sitchensis	Sitka willow	FACW
	Spiraea douglasii	Hardhack	FACW

1 Acres, elevations, and water surface elevation ranges as per Section 4.2.2, Tables 1 and 3

2 Acres, elevations, and water surface elevation ranges as per Section 4.2.2 Table 3 and Section 6. Tables 7 and 8.

3 The U.S. Army Corps of Engineers (Corps), as part of an interagency effort with the U.S. Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service (FWS) and the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) developed the final 2020 National Wetland Plant List (NWPL). Wetland indicator status (WIS) ratings per Western Mountains Valleys and Coast regional list available at: https://cwbi-app.sec.usace.army.mil/nwpl_static/data/DOC/lists_2020/Regions/pdf/reg_WMVC_2020v1.pdf

Wetland indicator status defines plant species based on their ability to withstand saturated soil conditions. Plants are rated, from highest to lowest probability of occurrence in wetlands (Table 2), as obligate (OBL), facultative wetland (FACW), facultative (FAC), facultative upland (FACU), and upland (UPL), respectively (https://www.federalregister.gov/documents/2020/05/18/2020-10630/national-wetland-plant-list; Lichvar et al. 2012).

Table 2. Plant Species Indicator Category Definitions.

CATEGORY	DEFINITION
Obligate (OBL)	Plants that almost always occur in wetlands (estimated probability > 99%) under natural conditions.
Facultative Wetland (FACW)	Plants that usually occur in wetlands (estimated probability 67 to 99%) but are occasionally found in non-wetland areas.
Facultative (FAC)	Plants that are equally likely to occur in wetlands or non-wetlands (estimated probability 33 to 67%).
Facultative Upland (FACU)	Plants that usually occur in non-wetlands (estimated probability 67 to 99%).
Upland (UPL)	Plants that almost always occur in non-wetlands (estimated probability > 99%) under natural conditions.

Source: Lichvar et al. 2012

The Wetland Indicator Status provides an indication of the extent to which the species proposed for replanting are adapted to conditions of prolonged seasonal (FAC and FACW status), if not permanent (OBL status), soil saturation within the upper portion of the soil profile. Such conditions are characterized as creating 'hydric' soil conditions, in contrast to well-drained soil conditions as are mapped throughout the proposed reservoir area. The following definitions describe the general conditions of well-drained soil compared to hydric soil.

> Well drained soil. "*Water is removed from the soil readily but not rapidly. Internal free water occurrence commonly is deep or very deep; annual duration is not specified. Water is available to plants throughout most of the growing season in humid regions. Wetness does not inhibit growth of roots for significant periods during most growing seasons. The soils are mainly free of the deep to redoximorphic features that are related to wetness*." (USDA NRCS Soil Science Division 2017)
>
> Hydric soil "*is a soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part*." (USDA NRCS, 2022a)

The VMP divides the reservoir into areas of various inundation duration based on elevation and proposes to establish plant communities tolerant of the (incorrectly) anticipated 7-year recurrence interval "flooding" of the reservoir during operation of the proposed FRE facility (Table 1, Figures 4 and 5). The FRE facility will retain precipitation and runoff from seasonal storms which occur primarily during the dormant (non-growing) season for vegetation in the Centralia/Chehalis region of Lewis County (I.e., between November 23 and March 6 based on 28-degree Fahrenheit or higher growing season in Lewis County) (USDA NRCS, 2022b).

Compared to the Conceptual VMP (FCZD 2020), the VMP presents a plan in which less of the reservoir area is cleared prior to the first operation of the FRE facility. The VMP puts forth a plan to "*minimize the extent of tree clearing and vegetation removal in the Flood Retention Expandable (FRE) facility and temporary reservoir footprint to the extent practical, while balancing the need to reduce the amount of woody material that would be generated within the area during a flood event that triggers FRE operation*." (VMP preface, page i) As such, the VMP aims to avoid, minimize, and mitigate potential effects of the "*proposed project on aquatic habitat and* *species as they relate to the potential loss of vegetation in the temporary inundation area of the FRE facility site*." (VMP Section 1.1, page 1-1)

The VMP prescribes pre-operational in-planting in the Debris Management Evacuation Area with 20% of non-flood tolerant trees removed each year during the 5-year construction period (VMP Section 5.2.5, page 5-2) and in the Final Reservoir Evacuation Area where the existing vegetation community is intolerant of 'flood inundation' and thus will experience mortality at the time of the first activation of the FRE facility and filling of the reservoir. The VMP proposes limited interplanting of flood tolerant trees within the upper elevation Initial Reservoir Evacuation Area following the vegetation monitoring aimed at identifying trees for signs of stress after reservoir inundation events (Section 5.3.1, page 5-3). 'Pre-operational in-planting' using three tree species (I.e., black cottonwood, Oregon ash, and Pacific willow) is designed to reestablish forested vegetative cover along the river channel and the adjacent hillslopes with the more 'flood tolerant' plant species (Table 1) in advance of the activation of the FRE facility and the first reservoir inundation event.

> *"Initial planting of the riparian zone and other portions of the temporary reservoir will commence as soon as the District has control of the land and permits are secured for construction of the facility.* ***This is expected to occur in Year 1 of the construction timeline.*** *Different vegetation management strategies will be initiated within each of the identified inundation areas, as duration, extent, and frequency of flooding will be the primary drivers for survival of vegetation in replanted areas.... In-planting within the riparian areas is recommended to help limit erosion along the streamside and to accelerate riparian tree height development."* (VMP Section 6.4, pages 6-2 and 6-3, **emphasis added**)

The shrubs and three species of trees proposed for the Debris Management Evacuation Area and Final Reservoir Evacuation Area (VMP Table 7; page 6-4) are all Facultative, Facultative Wet or Obligate hydrophytic species (2020 National Wetland Plant List). They typically grow in and adjacent to wetlands—areas with soils that are inundated or saturated at a frequency and duration sufficient to support hydrophytic vegetation. The VMP supposes these areas will effectively become areas with hydrology that supports the specified wetland vegetation presumably based on the soil saturation provided during each zone's reservoir inundation duration (Table 1). There is no source of hydrology outside precipitation on the hillslopes in these zones (see Figure 1) and even with the estimated frequency and duration of the reservoir inundation, these areas will not support species adapted to wetter soils during the years-long intervals between inundation events.

Given that the Debris Management Evacuation Area Treatment, Final Evacuation Area Treatment, and much of the Riparian Area Treatment planting areas are located on slopes with well-drained, non-hydric, soils, the VMP fails to credibly establish how the proposed facultative, facultative-wet, and obligate species will be able to establish in advance of the first inundation event and subsequently survive and grow in stature to their 50-year growth height (Section 6.6, page 6-10 and VMP Figure 7) without regular and prolonged soil saturation between reservoir inundation events. The VMP fails to consider that soil conditions will be too dry and too well-drained to support these wetland/hydric soil-adapted species. Tree establishment will be further inhibited along the riverbanks which will be subject to repeated deposition and erosion that will limit any vegetation on the river's banks. This is even the case in Mud Mountain Dam reservoir (see Figures 7, 8, and 11-15 as described below).

Figures 6 through 8 illustrate the characteristic zone of repeatedly impacted vegetation that forms around reservoirs where water levels fluctuate as the reservoir submerges entire vegetation communities and then is drawn down. Note this zone around Mud Mountain Dam (Figures 7 and 8), a facility considered in the VMP to be analogous to the conditions which would occur at proposed FRE facility.

Figure 6. Keechelus Dam Reservoir, illustrating 'ring' of sparse vegetation in the zone of water level fluctuation. Source: U.S. Bureau of Reclamation: https://www.usbr.gov/projects/index.php?id=294

Figure 7. Looking upstream from Mud Mountain Dam spillway toward reservoir, undated photo. Note the sparsely vegetated slopes of the inundation zone upstream of the dam. https://www.westconsultants.com/services/hydrologic-data/mud-mountain-dam-sedimentation-survey-wa/

Figure 8. View of White River reservoir zone upstream of Mud Mountain Dam facility. Note limited height of vegetation within zone of inundation and lack of shade along the river. Undated photo from Vista Point on Mud Mountain Dam Vista Trail. https://www.wta.org/go-hiking/hikes/mud-mountain-dam-vista-trail.

As is well documented at both Mud Mountain Dam and Howard Hanson Dam (U.S. Army Corps of Engineers ERDC Environmental Laboratory 2019) repeated cycle of disturbance creates conditions in which mature woody vegetation struggles to establish and persist, creating a zone of low-stature, ruderal vegetation characterized by typically early successional, often annual species adapted to high disturbance regimes. **The VMP fails to address the continuous cycle of repeated loss of native trees, shrubs, and perennial understory vegetation within most zones of the proposed reservoir.**

In addition, the loss of robust woody vegetation and the potential colonization of weedy and/or invasive plants will initiate a positive feedback loop in which many of the root cohesion and slope stability impacts discussed below are amplified. Hillslope erosion and loss of topsoil would be exacerbated, and the likelihood of establishing a native forested or scrub-shrub plant community declines even further. The reduction in streamside shading would be amplified with little to no shade provided and consequent continued increases in water temperature and related impacts to aquatic species, not reduced as the VMP incorrectly anticipates (see section below regarding failures of the water quality model). Recruitment of large wood, or any woody material, further drops, which affects channel-forming processes and further impairs the establishment of mature riparian forests and forested wetlands. Early successional and invasive plants would also be expected to increase in dominance, counter to the VMP adaptive management goal 5 of limiting invasive weeds (VMP Section 7.2.5, page 7-3).

Further, given the high probability of extensive hillslope destabilization and landslides (as presented below), it is our opinion that successful revegetation in many areas will be impossible to attain. The result of the loss of deep-rooting woody vegetation will result in a loss of hillslope stability, especially in steeper areas of existing hillslope mass failures (e.g., the landslides mapped in the DEISs slated for Debris Management Zone harvest, example cross section Figure 9; see also Figure 20).

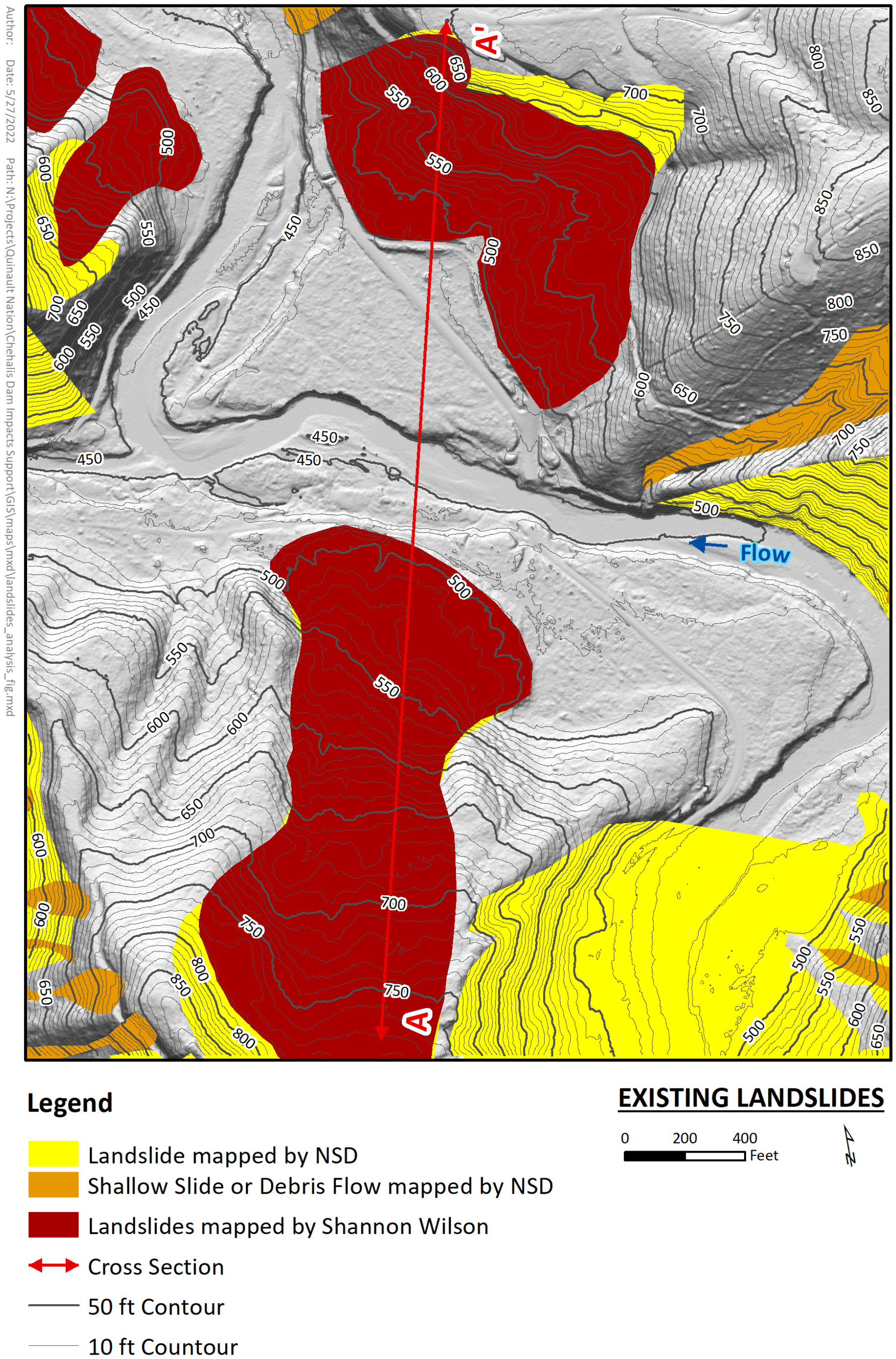


Figure 9. Landslides mapped by Shannon and Wilson (SW), per the DEISs, as well as by NSD and Saturna Watershed Sciences (2020a and 2020b) along example cross section of proposed reservoir just upstream of the proposed FRE facility location. The map only delineates landslides. All the steep slopes are susceptible to sliding and proposed reservoir operations will certainly trigger new landslides.

