Chehalis River Basin Flood Control Zone District (Kathy Burnaman)

Comments of Chehalis River Basin Flood Control Zone District on Revised Draft Environmental Impact Statement for the Proposed Chehalis River Basin Flood Damage Reduction Project.

Chehalis River Basin
Flood Control Zone District

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VIA Online Filing

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Re: Comments on Revised Draft Environmental Impact Statement for the Proposed Chehalis River Basin Flood Damage Reduction Project

Mr. Talebi:

The Chehalis River Basin Flood Control Zone District (District) appreciates the opportunity to provide comments on the Washington State Department of Ecology's (Ecology) Revised Draft Environmental Impact Statement (RDEIS) for the Proposed Chehalis River Basin Flood Damage Reduction Project (Project). The District is the proponent of the proposed Project, which is a publicly-funded critical infrastructure project designed to reduce basin-wide risks along 100 miles of the Chehalis River, from Pe Ell to Cosmopolis and Interstate 5, from major and catastrophic floods.

The District's elected supervisors have committed publicly that they will only support bringing the Project to construction *if it is clear that the Project will not result in negative environmental impacts*. Consistent with that commitment, over the past several years the District has: (1) refined the Project design to avoid and minimize many of the adverse impacts previously identified by Ecology; and (2) developed a 1000+ page publicly available Mitigation Plan that includes robust, thoughtful and detailed implementation plans.[1]

Ecology acknowledges that, if implemented, the District's Mitigation Plan would address most of the Project's anticipated impacts.[2] Yet Ecology chose not to analyze the beneficial

[1] The Mitigation Plan is available for public review under "Revised Mitigation Plan" here: https://www.chehalisriverbasinfczd.com/resources.
[2] *See infra* note 8 and associated text.

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effects of the Mitigation Plan in the RDEIS and concluded, inexplicably, that the Project's *avoidable* impacts are *unavoidable*. As discussed in Section II.A., below, this is prejudicial to the Project, contrary to the requirements of the State Environmental Policy Act (SEPA), and has resulted in significant public confusion regarding the Project's probable impacts.

The RDEIS also contains widespread misstatements and voluminous technical and analytical errors that are described and substantiated in Sections II.B and C below and in the attached detailed comment table (Attachment 1). These material inadequacies – which may be a result of the time pressure Ecology faced to issue the RDEIS by November 2025 – result in impact findings that are neither accurate nor consistent with law.

Specifically, the RDEIS:

- Materially overstates and misrepresents the Project's probable impacts, often on internally inconsistent or scientifically unsupported bases;
- Assumes the Project will operate for six months when the maximum flood operational period was 34 days – which has now been reduced to 21 days through the operational refinements discussed below;
- Makes erroneous claims that are contrary to common and foundational concepts of science, such as fish passage mortality numbers that defy scientific explanation;
- Inappropriately attributes climate change impacts to the Project;
- Fails to acknowledge the Project's critically important flood control and corresponding environmental benefits, including that Project flood operations will *reduce* the adverse effects to upper basin Chinook Salmon from increased flooding due to climate change;
- Contains unclear assertions of potential impacts on undefined tribal interests;
- Understates or ignores the foreseeable adverse environmental impacts of the No Action and Local Actions alternatives to the Project; and
- Reaches inaccurate and misleading "significant unavoidable adverse impact" conclusions for the Project across most resource areas.

As a result of these serious issues, the RDEIS has already resulted in substantial public confusion by declaring that the Project will have significant, unavoidable impacts – an assertion that is demonstrably false. Put simply, the RDEIS does not provide the required impartial discussion of the Project's probable and significant environmental impacts, alternatives and mitigation measures and therefore cannot accurately inform state and local agency decision making and the public, as required by SEPA and Ecology's own

regulations.[3] Ecology must correct these errors in its Final Environmental Impact Statement (FEIS) so that the public and governmental decisionmakers may reasonably rely on the FEIS when evaluating the Project.