Together the loss of woody species root cohesion with more frequent flood inundation will likely result in large-scale mass wasting as seen at Mud Mountain reservoir. The VMP will create optimum conditions for landsliding by eliminating native conifer forests and implementing regular harvest of trees over 6 Inches in diameter every 7-10 years (VMP p.1-4). Given the inherent instability of the reservoir terrain post selective harvest and flood inundation, extensive and costly actions to stabilize slopes will be necessary due to pore water pressure during reservoir drawdowns, a lack of root cohesion, and landslide issues as described herein.

Flawed Application of Mud Mountain Dam as Analogous System

A key failing of the VMP is the supposition that any increase in frequency of reservoir formation will not affect the viability of the proposed approach because it is based on the Mud Mountain Dam which floods "more frequently than the proposed FRE". Specifically, the VMP states:

> "*The proposed Flood Retention Expandable (FRE) facility would temporarily store floodwater during major floods and then release retained floodwater following the flood peak. Specific flow release operations would depend on inflow and the need to hold water to relieve downstream flooding. Major floods include events with river flows forecasted to reach 38,800 cubic feet per second (cfs) or more as measured at the Chehalis River Grand Mound gage located in Thurston County. Hydrologists have estimated that, based on historical data, a flow event of this magnitude has a 15 percent probability of occurring in any 1 year. This translates to an approximate 7-year recurrence interval.* ***Under future climate change projections, flood events that trigger the operation of the FRE facility are predicted to occur more frequently. This potential increase in frequency of flood occurrence does not affect the conclusions of the vegetation management recommendations since the Vegetation Management Plan predicts tree mortality and plant species survival based on a modelled event and conservative estimates using the Mud Mountain Dam for reference (HDR 2021a).*** *That facility floods much more frequently than the proposed FRE. The replanting plan and the adaptive management plan are also intended to address the inherent unpredictability of future disturbances and provide resilience through robust monitoring and periodic adjustments to vegetation management over time.*" (VMP Section 1.4, pages 1-3 and 1-4; **emphasis added**)

The use of Mud Mountain Dam (MMD) as evidence for the (1) viability of the VMP and (2) average heights for vegetation in the three reservoir zones is not supported by a comparison of actual conditions at MMD to the proposed conditions with operation of the FRE. The proposed FRE facility differs from the MMD in the following key aspects.

MMD reservoir is located within a completely different geologic setting (I.e., quaternary glacial deposits, resistant lahar deposits and alluvium with few mapped faults) that is far less susceptible to landsliding than the Upper Chehalis site. In contrast, the proposed FRE facility and reservoir would be in an area of older (Tertiary 50-million-year-old) volcanic deposits interbedded with marine deposits, with numerous mapped faults. Tertiary crescent formations are weak rocks prone to deep weathering and mass wasting due to interbedded weak layers and faults. This creates conditions more susceptible to landsliding and episodic destruction of reservoir slope vegetation, both existing and planted.

MMD and the proposed FRE facility also differ in the frequency and duration of impoundment within their analogous final evacuation zone, debris management zone, and initial evacuation zone. This key difference suggests that MMD is not a reasonable analog on which to base the tree and shrub species proposed for interplanting or to validate the assumptions made in the VMP regarding mature height providing shade to the river channel. The Water Temperature Model Sensitivity Analysis asserts that MMD "floods to similar depths and for similar durations as the proposed FRE facility" (3.2.1, p 3.5), but this similarity is unsupported by data.

The frequency of FRE operation was modeled as 7 years with a maximum inundation duration of 35 days (although previous critical review suggests that the maximum frequency and duration are substantially underestimated in the DEIS analyses, see *SEPA Hydrology Technical Memo 2* (NSD 2020c)). In contrast, at MMD during September 2021 through April 2022, there were at least three independent flooding events during which the reservoir was filled with a maximum duration of 12 days at the lowest elevations of the reservoir (Figure 10). The elevation threshold for upper elevation bound of the final evacuation zone near the downstream end of MMD (Figure 11) is approximately 1,045 feet elevation (i.e., based on digital terrain model and shapefiles included with Attachment C of the Water Temperature Model Sensitivity Analysis).

Based on an elevation threshold of 970 feet, which is somewhat lower elevation than the upper bound and therefore within the Final Evacuation Zone and more representative of inundation duration within that zone, the observed duration of inundation events included: 10 days (November 12-22), 2 days (November 28-30), 6 days (January 6-12), 5 days (January 12-17), and 7 days (March 1-8) (Figure 10). These inundation durations are even shorter if the upper bound elevation of approximately 1,045 feet is considered relative to the observed data.

Thus, the vegetation communities at MMD that are presented as an analog for the potential vegetation community in the FRE Final Evacuation Zone are subject to more frequent and much shorter duration inundation. This example is based on visual inspection of one winter of data only. However, it suggests that **the lack of a quantitative assessment of the frequency and duration of hydrologic conditions in the MMD reservoir results in a serious omission and renders the use of MMD as an analog to support viability of the VMP invalid. The existence of vegetation at MMD that is adapted to frequent and shorter duration inundation is not evidence for the viability of the proposed vegetation during and after FRE operation.**

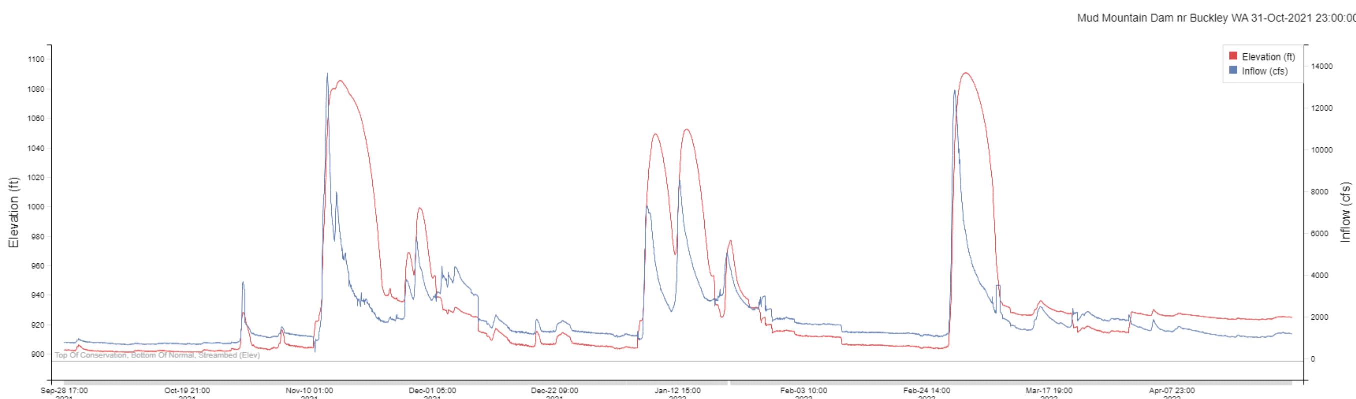


Figure 10. Mud Mountain Dam reservoir elevation (red) and inflow (blue) data during September 2021 through April 2022 (data and screen shot accessed from: https://water.usace.army.mil/a2w/f?p=100:1:0). The time series water elevation data (red line) was used to estimate the duration of inundation for each instance in which the reservoir was filled above 970 feet.

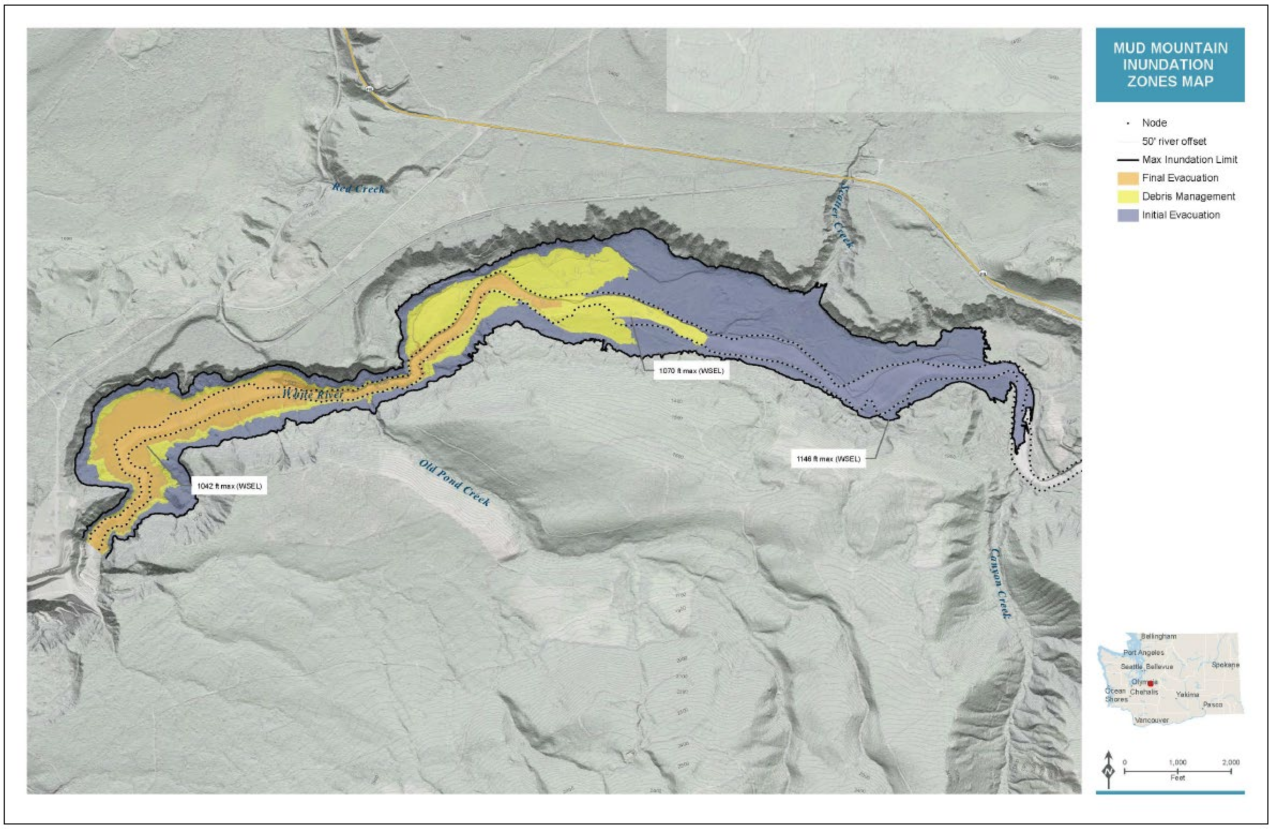


Figure 8. Mud Mountain Temporary Inundation Area with Three Inundation Zones

Figure 11. Zones at Mud Mountain Dam that are described as analogous to the inundation zones within the FRE footprint, presented as Figure 8 of the Water Temperature Model Sensitivity Analysis. The dotted line is the line of nodes that are 50 feet offset of the streambanks used to determine average riparian vegetation height. Terrain clearly shows that reservoir hillslopes lack the extensive landslides found around the proposed FRE reservoir.

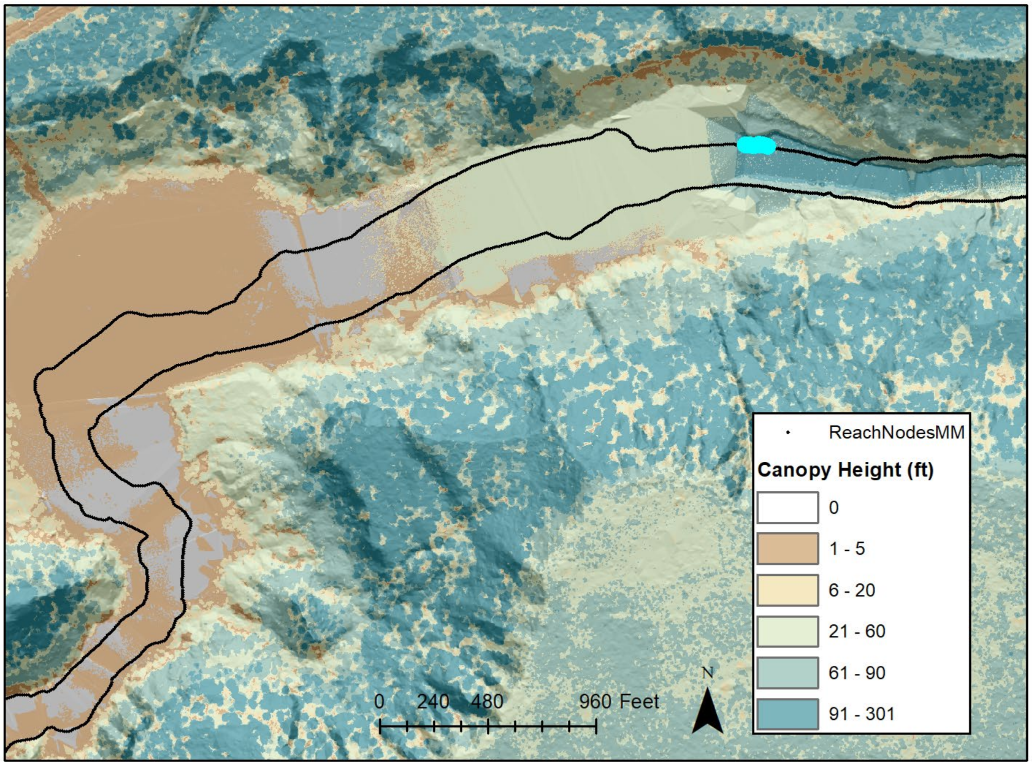
The presence and height of vegetation at MMD is further used to validate the heights of vegetations used in the Water Temperature Model Sensitivity Analysis, discussed below. An average riparian vegetation height of 28 feet is estimated for the MMD inundation zones by extracting and averaging lidar-derived vegetation heights at points along a line of nodes that are 50 feet offset from the stream edge along both banks (see dotted line in Figure 11, above). This average height is further used as validation of the use of a 20-foot vegetation height as the "low vegetation scenario" in the Water Temperature Model Sensitivity Analysis: "*The 20-foot height is also validated within the Mud Mountain vegetation height data, as the average riparian vegetation height at Mud Mountain is approximately 28 feet, even though some parts of the Mud Mountain facility have lower and higher vegetation*" (p 3-8).

However, the supporting analysis is erroneous. The lidar canopy height data that were used in the analysis and are included as Attachment C of the Water Temperature Model Sensitivity Analysis show that **the canopy height data from which the majority of the values were extracted has erroneously high vegetation values, with heights of 60-110 feet along and <u>through</u> the active channel (Figure 12).** Canopy heights of over 20 feet are present within over 3,500 feet of the active channel in this dataset. The presence of vegetation in the active channel, and within the zone that was clearly impounded when the 2011 lidar data were collected (as evidenced by the smooth water surface in the hillshade map) are indicative of problems with the underlying dataset. The

2003 lidar dataset shows a more reasonable representation of canopy heights without the obvious problems in the 2011 dataset (Figure 13). However, based on examination of the attribute table associated with the nodes in Attachment C (Figures 12 and 13), the vegetation values that were extracted at each node and then averaged are largely based on the erroneous 2011 data rather than the 2003 data when the reservoir was not impounded. Thus, the average vegetation height of 28 feet that is presented as validation of the vegetation height assumptions in the Water Temperature Model Sensitivity Analysis is **based on an average that includes large swaths of erroneously tall vegetation.**

In addition to errors in the canopy height analysis, there is further photographic evidence which indicates that vegetation immediately adjacent to the channel is much shorter than the average value of 28 feet that is used to "validate" the vegetation height used in the "low vegetation" scenario presented in the Water Temperature Model Sensitivity Analysis (Figures 12-15).

The Water Temperature Model Sensitivity Analysis acknowledges that MMD is not an "exact comparison" and that there are differences in "flooding regime, soil type and geomorphology … and other local factors that affect plant growth" (Section 3.2.1, p 3-9). However, the Water Temperature Model Sensitivity Analysis also claims that the analog "*validates many of the assumptions made" (Section 5.2, p 5-2) and "confirms that higher vegetation heights than previously assumed… are highly likely to result from implementation of the VMP*" (Section 5.4, p 5-3). **It is unreasonable to use MMD as analog to justify modeling riparian shade using unrealistically high vegetation heights assumed from implementing a deeply flawed VMP.**



Table

ReachNodesMM

OBJECTID *	SHAPE *	Bank	Pool_Area	NodeNumber	Canopy_DHM	DSM	DTM	DSM_2003	DTM_2003	DHM_2003	DHM
629	Point	Right Bank	Initial Evacuation	629	71	1050	979	<Null>	<Null>	<Null>	71
630	Point	Right Bank	Initial Evacuation	630	84	1063	979	<Null>	<Null>	<Null>	84
631	Point	Right Bank	Initial Evacuation	631	103	1082	979	<Null>	<Null>	<Null>	103
632	Point	Right Bank	Initial Evacuation	632	103	1082	979	<Null>	<Null>	<Null>	103
633	Point	Right Bank	Initial Evacuation	633	103	1082	979	<Null>	<Null>	<Null>	103
634	Point	Right Bank	Initial Evacuation	634	98	1077	979	<Null>	<Null>	<Null>	98
635	Point	Right Bank	Initial Evacuation	635	104	1082	978	<Null>	<Null>	<Null>	104
636	Point	Right Bank	Initial Evacuation	636	99	1077	978	<Null>	<Null>	<Null>	99
637	Point	Right Bank	Initial Evacuation	637	104	1082	978	<Null>	<Null>	<Null>	104

Figure 12. Canopy height values and node locations for MMD that were included in Attachment C of the Water Temperature Model Sensitivity Analysis. Nodes highlighted in blue are shown in a clip of the attribute table, which shows the canopy height values (i.e., the final column entitled DHM, or digital height model) that were extracted from the dataset range from 71 to 104 feet. Also note erroneous canopy height of 21 or more feet throughout the active channel corridor upstream and downstream of the highlighted nodes.

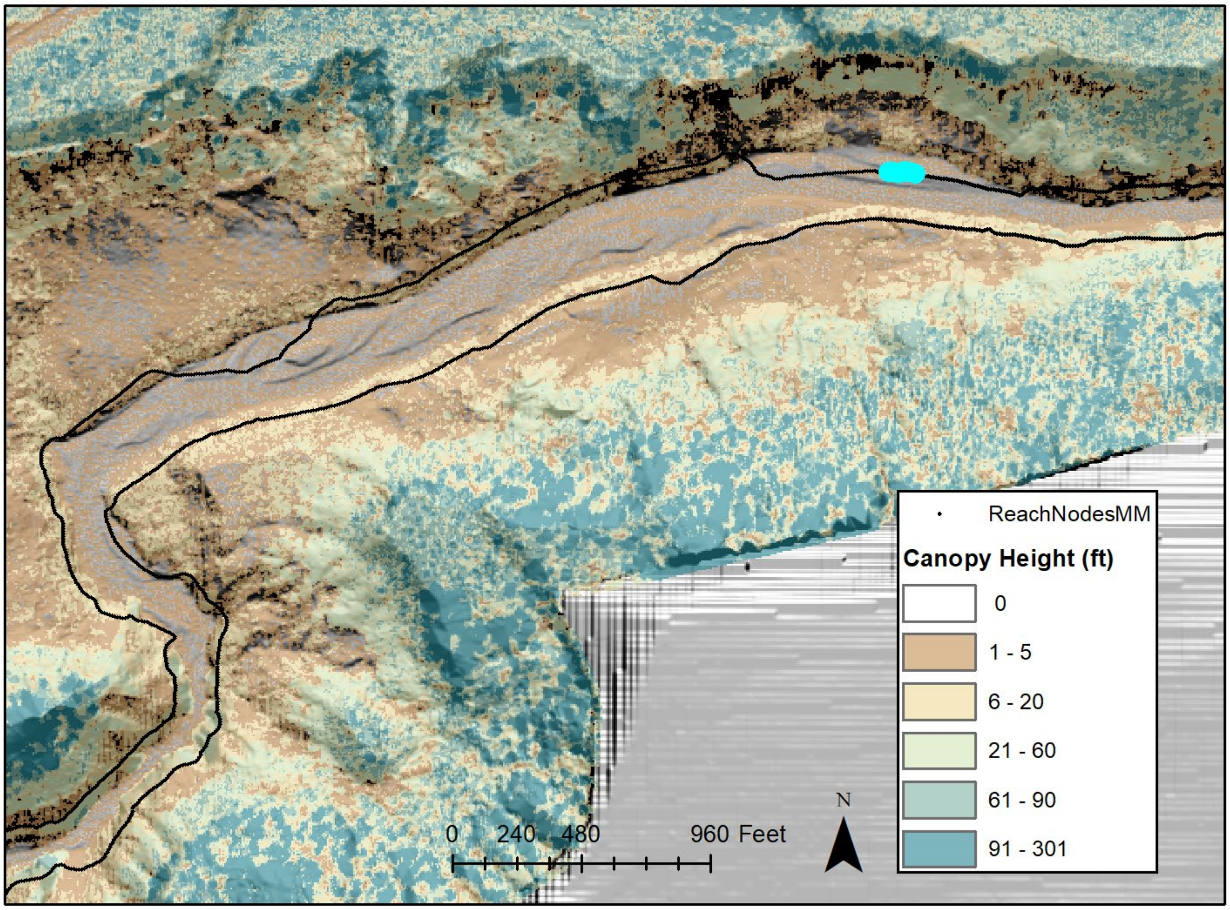


Figure 13. Canopy height values calculated from 2003 King County lidar downloaded from the Washington Lidar Portal, shown with node locations for MMD that were included in Attachment C. Nodes highlighted in blue are the same as in the figure above, but canopy height values are actually 0-5 feet. Note that there is no tall vegetation in the active channel corridor, in contrast to data used in the Water Temperature Sensitivity Analysis (Figure 12).

Figure 14. Photo of White River at Mud Mountain Dam during the growing season showing vegetation immediately adjacent to the stream. Note extensive fine sediment input to river, sparse riparian vegetation, bare river banks and lack of any shade along the river channel. Photo by Scott Anderson, Washington Water Center: https://www.usgs.gov/media/images/white-river-mud-mountain-dam

Figure 15. View of White River reservoir zone upstream of Mud Mountain Dam facility. Note short tree heights and lack of riparian shade. Undated photo from approximately Vista Point. https://visitrainier.com/wp-content/uploads/2014/07/white_river1.jpg

Failure to Consider Vegetation Root Cohesion and Hillslope Stability

Vegetation mortality and rapid changes in soil hydrostatic pressure from reservoir inundation and rapid drawdown contribute to a loss of root cohesion, increase in erosion, and hillslope instability in the steep forested terrain of the proposed reservoir (Natural Systems Design and Saturna Watershed Sciences, 2020a and 2020b). As previously detailed, the 'advance planting' approach proposed in the VMP is deeply flawed and based on multiple unsubstantiated assumptions. **Most species of deep-rooting, woody vegetation cannot survive the stochastically fluctuating extremes of prolonged submersion punctuating extensive periods of dry conditions typical of the low water holding capacity soils which characterize the steep upland slopes of the proposed reservoir.** As a result, significant vegetation mortality will occur within the reservoir and the VMP will fail to establish broad areas where dense, deep-rooting forest vegetative cover will mature between cycles of submersion, mortality, and subsequent colonization by ruderal species adapted to disturbed areas. Once vegetation dies, the root systems will collapse and there will be a loss of functional root cohesion and a consequent increase in erosion and soil instability.