Critically, the District has been unable to evaluate and provide comments on some of the RDEIS's most extreme claims regarding Project impacts because supporting technical analyses and modeling information was not provided coincident with the RDEIS, as required by law.[4] This includes, for example, the Ecosystem Diagnosis and Treatment (EDT), water quality and turbidity models and their supporting reports. As described in Section II.D, below, the opportunity to evaluate RDEIS supporting analyses is fundamental to the District's ability to meaningfully comment on the RDEIS itself. Ecology's failure to timely provide this information has prevented the District from commenting on critical aspects of the RDEIS.

Finally, and independently of any of the analytical or procedural errors noted above, the District has made a number of significant and important refinements to the Project design to further avoid and minimize identified Project impacts and meet flood reduction objectives. These were made after the 2024 Revised Project Description (RPD) which is reviewed in the RDEIS, and were necessitated by the U.S. Army Corps of Engineers' (USACE) separate and robust federal environmental review process. In Section II.E below, and in the technical memoranda and reports attached to these comments (Attachments 2 through 4), the District summarizes these changes for the public's information and for Ecology to consider in its FEIS.

I. Background

Over the past several decades, major and catastrophic floods have caused loss of life; significantly damaged area homes, business and agricultural areas; required the evacuation and temporary relocation of area residents; damaged and blocked access to critical public facilities; interrupted utility and sanitation services; temporarily shut down major transportation corridors and the Chehalis Airport; killed livestock and destroyed farm equipment; and caused untold economic damages. Long closures of public infrastructure like Interstate 5 have both public safety and economic ramifications. The 2007 flood alone resulted in estimated damages of over $900 million ($1.4 billion in 2026 dollars). Future

[3] *See* RCW 43.21C.031(2)(EIS must analyze "probable adverse environmental impacts which are significant."); WAC 197-11-402(1) (same); *id.* at 197-11-400(2) ("An EIS shall provide impartial discussion of significant environmental impacts and shall inform decision makers and the public of reasonable alternatives, including mitigation measures, that would avoid or minimize adverse impacts or enhance environmental quality.").

[4] *See*, *infra*, note 90 and associated text.

major and catastrophic floods will continue to put lives, property, public safety and the environment at risk.

To address this, the District proposes to construct and operate a proposed flow-through dam for flood control that would be located on the Chehalis River near the town of Pe Ell – also referred to as the Flood Reduction—Expandable facility (FRE). The FRE would directly address the foreseeable risks described above by reducing peak flood levels during major and catastrophic flood events. Once constructed, the FRE will allow for the free flow of the Chehalis River and volitional fish passage, closing only when specific flood levels are predicted to occur. An area behind the FRE will then temporarily hold water that would otherwise flood downstream communities, while continuing to provide normal winter flows to the river below. Flood waters will be slowly released over the following weeks once peak floods have passed. A comprehensive Mitigation Plan – which is an integral and enforceable component of the proposed Project – will mitigate for Project impacts and ensure a net ecological lift for aquatic and terrestrial resources. Improvements to the Chehalis Airport levee will work in tandem with the FRE's flood damage reduction protocols.

Recognizing the significance of this Project to the Chehalis Basin, the District engaged respected experts in engineering, geology, hydrology, and biology to ensure the Project's design, construction, and Mitigation Plan are of the highest quality. Our engineering firm has extensive experience designing and building dams and other significant structures across the country and is following a rigorous and iterative design process that will meet or exceed all state and federal design criteria, rules, regulations and guidelines. Our team of scientific consultants have developed avoidance, minimization and mitigation plans that will ensure the Project has the least practicable impact on Chehalis Basin resources and that the Project will result in a net ecological lift.

In Section II below, this comment letter addresses a number of the District's most serious concerns regarding the RDEIS, including misstatements, errors and legal failings. Additional technical corrections and substantive comments are provided in the attached comment table (Attachment 1). Where detailed technical memoranda (TM) or reports are referenced in these comments, those are attached for Ecology's review and use in developing its FEIS (Attachments 2 through 4). The District requests that these comments and all attachments be addressed in Ecology's FEIS and appended to that document without modification.[5]

[5] *See* WAC 197-11-560(2).