The influence of vegetation on slope stability is most effective on shallow, translational mass wasting processes and surface erosion; however, the cumulative effect of fluctuating hydrology with prolonged inundation, rapid reservoir drawdown rate with hydrostatic conditions beyond the soil capacity, and the loss of vegetation and root cohesion will have a profound impact on large-scale mass wasting processes. **It cannot be overstated that the hydrostatic groundwater conditions resulting from alternating inundation and drawdown within the reservoir, combined with the loss of functional vegetation, are significant impacts to the entire reservoir area, as well as the Chehalis River and its aquatic and terrestrial species and habitats.** As described in detail below, the VMP fails to consider the complexities posed by the steeply sloped landscape context of the FRE facility reservoir area, the prevalence of historic landslides, and the significant potential for hillslope destabilization and loss of root cohesion. The VMP proposes an approach that is focused on the selection of 'appropriate' vegetation species and is not grounded in the physical setting and the slope and soil conditions present.

The operation of the proposed FRE reservoir creates a "worst case scenario" of significant slope instability and large-scale erosion conditions within the reservoir which the approach proposed in the VMP does nothing to mitigate.

Vegetation Root Cohesion

Once tree removal occurs, shrub and herbaceous vegetation cover will provide the only root cohesion supporting hillslope stability. *Mixed Coniferous/Deciduous Transitional Forest* (29% of the study area) and *Coniferous Forest* (28% of the study area) are the dominant forest communities cited in the land cover classification (VMP Table 2 page 3-2). However, the summary of land cover classification as presented includes no shrub or herbaceous species, which is ecologically nearly impossible. Soil cohesion from roots significantly affects the stability of slopes with shallow soils (Cohen and Schwarz 2017). Other than the fifth objective under Goal 5.2.3, to "use reasonable care during timber yarding to minimize damage to the vegetation providing shade to the stream or open water areas and to minimize disturbance to understory vegetation, stumps, and root systems" (VMP Section 5.23, page 5-2), the VMP offers no actual means or methods to avoid destruction of the understory community.

The immediate effects of selective tree harvest in the Debris Management Zone and subsequent anticipated mortality of 'inundation intolerant' vegetation communities, coupled with the cumulative effect of failing to reestablish functional mature forests with a complex understory across 808 acres of the reservoir, will result in a catastrophic loss of root cohesion and hillslope destabilization and landslides (e.g., Montgomery et al. 2000;

Schmidt et al., 2001). The loss of anchoring Douglas fir trees results in root death and loss of root cohesion, resulting in subsequent hillslope instability (e.g., Montgomery et al., 2000; Amaranthus et al. 1985). Landslides in coastal Pacific Northwest mountains have been shown to occur during common storms in the decade following tree loss in steep, landslide-prone terrain (Montgomery et al. 2000). Furthermore, studies have shown that **tree loss modifies root cohesion for at least a century,** contributing to an increase in regional landslides compared with landslide frequency in mature, intact forests (Schmidt et al. 2001). It is well established in the scientific literature that forest clearing increases slope instability. The VMP will clear the slopes of the FRE and then conduct regular cutting on a frequency of 7-10 years. This is an optimal plan for maximizing slope instability over the life of reservoir (Figure 16). Research has also shown that hardwoods and understory vegetation such as proposed in the VMP have an order of magnitude less cohesion than native conifer forests (Figure 17, Schmidt et al. 2001). Work by Roering et al. 2003 also showed that conifer forests are less susceptible to sliding and slides are more susceptible with lower stem densities.

Root strength is proportional to root diameters, root density in the soil, and rooting extents (laterally and vertically) both of which increase with tree age. Since conifers have greater diameters, they have greater rooting depths and more extensive rooting networks (Roering et al. 2003). Larger roots also decay more slowly (Figure 18). Schmidt et al. 2001 demonstrate that industrial forests have much lower lateral root cohesion (Figure 19). The loss of root cohesion due to tree removal and inundation/submergence mortality, and related impacts on understory shrubs and herbaceous plants during and after harvest and submergence together will significantly decrease hillslope root cohesion. As detailed herein, the pre-operational in-planting approach proposed in the VMP will not successfully establish robust communities of trees and shrubs in advance of reservoir inundation and will thus not moderate this loss of root cohesion. This loss of root cohesion will result in an increase in the rate of shallow landslides and erosion in a landscape already prone to hillslope instability and landsliding as described in more detail below (NSD and Saturna Watershed Sciences 2020a).

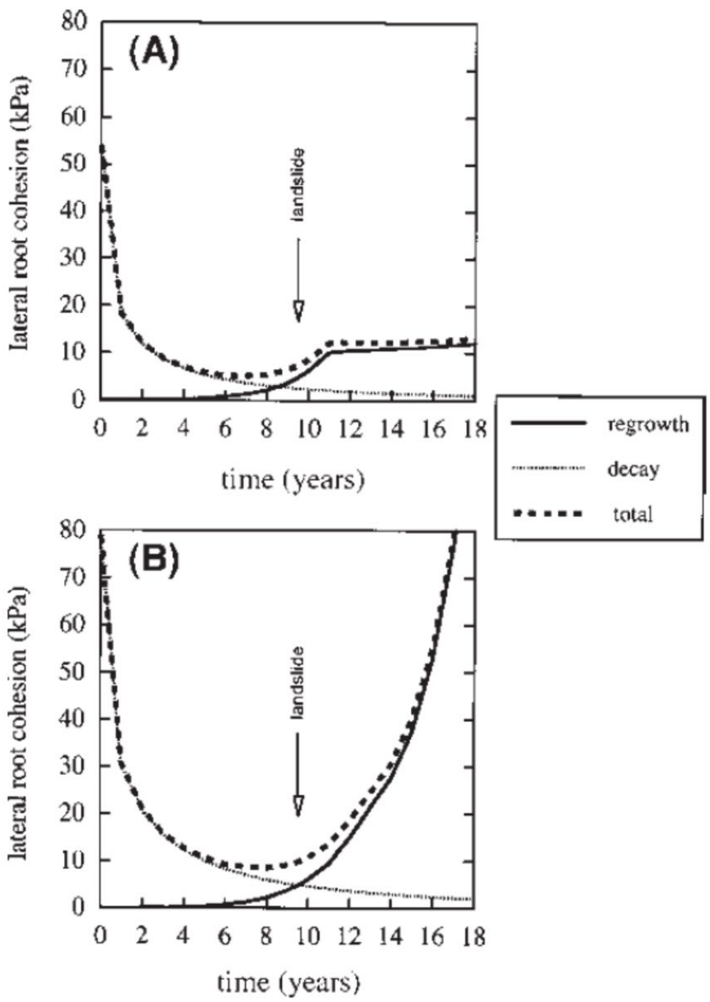


Figure 16. Schmidt et al 2001 present plots of regrowth and decay contributions of total lateral root cohesion for two sites clear-cut logged in 1986 and landslides occurred in 1996. Both sites show that root decay reduces root cohesion to a minimum of seven years after cutting. After seven years regrowth begins to compensate for losses due to decay. Landslides occurred close to the minimum 10 years after cutting. Site A is dominated by understory vegetation whereas Site B had hardwood and conifer regrowth. The VMP proposes to conduct tree clearing every 7-10 years, the optimal time of slope instability with respect to root cohesion.

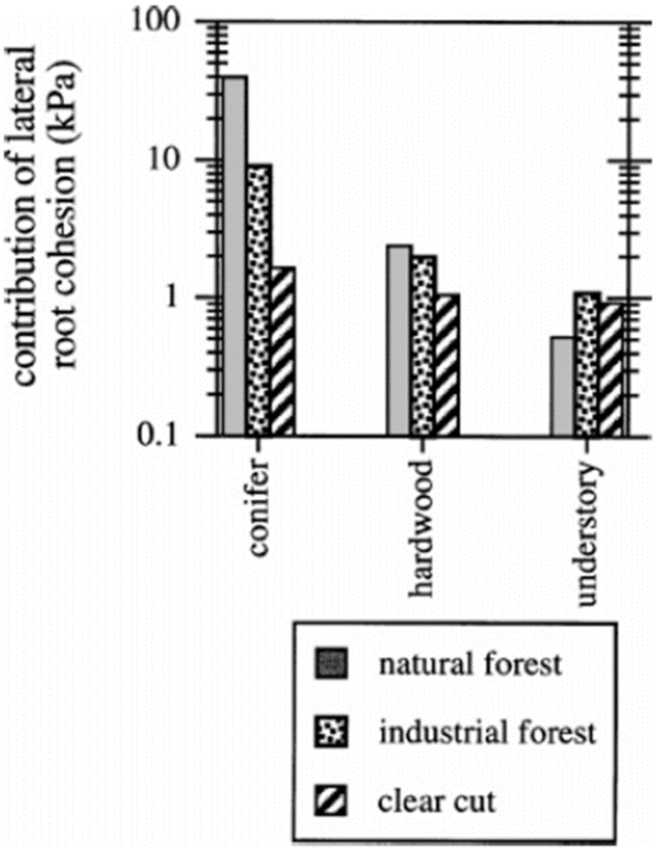


Figure 17. Schmidt et al. 2001 show that native conifer forests have lateral root cohesion over 10 times greater than the hardwood and understory forest proposed in the VMP.

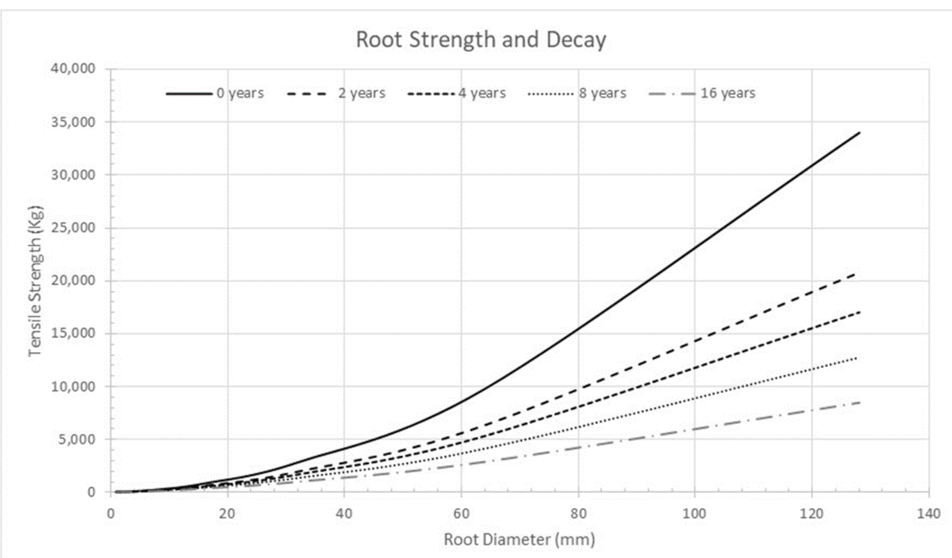


Figure 18. Plot of Douglas fir root tensile strength as a function of root diameter and years since cutting (different curves are years since cutting). NSD plot based on decay function defined by Burroughs and Thomas 1977.