II. Detailed Comments

A. The RDEIS's dismissal of planned mitigation measures is contrary to law and results in fundamentally flawed conclusions.

The District has developed thoughtful and robust mitigation measures[6] in direct response to Ecology's 2020 Draft Environmental Impact Statement (DEIS) to address potential impacts identified in that document.[7] The RDEIS largely accepts that the District's planned mitigation, if feasible, will be effective.[8] Furthermore, both the RDEIS and Ecology's public statements make clear that Ecology did not analyze the feasibility of the Project's planned mitigation measures and has no basis for considering them infeasible.[9] Through considerable work described in the Mitigation Plan itself, the District has determined that the proposed measures are technically feasible and economically practicable and will be effective at offsetting most Project impacts and providing a net ecological lift.[10] Nevertheless, for most resource areas, the RDEIS describes but dismisses the District's planned mitigation,[11] allowing the RDEIS to then characterize the Project as having "significant unavoidable adverse impacts."

For example, with regard to fish species and habitat impacts, the RDEIS summarizes mitigation measures including but not limited to the Project's fish passage conduits, avoidance and minimization measures, the Fish and Aquatic Species and Habitat Plan, and

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[6] "Mitigation" refers to all measures that avoid, minimize, rectify, reduce, or compensate for impacts, or that monitor impacts in order to take corrective measures. WAC 197-11-768.

[7] *See* Ecology, State Environmental Policy Act Draft Environmental Impact Statement Publication - Proposed Chehalis River Basin Flood Damage Reduction Project, No. 20-06-002 (Feb. 27, 2020) (hereinafter "DEIS").

[8] The RDEIS generally acknowledges that, if District-planned mitigation is implemented as proposed, impacts labeled as "unavoidable" would be avoidable. *See* RDEIS at S-14 to S-19 (stating for eight resource areas that "significant and unavoidable impacts" would occur "*unless* mitigation is feasible") (emphasis added). There are also resource-specific acknowledgments that the District's planned mitigation will effectively offset some impacts. For example, the RDEIS's Water Discipline Report states that mitigation will offset temperature increases if implemented appropriately, thus mitigating for shade-related summer water temperature impacts. *See id.*, App. N., at 113. Similarly, the RDEIS's Air Quality and Greenhouse Gas Discipline Report credits the District's planned re-use of large wood in habitat restoration with reducing air emissions. *Id.*, App. A, at 32. The Earth Discipline Report also concludes that the Mitigation Plan's large wood measures are, along with other mitigation, "likely to improve fish habitat between the FRE facility and South Fork Chehalis River." *Id.*, App. F, at 86. Despite this finding, the planned mitigation measures are disregarded in the RDEIS's impact findings in the Fish Species and Habitat Discipline Report. *See, e.g.*, *id.*, App. E, at 156, 162.

[9] *See, e.g.,* RDEIS at S-12 (stating that feasibility of mitigation will be determined later); comments of Meg Bommarito (Ecology) at Virtual Public Hearing, Transcript at 6-7 (Jan. 8, 2026) (explaining that an "EIS does not analyze for the feasibility or effectiveness of that mitigation").

[10] *See, e.g.*, Mitigation Plan, *supra* note 1, at 101-216 (describing, *inter alia*, mitigation approach; actions to avoid, minimize, restore and mitigate; feasibility assessment for fish and aquatic species habitat mitigation; framework, feasibility, candidate sites and landowner engagement; site-specific mitigation plans; and effectiveness monitoring and adaptive management).