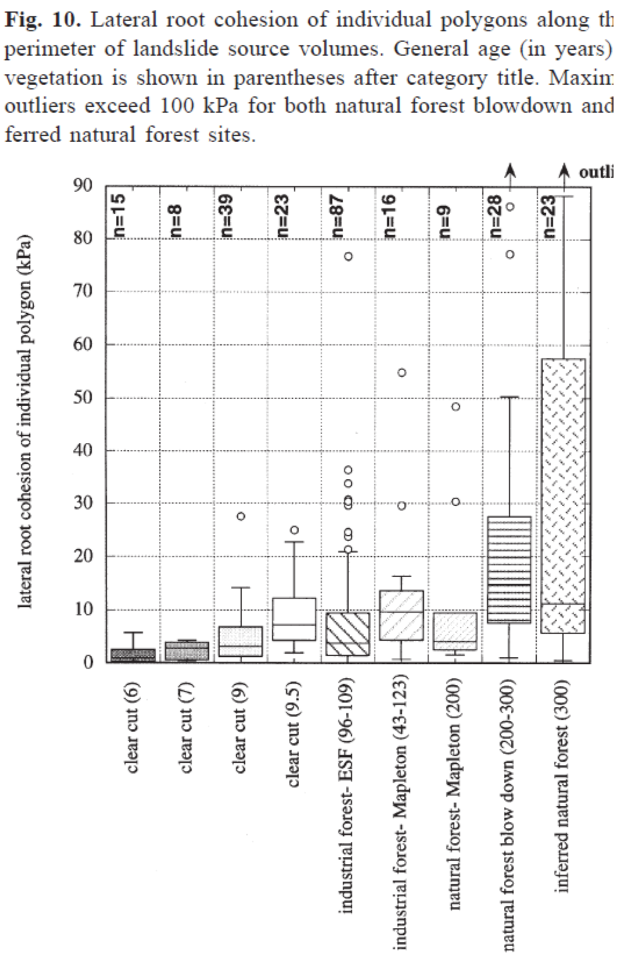


Figure 19. Lateral root cohesion for different forest covers from Figure 10 in Schmidt et al. 2001.

Hillslope Instability

The findings of previous analysis presented in the "*Earth Discipline Report–Geology Technical Analyses Review"* (NSD and Saturna Watershed Sciences 2020a) identified three elements presented in the SEPA DEIS Earth Discipline reports found to be in error and to consequently underestimate the impacts on slope stability from the operation of the FRE facility and the repeated formation and drawdown of the reservoir. These errors are also reflected in the NEPA analysis, see Geology Discipline Report Review – Addendum [NSD and Saturna Watershed Sciences 2020b]). These assumptions are critical to evaluating the VMP findings and revegetation approach:

> "*1) Landslides and landslide potential are underrepresented in the DEIS and thereby the estimated 840,500 cubic yards of sediment delivered by landslides is underestimated in the impact analyses; actual sediment volumes will be much higher (potentially as high as 16 million cubic yards). This error is propagated in the sediment transport impact analyses and habitat impact analyses and not considered in the FRE Operations Plan.*
>
> *2) The proposed reservoir pool drawdown rate is stated as 10 feet/day is not supported by site's geologic conditions and is not consistent with design standards. This error is propagated in the sediment transport impact analyses and habitat impact analyses and not considered in the FRE Operations Plan. This error*

would result in unsafe conditions that threaten public safety. To address this error, the drawdown rate would have to be significantly reduced, thus greatly increasing the impoundment duration. Alternatively, if the stated drawdown rate were maintained, it would have to be disclosed that the project will dramatically increase slope instability and further increase risks and impacts to public safety, FRE operations, and habitat than was disclosed in the DEIS. Other variables and assumptions used in landslide stability modeling are inconsistent with operations stated in the DEIS and appear to have bias favoring the project; there is no mention of uncertainties with the analysis in the DEIS.

3) The loss of topsoil and vegetation in the reservoir will decrease the function and benefit of preventing erosion and providing slope stability. It is our opinion that the fine-grained sediment delivery to the reservoir, and mobilized from the reservoir to the downstream reaches, will result in downstream habitat impacts that are greater than was considered in the DEIS. This error is propagated in the sediment transport impact analyses and habitat impact analyses. This condition will be exacerbated by an increase in landslides."

The *SEPA Geology Technical Memo* (NSD and Saturna Watershed Sciences 2020a) critique of the SEPA DEIS Earth Discipline Report and related geotechnical analyses, demonstrated that the degree of slope stability, history of and potential for landslides in the FRE facility reservoir area is grossly underestimated. In that analysis, NSD and Saturna Watershed Sciences (2020a) performed a desktop landslide mapping (Figure 20) that demonstrated:

1. widespread slope instability within the watershed,
2. a greater potential for slope instability resulting from vegetation removal and fluctuating reservoir levels than was disclosed in the DEIS, and
3. the resulting underestimation of sediment inputs into the Chehalis River from landslides and erosion, and consequent water quality and aquatic species and habitat impacts.

As illustrated in Figure 20, the proposed FRE facility reservoir would be located within a landslide-prone landscape. Landslides and mass hillslope failures have repeatedly occurred throughout the reservoir area under somewhat intact forest conditions. The legacy of forest clear cuts and industrial forestry has resulted in a system with large areas of increased slope instability compared to historic background rates.

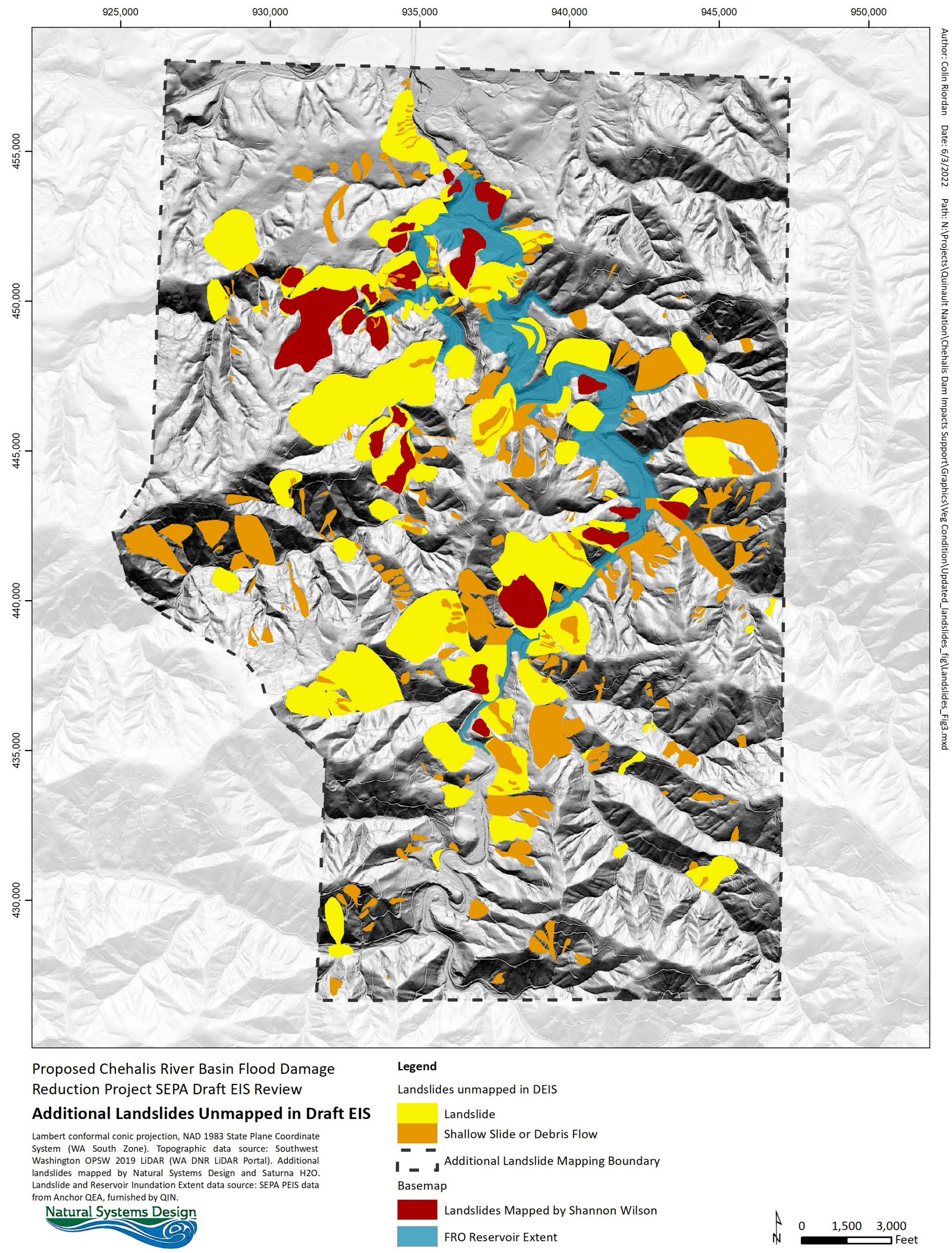


Figure 20 NSD and Saturna Watershed Sciences mapping of landslides within and adjacent to the FRE facility reservoir compared to landslides mapped by Shannon and Wilson in 2017 presented in the SEPA DEIS. Map does not show steep slopes susceptible to shallow landsliding, slopes that dominate the region (NSD and Saturna 2020a and 2020b).

The extent of relict landslides mapped within and adjacent to the FRE reservoir is significant, covering approximately 1,600 acres (Table 3). It should be noted that this estimate is for only relict landslides and does not include the many acres of new unstable slopes which will be triggered by FRE operations.

Table 3. Summary of area and volume calculations from mapped landslides susceptible to influence of FRE reservoir pool inundation and drawdown (modified from NSD 2020a).

MAPPED LANDSLIDES QUANTITIES CONTACTING OR WITHIN 100 YEAR FRE RESERVOIR			
Mapping Source	***Acres (square feet)***	***Estimated Depth***	***Minimum Volume (cubic yards)***
Mapped deep-seated landslides (NSD and Saturna)	1,033.27 acres (45,009,419 sf)	At least 6 feet slide depth	10,002,093
Mapped deep-seated landslides (Shannon & Wilson)	246.05 acres (10,717,907 sf)	At least 6 feet slide depth	2,381,757
Total Mapped Deep-seated Landslides	*1,279.32 acres (55,727,327 sf)*		*12,383,850*
Mapped Shallow Landslides and Debris Flows (NSD only)	326.22 acres (14,209,951 sf)	Estimated 6 feet slide depth	3,157,767
Combined Deep-seated and Shallow Landslide Quantities	*1,605.54 acres (69,937,278 sf)*		*15,541,617*

Broad areas of unvegetated steep slopes and low-cohesion soils are anticipated because of the repeated cycles of inundation, vegetation mortality, and gradual establishment of ruderal, weedy species with poor root cohesion. The pre-operational in-planting approach articulated in the VMP will not moderate these conditions.

These conditions, combined with the repeated cycles of inundation and rapid reservoir drawdown rates will dramatically increase the sediment volume estimates provided in Table 3. Erosional processes will deliver additional tons of additional fine-grained sediment to the reservoir over the volumes delivered by landslides. Fine grained sediment will be mobilized from the reservoir to the downstream reaches and will result in downstream habitat impacts. These massive volumes of sediment will repeatedly and continuously flow into the river significantly affecting water quality, fish and wildlife species, aquatic and riparian habitats, and sedimentation rates. Increase in fine sediment inputs will increase salmonid egg mortality by infiltrating redds within the reservoir and far downstream.

Landslides within the FRE facility reservoir destabilized by continuous cycles of vegetation mortality, ruderal stage recolonization, recurrent impoundment and submergence, and rapid reservoir drawdown will compound the impacts to valley bottom riparian and in-stream aquatic habitats and ecosystems (NSD and Saturna Watershed Sciences 2020a). Restabilizing unstable slopes and landslides that form within the reservoir will be particularly challenging and costly.

The use of vegetation to stabilize shallow landslides as prescribed in the VMP would only be effective if deep-rooted, woody vegetation could reliably be established, maintained, and reach maturity. As described in detail herein however, it is unlikely that the application of the proposed pre-operational in-planting approach articulated in the VMP will succeed. Furthermore, the loss of soil and the broad extent of landslides will further and continuously negate the 'adaptive management' approach articulated in the VMP, making for example goal and objective 6 impossible to achieve.

> "*Minimize loss of vegetation communities as a result of landslides and slope failure throughout the planting areas in the FRE temporary reservoir*" and "*In the event of a landslide, monitor vegetation*

> *communities survivorship and percentage plant cover through the use of belt and/or line transects*" (VMP Section 7.2.6, pages 7-3 and 7-4).

The lack of acknowledgement in the VMP of the challenges to vegetation establishment, monitoring, and adaptive management posed due to shallow landslides and slope instability is a significant error of omission given the preponderance of landslide occurrence evidence within the reservoir area (NSD and Saturna Watershed Sciences 2020a).

Failure to Consider Hydraulic Stability During Reservoir Operation

A critically important aspect of the proposed FRE facility operation, and thus of the potential for the VMP to succeed, is the role of reservoir fluctuation and drawdown operations in adjacent hillslope soil stability. Reservoir hillslope landslides resulting from reservoir filling and drawdowns have been documented worldwide and in Washington State (Philley et al. 2019; Xia et al. 2014; Schuster 1979). Regionally, evidence of mass failure and landslides is common at Mud Mountain Dam reservoir on the White River (Figure 21, Philley et al. 2019).

Figure 21. Active landslide along the south side of the White River, Mud Mountain dam reservoir (Philley et al. 2019). Example is a slope considerably less steep than those along the proposed Chehalis FRE reservoir. The example also shows some of the trees are deciduous, which are more prone to landsliding than conifers (Schmidt et al. 2001, Roering et al. 2003).

Reservoir hillslope stability has been found to be a function of the rate of reservoir fluctuation and soil hydraulic conductivity (Xia et al. 2014). The findings of the SEPA Geology Technical Memo (NSD and Saturna Watershed Sciences 2020a) summarize the geomorphic mechanisms of reservoir hillslope failures:

> "The greater the rate of reservoir level changes, the lower factor of safety. During draw-down operations, slope destabilization results from a combination of the loss of external hydrostatic pressure (reservoir buttressing the slope) and excess pore water pressure during rapid draw-down… According to Berilgen (2007): 'If the change in external water level happens without allowing the time needed for the

drainage of the slope soils, it is called sudden or rapid drawdown (RD). Due to rapid drawdown there will be a decrease in the slope stability, which may lead to slope failures'."

As presented in detail in the *SEPA Geology Technical Memo* (NSD and Saturna Watershed Sciences 2020a), "*If the drawdown rates in the DEIS are correct, the slopes will be VERY susceptible to failure during drawdown as they are more extreme than the conditions analyzed by Shannon and Wilson. The drawdown rate proposed in the DEIS is very aggressive and the water stored in the soil during high-pool cannot drain quickly enough; the excess pore-water pressure at the base of the soil will induce seepage and result in widespread failures*."

The VMP fails to consider this aspect of slope instability in promulgating its premise of 'resilience in the face of disturbance' and 'adaptative management' approach to ensuring vegetation survival and stature throughout the reservoir sufficient to mitigate for the loss of tree canopy, shading, and consequent increases in water temperature. Reservoir drawdown and the resultant unpredictable areas and extents of slope failure has the potential to create an endless cycle of massive sediment input and areas too unstable and inaccessible to be planted, let alone restored to the functional upland forest habitats which are currently present throughout the reservoir area.

Failure of VMP to Reduce Impacts to Water Quality

The updated water quality modeling purports to show a lessening of the significant impacts to water quality, principally elevated water temperature, and thus to aquatic habitat and species compared to the impacts which were presented in the NEPA and SEPA DEISs. The Water Temperature Model Sensitivity Analysis uses vegetation scenarios that are based on recent lidar-derived vegetation heights for the baseline, and on the assumed success of the VMP for 'low' and 'high' vegetation height scenarios.

The low vegetation scenario assumes successful colonization by volunteer willows throughout the riparian zone of the entire FRE reservoir footprint (defined in the Water Temperature Model Sensitivity Analysis by a line of vegetation height nodes that are 50 feet offset from the stream edge along both banks). The low vegetation scenario assumes a resulting uniform riparian vegetation height of 20 feet (6.1 m) in the Final Evacuation Area, Debris Management Area, and Initial Evacuation Zone. The high vegetation scenario assumes that the VMP is successful and there is uniform 20-foot, 60-foot, and 90-foot vegetation in the Final Evacuation Area, Debris Management Area, and Initial Evacuation Zone, respectively. The previous DEIS modeling, which found increases to summer water temperature of 2 ^{o}C (NEPA DEIS, as reported in Section 2.1 of Water Temperature Model Sensitivity Analysis) and 2-3 ^{o}C (SEPA DEIS, as reported in Section 2.1 of Water Temperature Model Sensitivity Analysis) used a 'no shading' scenario of 0-foot (0 m) vegetation and a riparian shading scenario of uniform 6.6 feet (2 m) vegetation height along the riparian zone within the entire FRE reservoir footprint.

Not surprisingly, changing the assumption to taller riparian vegetation throughout the reservoir area resulted in a reduction of summer water temperature impacts due to changes in riparian vegetation condition within the proposed FRE reservoir. In particular, the Water Temperature Model Sensitivity Analysis asserts that under the "low" and "high" vegetation height scenarios the average increases in stream temperature (based on the 7-day average of the daily maximum water temperature or 7-DADMax) would be 1.0 ^{o}C and 0.3 ^{o}C, respectively, relative to baseline vegetation within the FRE reservoir (Table 3 of the Water Temperature Model Sensitivity Analysis). **These values are less than the temperature increase impacts reported in the NEPA and SEPA DEISs <u>entirely because</u> they use unsupported assumptions of higher riparian vegetation heights.**

Thus, the assertion of diminished negative water temperature impacts (I.e., less increase in water temperature) is unsupported because it is based on two underlying flawed assumptions: (1) the VMP will successfully result in continuous riparian vegetation of the assumed mature heights listed above, and (2) the mature heights of each vegetation scenario are constant through time rather than variable due to mortality and regrowth following periodic inundation and submergence.

Flaws in Determination of Mature Vegetation Heights

As detailed in previous sections, the assumption that the VMP would result in continuous mature riparian vegetation is deeply flawed. The actual heights of riparian vegetation are likely to be much lower than the assumed heights due to the challenges in establishing 'flood tolerant' riparian species in inappropriate hydrologic and soils conditions, periodic mortality due to inundation and submergence, and the loss of root cohesion and consequent slope instability within the reservoir area. Furthermore, **even under existing, unimpacted conditions the existing unimpacted vegetation heights are shorter than the assumed heights for mature vegetation used in both the low and high vegetation scenarios.** For example, in the "low vegetation" scenario, which is described as "worst case" (p 3-8 of the Water Temperature Model Sensitivity Analysis), the modeled vegetation is taller than existing vegetation, which has not yet been impacted by inundation and submergence, vegetation removal or replanting, in at least 4 of the modeled stream segments, each of which is 492 ft (150 m) long (see Figure 9 of the Water Temperature Model Sensitivity Analysis). **Thus, for some stream segments, there is more shade being modeled in both the worst case and infeasible best case than under existing, unimpacted conditions.** Both the realism of the two vegetation scenarios and the assertion of reduced water temperature impacts due to these vegetation scenarios are unsupported.

Flawed Assumption of Continuous Mature Vegetation Height in Space and Time

The second flawed assumption is built into the quantification of stream temperature impacts during two years of simulation, over which time riparian vegetation heights are assumed to be at their mature potential. However, mortality due to 30+-days of inundation and submergence under 212 feet of water (e.g., maximum water depth in the Final Evacuation Area) is unaccounted for. After each inundation event, significant mortality will occur. The worst-case scenario would be no trees or shrubs of a stature sufficient to shade the river channel over multiple years following each FRE operation event. Assuming there is recolonization and re-growth of willows during the interval between inundation/submergence events, the time to reach 20 feet is at least > 5 years, as supported by Figure 7 of the VMP (Figure 22 below). T**hus, there are at least 5 years after each inundation event during which the assumption of 20-foot vegetation is invalid. To appropriately characterize the potential effect of the VMP on stream temperature, the duration for which vegetation is at different heights needs to be explicitly included.**

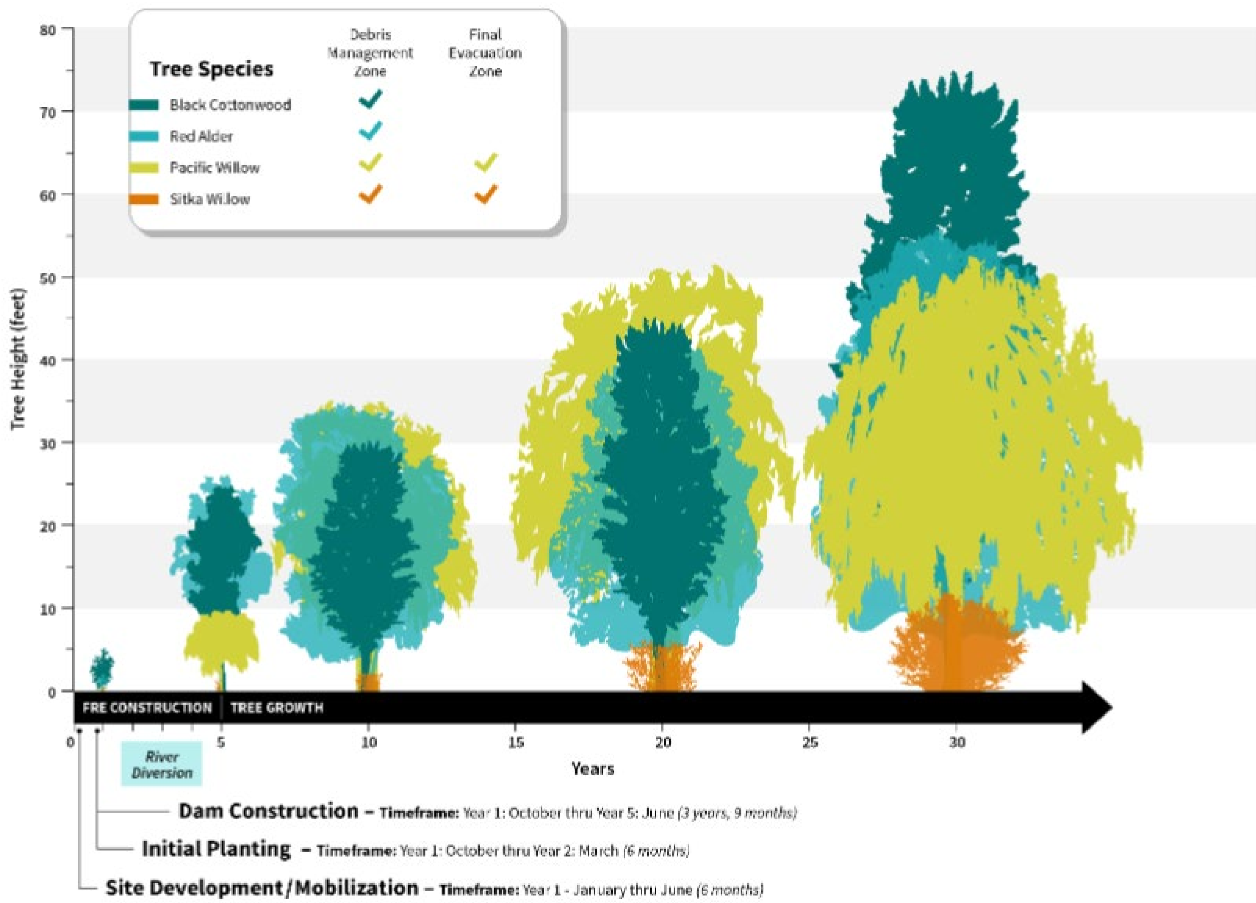


Figure 7: Conceptual VMP Implementation and Tree Growth Timeline

Figure 22. Figure from the VMP illustrating that growth of vegetation is not immediate. Each reservoir inundation event will result in mortality. Thus, there will be repeated periods of regrowth during which vegetation is shorter than the assumed mature heights presented in the Water Temperature Model Sensitivity Analysis.