[11] *See* RDEIS at S-12, S-20.

compensatory mitigation for habitat loss. However, the RDEIS claims that "uncertainty" exists, not with regard to whether such measures will be effective, but with regard to whether such measures are "technically feasible and economically practicable."[12] The RDEIS states that, "[i]f regulatory agencies determine the plans meet their guidelines and implementation is feasible, then the impacts [of the Project] may be addressed as part of the permitting process.[13] This is in stark contrast to the RDEIS's treatment of the Local Actions Alternative, which is credited in the RDEIS for highly conceptual and vague floodplain storage and erosion management activities although these actions are not even proposed yet, let alone at the permitting-level of detail the RDEIS claims is required to credit the Project's planned mitigation.[14]

Ecology's dismissal of the Project's planned mitigation measures violates both the letter and intent of SEPA. SEPA does not instruct agencies to engage in illogical analytical contortions in which an impact that *can be avoided* is characterized as *unavoidable*. An Environmental Impact Statement (EIS) must describe impacts "which cannot be avoided"[15] and "which cannot be mitigated."[16] An EIS does not satisfy these requirements by mislabeling avoidable impacts as unavoidable. This is particularly true when the EIS acknowledges that the measures, if implemented, would succeed in avoiding significant impacts.[17]

Second, the fact that permitting has not yet occurred does not relieve Ecology of its obligation under SEPA to describe the proposed Project's probable environmental impacts, including its mitigation measures, in a manner that *accurately informs state and local agency decision making and the public*.[18] Ecology's unintuitive and uncommon usage of

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[12] *Id.* at 96-97.
[13] *Id.* at 97.
[14] *Cf.* RDEIS, App. E, at 178 (crediting the Local Actions Alternative with benefits for these programs based on no details), *with id.* at 171-73 (concluding that Project's detailed mitigation plans are too uncertain to rely upon despite them outlining, *inter alia*, two and a half times as much benefit as the quantified Project impact).
[15] RCW 43.21C.030(c)(ii) (EIS must include "any adverse environmental effects *which cannot be avoided* should the proposal be implemented.") (emphasis added).
[16] *Id.* at 43.21C.031(2) (EIS must include discussions of "significant short-term and long-term environmental impacts, … significant alternatives including mitigation measures, and significant environmental impacts *which cannot be mitigated* …") (emphasis added).
[17] *See supra* note 8.
[18] WAC 197-11-400(2) (one purpose of an EIS is to "inform decision makers and the public of reasonable alternatives, including mitigation measures, that would avoid or minimize adverse impacts or enhance environmental quality."); *id.* at 197-11-400(4) ("The EIS process enables government agencies and interested citizens to review and comment on proposed government actions, including government approval of private projects and their environmental effects."); *see also id.* at 197-11-440(6)(a) (EIS shall describe "significant impacts of alternatives including the proposed action, and discuss reasonable mitigation measures that would significantly mitigate these impacts.").

the word "unavoidable" has already confused the public: many commenters during the RDEIS hearings and meetings expressed concern regarding the Project based on the RDEIS's statements that impacts would be unavoidable, and their comments did not reflect an understanding that planned mitigation would (or even could) render those impacts avoidable. Ecology's repeated references to uncertainty about the mitigation has caused the public to doubt whether the planned mitigation will occur. This is in direct contravention of the purpose of an EIS.[19]

Third, the fact that regulatory agencies have not yet weighed in on whether the District's proposed mitigation will fully satisfy their permitting requirements does not lessen the District's commitment to fully implement those measures as minimum mitigation obligations. The only thing that is unclear is whether the agencies will require *more* mitigation than the District has already committed to implement. The FEIS should make clear that what is uncertain is not whether the District's planned mitigation will occur, but whether more may be required through permitting – in other words, there may be more mitigation, but there will not be less.

Fourth, alternatives evaluated in an EIS must "[i]nclude the proposed action, *including mitigation measures that are part of the proposal*."[20] SEPA does not require assurance that mitigation will be implemented before it can be considered (although the District has provided that assurance here); the obligation under SEPA is to make a reasonable evaluation of the entire Project's impacts, including mitigation.[21] Moreover, even where future agency approvals may be required, a proposal must still be evaluated "as long as proposed future activities are specific enough to allow some evaluation of their probable environmental impacts."[22] In other words, the threshold for requiring analysis of the Project's mitigation measures is not high; if even "some" evaluation of mitigation measures can be conducted, Ecology's own regulations require them to be considered as part of the Project's probable impacts.[23]

Fifth, the District has provided a comprehensive Mitigation Plan that is over 1000 pages long and which provides more than enough detail to allow "some evaluation of their probable environmental impacts."[24] Specifically, the Mitigation Plan includes detailed

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[19] *Id*.
[20] WAC 197-11-440(5)(c)(1) (emphasis added).
[21] *See supra* notes 3, 16 and 18; *see also Glasser v. City of Seattle*, 139 Wash. App. 728, 741-42 (Wash. Ct. App. 2007) (rejecting argument that SEPA requires "reasonable assurances" that adaptive management would actually occur because the purpose of SEPA is to "provide decisionmakers and the public with information about potential adverse impacts of a proposed action.").
[22] WAC 197-11-055(2)(a)(1).
[23] *Id*.
[24] *See* Mitigation Plan, *supra* note 1.

implementation plans for fish and aquatic species and habitat, riparian and stream buffer expansions, wildlife habitat conservation, forest conversion, large wood material recruitment and placement, surface water quality, and wetland enhancement. These plans, which include specific actions, performance standards and adaptive management, are entirely capable of being evaluated for their ability to avoid, minimize and mitigate for potential impacts related to Project implementation. Indeed, the District's own scientific experts have undertaken extensive evaluation of these measures throughout their development to ensure they will accomplish their stated goals. Ecology lacks the discretion to issue an EIS that defers – until some future time outside the SEPA process – its obligation to consider proposed mitigation when evaluating the Project's probable environmental impacts.

Notably, Ecology's handbook encourages an EIS to identify, to the extent possible, whether a mitigation measure will be "a condition of a permit" or not, to allow reviewers to better assess a proposal, and to discuss any uncertainties.[25] It does not follow, however, that measures not yet reviewed in permitting *should then be disregarded*. As SEPA's implementing regulations provide, an EIS must:

> [c]learly indicate those mitigation measures (not described in the previous section as part of the proposal or alternatives), if any, that could be implemented or might be required, *as well as those*, if any, that agencies *or applicants are committed to implement*.[26]

Ecology's handbook reinforces this, explaining that mitigation "may be *suggested by the applicant*; mandated by local, state, and federal regulations; or required through the use of SEPA substantive authority."[27] Nothing indicates that these categories should be treated differently for purposes of an EIS's analysis. Indeed, SEPA is explicit that mitigation measures must only be "reasonable and capable of being accomplished."[28] Ecology may not escape its obligation to evaluate District-proposed mitigation measures on the basis that they have not yet undergone permitting. Indeed, the FEIS must precede issuance of state permits, not the other way around.[29]

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[25] *See* Ecology, Washington State Environmental Policy Act (SEPA) Handbook, No. 25-06-009, at 59 (Sept. 2025) (hereinafter "SEPA Handbook").
[26] WAC 197-11-440(c)(iii) (emphasis added).
[27] SEPA Handbook, *supra* note 25, at 59 (emphasis added).
[28] RCW 43.21C.060; *see also* SEPA Handbook, *supra* note 25, at 74.
[29] *See id.* at 43.21C.030(c) (requiring EIS for major actions significantly affecting the quality of the environment); WAC 197-11-055(1) (SEPA must be completed "at the earliest possible time" in the decision making process).

Ecology's own handbook clarifies that mitigation does not need to be included in a permit condition or other legally binding document so long as the project design has been revised to include it:

> Mitigation must be included as permit condition [sic] or other legal binding document to be enforceable. *The exception is when an applicant alters the permit application(s) or project design to include the needed changes or conditions*.[30]

Consistent with this direction, the District included planned avoidance, minimization and mitigation measures, including its Mitigation Plan, in the RPD, which forms the basis for the RDEIS's proposed action. Accordingly, the RDEIS's conclusion that the District's proposed measures are uncertain because "they have not been permitted or approved as mitigation"[31] is flawed.