In the hypothetical 7 years between FRE operation events posited in the DEISs, it is more reasonable to expect that there would be 0-2 years with no vegetation followed by 1-3 years with vegetation that is shorter than the 20-foot mature height. As noted herein and in critique of the DEISs (NSD 2020b and 2020c), the actual frequency and duration of inundation event is underestimated, thus increasing the prevalence and duration of vegetation recovery periods during which shade is limited. **Thus, it is completely unreasonable to assume 1) that the modeled "low vegetation" scenario of mature 20-foot vegetation is continuous in both space and time across the riparian zone within the FRE reservoir footprint and 2) that this "low vegetation scenario" is representative of a "worst case" scenario for water temperature effects.**

Potentially Insufficient Model Timeframe

In addition to the flawed assumptions that underlie the modeling, it is unclear from the Water Temperature Sensitivity Analysis if the representativeness of two years of water quality modeling has been assessed. Only two years of water temperature modeling are likely insufficient to represent impacts across the interannual variability of climate conditions. Modeled water quality results depend on air temperature, relative humidity, cloud cover, and wind speed, all of which determine the magnitude of shading effect provided by vegetation (see Section 2.3.1 in the Water Temperature Sensitivity Analysis). Therefore, the effect of riparian vegetation on stream temperature will be highly variable year to year. The Water Temperature Sensitivity Analysis does not present analysis to justify the use of just two years to quantify impacts to water quality, or the representativeness of those two years relative to climatic conditions.

Consequences of Increased Water Temperature for Aquatic Habitat and Species

Riparian forest conversion impacts directly degrade local aquatic habitat quality due to increased water temperatures, reduced in-stream cover, and reduced in-stream organic material (Moore et al. 2006; Tockner et al. 1999). The DEIS's acknowledge that the loss of coniferous forest slopes and forested riparian zones will affect water quality through the drastic reductions in shading and large wood recruitment, raising water temperatures in the temporary reservoir area and upstream of the FRE facility by 2°C to 3°C when not inundated.

> "*The probable adverse impacts from the permanent conversion of the entire temporary reservoir inundation area to herbaceous or shrub and sapling-dominated zones and the subsequent increased temperature are considered significant for wildlife habitat within the temporary reservoir*." Appendix P, Wildlife Species and Habitats Discipline Report, SEPA DEIS, p. P-73 and P-74)

The SEPA DEIS concluded that construction and operation of the proposed FRE facility would cause **significant adverse impacts to aquatic habitat function and associated species from an increase in temperature (2°C to 3°C increases in summer) due to lack of large trees in the temporary reservoir, degraded riparian function, and recurring inundation events affecting 800 acres of vegetation**. The SEPA DEIS further concluded that other adverse and compounding effects would occur due to reduced fish passage, bed scour affecting spawning grounds, degraded habitat, reduction in channel-forming flows and large woody material and reduced nutrient contributions to the river (SEPA DEIS Appendix E, page E-v). Elevated temperatures directly affect salmonid mortality due to changes in behavior and metabolism and increased risk to disease for all species. Maintaining suitable stream temperatures is especially important for pre-spawning spring Chinook during migration and holding periods.

As articulated in detail in the Lestelle and Morishima technical memos (Lestelle and Morishima 2020a and 2020b) prepared in response to the NEPA and SEPA DEIS's, the DEISs determined that the construction and operation of the proposed FRE facility would significantly impact the genetic diversity and abundance of populations of spring and fall Chinook, coho, and steelhead originating in the subbasins above the proposed dam site (near Crim Creek) and from Rainbow Falls to Crim Creek. The DEISs acknowledge that the genetic structure and diversity of coho and steelhead are unique in the upper Chehalis Basin and that the proposed FRE facility construction and operation will significantly impact these aspects of their populations based on findings in Seamons et al. (2017 and 2019).

Because of their run timing and high fat content, spring Chinook are highly coveted by both tribal and non-tribal fishers and are the first salmon to return to their rivers of origin. It is now known that the spring- and fall-run Chinook types are genetically distinct along the Pacific Coast (Prince et al. 2017; Thompson et al. 2019a) and in the Chehalis Basin (Thompson et al. 2019b).

The SEPA DEIS concludes that the proposed FRE facility would have significant and adverse impacts on the spring Chinook population in the Chehalis Basin. **Modeling results presented in the DEIS demonstrate that the upper Chehalis Basin population, i.e., upstream of the South Fork, would be driven to extinction, likely during the period of construction but no later than mid-century.** This event would heighten the risk of the complete demise of the aggregate spring Chinook population in the Chehalis Basin due to the contraction of spawning distribution (i.e., reduction in spatial structure) and loss of genetic resilience. Moreover, construction of the FRE facility and reservoir would foreclose the possibility of upper basin habitat restoration for spring Chinook and other salmon and steelhead.

Significant adverse effects on spring Chinook are of particular concern due to their genetic uniqueness and population sensitivity. Prince et al. (2017) concluded that the early migration of adults to their natal rivers is the result of a single mutational event associated with one allele within the genome of Chinook salmon. That event likely occurred hundreds of thousands of years ago and the allele for this migration pattern was subsequently spread to distant populations through straying and positive selection. Thus, such a mutational event is so exceptionally rare that if the allele is lost it cannot be expected to readily re-evolve. **In other words, if spring Chinook are extirpated, they would be effectively gone forever, further raising the risk and the consequence of the FRE facility and the approach proposed in the VMP.**

Failure to Mitigate the Cascade of Ecosystem Effects

Finally, and most substantially, the approach proposed in the VMP fails to offer any mechanism to mitigate the nature, scale, and irreparable significance of the cascade of ecosystem effects to the river, associated riparian habitats, wetlands, and upland forests and associated fish and wildlife which will occur if the FRE is built and operated. We incorporate herein by reference the *SEPA Cascade of Ecosystem Effects Technical Memo* (NSD 2020a) for details on the incorrect assumptions and lack of analysis related to multiple direct and indirect effects on natural processes, as well as related and additional issues presented in the *NEPA Ecosystems Addendum* (NSD 2020d).

In summary, given the well-established interactions between geomorphic, hydrologic, and ecological processes that form and maintain high quality aquatic habitat, **the consequences of the proposed tree harvest and loss of riparian and adjacent hillslope forests, loss of root cohesion and slope stability, and the infeasibility of replanting the reservoir as anticipated in the VMP will set in motion a much larger and potentially irrevocable "cascade" of ecosystem impacts** (see Jorde et al. 2008; Burke et al. 2009 for process-based hierarchical framework). The synchronous alteration to multiple, connected natural processes that sustains riparian and aquatic habitat sets up a positive feedback loop in which the overall impact to ecosystems is amplified relative to the alteration of any one process. These consequences were described in detail in the technical memos prepared in response to the SEPA and NEPA DEISs (NSD 2020a and NSD 2020d). Significantly, the underestimation of reservoir inundation, drawdown, hydraulic stability, and vegetation community impacts directly affects 'first order' ecosystem processes fundamental to riverine ecosystems including sediment supply and connectivity with groundwater. **The approach articulated by the VMP fails to consider the amplifying ecosystem effects on wetlands, river baseflow, and stream temperature from the loss of over-bank groundwater recharge and alteration to sediment supply and transport.**

The 'first order' processes of hydrology and sediment supply are affected by the frequency and duration of reservoir impoundment and inundation duration, as well as backwatering at the FRE facility low level outlets. The approach articulated in the VMP of logging the Debris Management Evacuation Area to manage wood within the proposed reservoir, coupled with prolonged inundation and reservoir water level fluctuation during flood impoundment and drawdown, will decrease root cohesion and the stability of the surrounding hillslopes and cause a greater degree of landslides and hillslope erosion. Further, the periodic removal of trees greater than 6 inches in diameter every 7 to 10 years will continuously repropagate this effect. These actions and effects will repeatedly impair establishment of mature riparian vegetation (Montgomery et al. 2000) which will further impair water quality and slope stability.

The increased frequency of landslides will cause a greater input of both coarse and fine sediment to the reservoir footprint and to the Chehalis River system downstream. These large, episodic inputs of sediment will immediately impair aquatic habitat by burying the river's channel, side channels, and riparian wetlands, and the increased sediment supply will contribute to a shift in morphology toward a braided channel system. The DEISs acknowledge that reservoir operations will increase fine sediment inputs, which will impact water quality and salmonid egg survival; however, predictions of fine sediment inputs due to increased landslides and erosion are grossly underestimated (see *SEPA Geology Technical Memo* (NSD and Saturna Watershed Sciences 2020a)). In addition, temporary ponding due to backwatering at the low-level outlets, which is stated in the SEPA DEIS as extending roughly 300 feet upstream, will trigger local deposition of fine sediment due to reduced stream velocities and will impair downstream transport of coarse sediment.

> "*As flows reach 8,500 cubic feet per second (cfs) at the outlet gates of the FRE facility, some backwatering upstream would begin to occur, resulting in more frequent drowning and disturbance of wildlife habitats for approximately 300 feet upstream of the FRE facility*." (Appendix P, Wildlife Species and Habitats Discipline Report, SEPA DEIS, p. P-73)

The approach proposed in the VMP will result in reductions in large wood recruitment and large wood supply as a result of direct harvest of 'flood-intolerant' trees from the debris management zone and the death of the forests on the slopes and in the riparian zone of the proposed reservoir. This will remove the primary source of large wood to the river and will impair natural wood recruitment from banks and hillslopes.

The recruitment of large wood is a critical component of establishing "hard points" in a stream, which allow for development of mature riparian forest and the maintenance of complex channel planforms that contribute to aquatic habitat diversity (Collins et al. 2012; Montgomery and Abbe 2006). "Hard points," which can be both logjams and stable key-pieced sized logs, increase the stability of the channel and floodplain morphology by dissipating the stream's energy – resisting erosion and reducing overall scour. This acts to focus flow into deep and narrow channels with high degrees of shade, allow for the development of complex aquatic habitat, and protect the surrounding riparian forest from erosion so that the trees can grow to sizes large enough to remain stable in the channel when they are eventually recruited. Such "hard points" also positively influence aquatic habitat by sorting spawning gravels, forming pools, and providing complex cover. Without these "hard points" and with the combined influence of increased sediment supply and elimination of mature riparian vegetation, the morphology of the stream within the reservoir footprint is likely to become braided. Braided river systems generally provide less shade and shallower channel morphology, both of which contribute to warmer stream temperatures, than meandering or anabranching streams (Montgomery and Abbe 2006; Beechie et al. 2006). Since braided channels are highly dynamic, this morphology also sets up a positive feedback loop in which the reduction of large wood recruitment triggers braided morphology, which impairs the establishment of mature riparian forest and further maintains braided morphology. The reduction in large wood recruitment will also degrade aquatic habitat quality by impairing geomorphic processes that depend on large in-stream wood, such as pool creation and retention of spawning gravels (Montgomery et al. 2003).

Need for Risk Assessment Based Decision-Making Given Uncertainty

The VMP acknowledges the unpredictability and uncertainty of the impacts it purports to anticipate and minimize. "*The Vegetation Management Plan looks at the anticipated flooding of the site through the lens of disturbance. Disturbance is the agent of change through which vegetation constantly adapts and evolves. In this case, the disturbance type (flooding) is planned and expected, but uncertainty remains surrounding the impacts.*

The intent of proposed vegetation management is to design for resilience in the face of disturbance." (VMP Section 1.1, page 1-2). Further, "*There will be uncertainty in predicting an elevation at which trees will likely be severely stressed or killed once the FRE facility is activated during major flood events. The uncertainty is due in part to the unpredictable nature of flood events and in part to the difficulty in predicting how individual trees will respond to inundation*." (VMP Section 5.4, page 5-5)

In environmental situations where outcomes are being estimated based on parameters with high uncertainty, an ecological risk assessment framework for decision making is warranted (Norton et al. 1992, U.S. Environmental Protection Agency 1998) and a sensitivity analysis is often used to identify uncertainties that have the greatest consequence (Harper et. al. 2011, Fullerton et. al. 2010, Nicholson and Possingham 2007). As presented herein, it is our conclusion that there are multiple areas of high uncertainty and high risk to sensitive resources inherent in the approach presented in the VMP. These uncertainties are driven by the inaccuracies, underestimations, and failures described herein, including:

- Underestimated projections of reservoir inundation frequency and duration
- Inaccurate characterization of vegetation 'flood tolerance' as indicative of tolerance of native trees and shrubs to the hydrostatic pressure created by complete submersion by 10's to 100's of feet of reservoir inundation
- Inaccurate projections and failure to adequately anticipate loss of root cohesion, decrease in slope stability, and increases in erosion and landsliding.
- Failure to consider the logic failings of 'advance planting' prior to the anticipated hydrologic regime.
- Failure to consider the consequent inability of pre-operational in-planting to stabilize the riparian zone and adjacent hill slopes at scale and to consistently provide a plant community of necessary stature and longevity to shade the channel and maintain water temperatures appropriate for salmonid spawning and rearing.

An ecological risk assessment framework that weighs risks and consequences with consideration of key uncertainties is also warranted due to the **large scale and pervasive and interconnected nature of the impacts** resulting from the frequency and duration of the proposed reservoir inundation and due to the speculative approach to 'adaptively managing' the reservoir articulated in the VMP. The FCZD has failed to provide any proof of concept at any scale to test critically important suppositions in the VMP of inundation and submergence tolerance, pre-operational in-planting, maintenance of root cohesion, and reservoir slope stability.

Further, the 'adaptive management' plan itself reinforces the issue of uncertainty but proposes a process of continuous and iterative monitoring, replanting, and reevaluating the success of the VMP approach.

> "*The inherent unpredictable nature of disturbance effects on natural systems requires the use of indicators and flexibility. A set of potential remedial actions is proposed to address ecological needs as they arise, but other actions may be revealed through monitoring and consultation with agencies or interested parties*." (VMP Section 7.2.7, page 7-4)
>
> "*Long-term monitoring will be conducted annually to evaluate vegetation conditions in the FRE temporary reservoir footprint, especially following periods of inundation. Monitoring efforts will focus on evaluating whether performance standards are being met. The monitoring phase of the proposed project is expected to consist of iterative and corrective measures, such as removing invasive species, and is expected to occur for the lifetime of the FRE facility operations*." (VMP Section 7.3.1, page 7-5)

If the proposed FRE facility is built and the VMP implemented there is **no return to the currently forested conditions of the riparian zone and surrounding hillslopes, only a cycle of continuous vegetation and slope stability issues spread across 808 acres in perpetuity.**

Because the reservoir is in the upper portion of the Chehalis River watershed and will affect the fundamental physical processes which drive riverine ecosystem structure and function, impacts will occur not only to the 808 acres of the reservoir area (VMP Section 1.4, page 1-4) but will also propagate downstream affecting miles of river and riparian resources outside the discrete footprint of the FRE facility and reservoir. **The issue of scale is thus amplified through effects to ‘first-order’ ecosystem processes (i.e., hydrology and sediment supply)** which inherently then affect all the subsequent processes linked to these drivers of ecosystem structure and function (e.g., water quality, aquatic habitat formation, trophic linkages, biodiversity).

The approach to ‘adaptively managing’ the reservoir is also fraught with uncertainties and risk. Monitoring is prescribed in the 238 to 527 acres of the Initial Reservoir Evacuation Area. Monitoring would determine the extent and nature of tree removal which would occur based on mortality following the first reservoir inundation event, as well as mortality over time following repeated periods of inundation and vegetation community disturbance. Thus, the scale and intensity of tree loss and impacts to the understory vegetation community along the river and its adjacent slopes is unquantifiable.

Harvest of <u>all trees</u> other than willows and black cottonwood is proposed across 122 acres of the Debris Management Evacuation Area and ‘pre-operational in-planting' of more ‘flood tolerant’ species is proposed in advance of the first inundation event. The VMP indicates removal of large trees near the facility and trees determined to pose a threat to the facility operation in the 159-acre Final Reservoir Evacuation Area along the river and on the adjacent slopes. It further proposes ‘pre-operational in-planting' of more ‘flood tolerant’ species, mostly willows, in advance of reservoir inundation, then monitoring following submergence events and removal of all dead trees.

Again, the scale and intensity of tree loss across these combined 281 acres of currently functional, forested habitats is unquantifiable. How many trees would remain? How many trees would be harvested? How will the understory be affected once nearly all trees are removed?

Twenty percent of all pre-operational tree removal is to occur in each of the anticipated 5 construction years and replacement of mature trees is to occur with tree <u>seedlings</u> in the Debris Management and Initial Reservoir Evacuation Areas (VMP Section 5.2.5, page 5-2). Replacement of trees and replacement with seedlings compounds the scale and intensity of the harvest impacts. Retention of “legacy habitat components including snags and stumps” is proposed to “limit ground disturbance, promote slope stability, and provide wildlife habitat”, as is “avoidance of burning” trees and cleared vegetation “to the extent practicable” (VMP Section 5.1 and 5.3, pages 5-1 and 5-3). Retention of snags and stumps in the absence of a functional forest ecosystem does nothing to reduce, minimize or mitigate significant habitat impacts.

In addition to the physical scale of the area directly and indirectly affected, the implications of the **uncertainties** and the **sensitivity of the resources affected** should also be considered. The approach presented in the VMP will deforest hundreds of acres with little certainty that forested vegetation communities can be intentionally reestablished or that forests will be able to persist and grow sufficiently to provide comparable ecological, habitat, and water quality functions. Rather, the approach presented is fraught with risk of catastrophic canopy loss, water temperature increases incompatible with salmon spawning and rearing, massive sediment input, and consequent destruction of terrestrial, riparian, and aquatic habitats throughout *at least* the reservoir area. In addition, the VMP anticipates continuous removal of trees greater than 6 inches diameter every 7 to 10 years from areas that will be “flooded frequently”, thus eliminating the speculative potential for mature forests to be present anywhere in the 808 acres of the reservoir area.

> *"Operation of the FRE facility will also require ongoing routine vegetation management in the temporary reservoir footprint to ensure that the FRE facility could be safely operated. Vegetation management will involve periodic selective tree/snag removal in the temporary reservoir when monitoring recommends action. This will happen about every 7 to 10 years to keep "large" trees (greater than 6-inches-diameter at breast height trees that have the potential to harm the facility) from growing in areas that will be flooded frequently when the FRE facility is activated*." (VMP Section 1.4, pages 1-4 and 1-5)

This risk is of particular consequence given the sensitivity of the spring and fall Chinook, winter steelhead, and coho populations in the upper Chehalis, as articulated in detail in the Lestelle and Morishima technical memos (Lestelle and Morishima 2020a and 2020b) prepared in response to the NEPA and SEPA DEIS's. As Lestelle and Morishima note, **the distinct upper Chehalis population may warrant listing under the Endangered Species Act. Undertaking a high-uncertainty plan in an area where Spring Chinook are at elevated risk of extirpation is of the utmost consequence and contrary to the public interest.**

Similarly, the operation of the FRE facility and the approach articulated in the VMP both involve the synchronous alteration of multiple, connected natural processes that sustain riparian and aquatic habitats. These alterations set up a positive feedback loop in which the overall impact to ecosystems is amplified by the interactions and feedback between physical and biological processes inherent in ecosystems. **The VMP proposes a high uncertainty plan over a large area inhabited by high sensitivity resources and thus is an approach with an exceedingly high consequence for the upper Chehalis basin ecosystem.** The potential for significant impacts and high-consequence outcomes merits increased scrutiny of the *risk and uncertainty* in the approach and actions proposed in the VMP.

CONCLUSIONS

Our review finds that the VMP fails to present a feasible approach to reestablishing ecologically viable vegetation along the channel of the Chehalis River and the adjacent slopes of the proposed reservoir. The VMP approach of advance planting 'inundation tolerant' species along the river and on the adjacent slopes in advance of the first inundation event is not feasible. Because of the poor water holding capacity of the soils, the slope instability, and the inability of native trees and shrubs to survive the anticipated duration and depth of full plant submersion anticipated, **the approach articulated in the VMP will not minimize or mitigate thermal loading and resultant increases in water temperature in the Chehalis River. The approach articulated will not minimize or mitigate the consequent cascade of ecosystem effects and the significant adverse impacts on aquatic habitat and salmonids which will occur if the proposed FRE facility is constructed and operated.**

The VMP also does not utilize best available science concerning the effect of the proposed alteration of vegetation communities on root cohesion, erosion, and attendant hillslope stability, particularly on the landslide prone slopes of the proposed reservoir. Further, the VMP fails to incorporate best available science related to climate change and its effects on hydrology and therefore perpetuates the errors and misrepresentations promulgated in the DEISs regarding the frequency and duration of FRE facility operations and the subsequent impacts upon reservoir vegetation survival, vegetation root cohesion, hillslope stability and sediment mobilization. The VMP therefore underestimates the scale, intensity, and duration of all reservoir operations impacts on terrestrial and aquatic habitats, fish and wildlife species, and water quality.

Based on our understanding of the proposed project and the analyses presented in the VMP and the NEPA and SEPA DEISs, we conclude that:

1. The VMP obfuscates the feasibility of implementing the approach it proposes by failing to acknowledge the complexities of redesignation and regulatory requirements under the Forest Practices Act for conversion of Weyerhaeuser commercial timber lands to lands in which the river's riparian zone and adjacent steep slopes can be converted to the FRE reservoir and periodically harvested as proposed in the VMP.
2. The VMP, and the NEPA and SEPA DEISs on which it is based, underestimate the frequency of peak flows that would trigger operation of the FRE facility under current conditions and therefore underestimates all impacts associated with frequency, magnitude, and duration of the operation of the FRE facility and reservoir inundation.
3. The VMP, and the NEPA and SEPA DEISs on which it is based, fails to include (NEPA), and fails to appropriately account (SEPA), for the ways in which climate change is altering precipitation patterns, intensity, and frequency of triggering flows, and thus similarly underestimated the frequency, magnitude, and duration of operation of the FRE facility and reservoir inundation on which the VMP is based.
4. The VMP offers an 'advance planting' approach that is based on a faulty analog of the Mud Mountain Dam reservoir, and which fails to account for soil moisture and slope conditions and is thus infeasible and fails to avoid or minimize the significant impacts associated with periodic inundation of 808 acres of currently functional riparian, wetland, and upland vegetation in the proposed reservoir area.
5. The VMP fails to include both reservoir vegetation root cohesion and associated hillslope stability analyses, necessary to assess the feasibility of the proposed 'advance planting' approach and the proposed 'adaptive management' approach of continuously assessing and replanting areas of vegetation establishment failure within the proposed reservoir.

6. The VMP similarly fails to recognize the pernicious effect of landslides and mass failures throughout the reservoir due to loss of hillslope root cohesion and the inability to establish plants both initially before the first inundation event and after repeated inundation events.
7. The VMP proposes to regularly remove trees over 6 inches in diameter every 7-10 years within frequently flooded areas of the reservoir. This plan will maintain the lowest root cohesion and maximize slope instability throughout the lifetime of the project.
8. Finally, the VMP fails to minimize or offer a viable strategy to mitigate the consequent significant impacts on water quality within the Chehalis River, particular increases in water temperature due to the loss of channel shade throughout the riparian zone of the proposed reservoir. The VMP also fails to present a viable strategy to reduce significant impacts to water quality through the introduction of vast quantities of fine sediment input into the river as a result of the loss of root cohesion, slope instability, and landslides.

Together, these flawed assumptions and analyses, result in an underestimation of all local reservoir impacts related to operation of the FRE facility, including the scale, intensity, and frequency of significant impacts to water quality, hillslope stability, sediment delivery and transport, instream aquatic habitat, and continued viability of salmonid populations in the upper Chehalis River. These flaws render the VMP poorly thought through and infeasible. As such, the VMP is a plan that does not lower or mitigate for the significant impacts acknowledged in the NEPA and SEPA DEISs.

Further, the VMP is a plan with high uncertainty, high risk, and high consequence for the Chehalis River and its ability to continue to support viable populations of salmonids and their associated aquatic, riparian, and upland habitats. **The inherent risk and uncertainty in predicting the outcome of the VMP approach, and indeed the feasibility of applying the VMP approach and 'adaptively managing' the outcome, is further amplified by the sensitivity of the resources affected, the consequence of the proposed actions, and the large scale and complex context of the landscape in question.**

The feasibility of implementing the VMP and 'adaptively managing' the reservoir as presented in the VMP is highly uncertain and the risks posed by the approach presented are incompatible with the scale of the impacts and the sensitivity of the resources which would be affected, including the upper Chehalis River's genetically distinct populations of Spring Chinook (Lestelle and Morishima 2020a and 2020b). Given the highly likely negative impacts on multiple, interconnected ecological outcomes, the scale of area affected, and the sensitivity of the aquatic resources affected, **the approach articulated in the VMP poses an unacceptable risk to the Chehalis River ecosystem and is incompatible with the public interest.**

Until uncertainty, consequence, sensitivity, and scale can be reduced, the reservoir management approach articulated in the 2021 Vegetation Management Plan cannot minimize or mitigate for the significant adverse environmental impacts detailed in the NEPA and SEPA DEISs.

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