Making impact findings that reflect the Project *without mitigation* fails to meet the minimum standards of an EIS, the purpose of which is to assist agencies and applicants in improving plans and decisions and inform the public of probable Project impacts, including mitigation measures.[32] By improperly postponing the most critical part of the analysis to future permitting, the RDEIS cannot reasonably inform the public or the very agency permitting decisions that the RDEIS implies must somehow come first. Moreover, it would be contrary to state and federal law for the Project to be constructed without mitigation necessitated by the many permits the RDEIS recognizes will be required.[33] Accordingly, the RDEIS does not identify the Project's *probable* significant adverse impacts; it identifies impacts from a highly improbable situation in which the Project is illegally constructed without mitigation.

The District's planned mitigation measures are an integral part of the Project design submitted to Ecology for review in the RDEIS. The District has concluded that the planned mitigation measures are reasonable and capable of being accomplished. Accordingly, Ecology must evaluate and consider them in making Project impact determinations.

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[30] SEPA Handbook, *supra* note 25, at 74 (emphasis added).
[31] RDEIS at S-20.
[32] *See supra* note 18.
[33] *See* RDEIS at 43-46 (listing federal, tribal, state, local and regional reviews and approvals applicable to the Project).

B. The RDEIS contains numerous technical and analytical errors and materially overstates the Project's probable impacts.

The RDEIS contains material misstatements and voluminous technical and analytical errors that undermine its accuracy, credibility, and ability to inform the public and government decision makers. These numerous errors must be addressed in the FEIS to ensure that it fairly and accurately represents the probable impacts of the Project and its alternatives.

Perhaps the most egregious of the RDEIS's analytical errors arises from its EDT modeling inputs for the Project scenario. These inputs are so extreme, and so disconnected from the manner in which the District (and the RDEIS) expects the Project to operate, that the SEPA EDT model's predictions for salmon and steelhead outcomes provide no useful information about the Project's probable adverse impacts.

For example, in the SEPA EDT model, the approximately six-mile reach of river upstream of the proposed Project was changed in the model from "riverine" to "reservoir" habitat for each species starting in October and continuing, inexplicably, through March.[34] There is no reasonable justification for presuming six-month-long operational periods when the Project will only operate infrequently for about one-sixth of the time assumed. The faulty assumption that the Project turns riverine habitat into reservoir habitat for six full months results in the model's patently erroneous conclusions that:

- The Project will prevent spawning and incubation for all species from October through March;
- Juvenile Chinook and Coho production will be zero; and
- Downstream passage effectiveness will be zero from October through March.

These false assumptions cause the model to essentially kill off every spawner, egg, embryo, sub-yearling and yearling salmon or steelhead from the reaches upstream of the Project as well as any sub-yearling or yearling salmon or steelhead that would have moved out of tributaries downstream into this area. Moreover, the model effectively counteracts upstream fish passage effectiveness because any adult Coho Salmon or fall Chinook Salmon transported and released in the upper reaches of the temporary inundation pool would, per the model's faulty inputs, have no habitat available for spawning. By falsely assuming operation of the Project for six months, the productivity and capacity of this reach of the Chehalis River is artificially driven to zero every year the Project would operate

[34] *Id.*, App. E, Att. E-2 at 2-31.

for all spring Chinook Salmon, a majority of fall Chinook Salmon and a significant percentage of Coho Salmon.

To be clear, there has never been any proposal or expectation that the Project would operate for a six-month duration. The RDEIS uses a 2017 Operations Rule set for the Project, which it finds would result in a maximum of 34 days of inundation for the longest-wetted portion of the temporary inundation pool, potentially increasing to 60 days in the unlikely event that two major or catastrophic floods occurred back to back.[35] Yet the EDT model assumes the Project would operate 5.3 times longer than the RDEIS anticipates (an increase of 529 percent), and three times longer than the longest back-to-back flood (an increase of 300 percent).[36] There is no legitimate scientific or governmental purpose in modeling Project impacts using such wildly over-estimated operational periods. Moreover, while Ecology was working on the RDEIS, the District finalized updated rule sets for operations that would reduce this inundation time by about 33 percent, as discussed in Section II.E, below and in Attachment 2. These updated operational rules reduce the maximum temporary inundation to approximately 20 days.[37] In other words, the EDT model assumes the Project would operate nine times longer than now anticipated (a 900 percent difference), or 4.5 times longer than even the longest anticipated operations under back-to-back flood conditions (a 450 percent difference).

Furthermore, even if the six-month inundation period was somehow an appropriate modeling input (which it was not), the assumption that no juvenile fish survive in a pool is inconsistent with well-understood salmon ecology throughout the Columbia River Basin. Juvenile salmon do not all die in reservoir habitats; some fish will rear.[38] If passage is provided, they will move downstream, but if not, they can delay their downstream migration for days or weeks and will move downstream when conditions allow. The SEPA EDT model considers none of this, nor does the RDEIS explain why its modeling assumptions are so wholly inconsistent with general knowledge of salmon biology.[39]

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[35] *Id*. at 13, 15.

[36] Notably, these are maximum times; the upper reaches of the temporary inundation pool would drain faster than the portion closest to the facility.

[37] With the updated operations rule sets, upper reaches are expected to remain inundated for just two to 14 days, with areas closer to the Project remaining inundated for a maximum of 21 days. *See* Section II.E, below, and Attachment 2, Att. 2.

[38] *See* Attachment 3 (Fish Passage Design Report to Inform SEPA) at section 6 (describing behavior studies of steelhead, Chinook Salmon, and Coho Salmon).

[39] Similarly, the RDEIS's texts and tables imply that the SEPA EDT model treats the upstream survival rate estimates in RDEIS Appendix E, Table E-10 as a multiplier for all fish arriving at the Project site, rather than recognizing that fish may spawn downstream of the Project. The model's approach effectively "kills" fish that do not attempt to pass the Project. *See* RDEIS, App. E, Att. 3 at 3-11. This is an absurd assumption, given that the majority of Chinook Salmon redds documented in the last comprehensive survey (Ronne et al. 2018 redd survey) were below the proposed Project site. *See* Attachment 2, Att. 3 (including redd maps depicting these

In addition, the SEPA EDT model failed to account for variability in the Project's operational duration and temporary inundation levels. Not every flood is a catastrophic flood. Based on the District's modeling, nine operational events would have occurred over a 30-year period. The duration of temporary inundation upstream of the facility using the 2017 Operations Rule would range from 23.3 to 29.4 days with a median duration of 26.7 days, and the upper extent of the temporary inundation pool would range in elevation (NAVD88) from 518 feet to 587 feet, with a median of 567 feet.[40] When the SEPA EDT projects these inundation levels into future climate scenarios, it uses only the maximum inundation,[41] even though future floods will vary, just as past floods have. By holding constant these high-level assumptions regarding the inundation area, inundation duration, and fish survival, the SEPA EDT model effectively obscures these variations in the extent and duration of individual floods. In this way, the model overestimates inundation of spawning habitat for spring and fall Chinook Salmon and Coho Salmon.

The use of fundamentally flawed assumptions to configure the SEPA EDT model means that the resulting equilibrium abundance values – the estimated number of salmonids that the habitat above the Project can support over time – are also invalid. The SEPA Integrated Model, which incorporates EDT results into a Life Cycle Model (LCM), relied on these values as a starting point for how the Project would affect these fish subpopulations over time. By using them in the LCM, the inaccuracy of the EDT evaluation is magnified over 100 years. As a result, the Integrated Model's outputs do not accurately reflect potential effects to upper Chehalis River salmon subpopulations or the overall populations of salmon and steelhead in the Chehalis River Basin.

In summary, many of the input assumptions used in the SEPA models do not reflect Project operations as proposed, are inconsistent with general knowledge of salmon biology, and are supported by no legitimate scientific or analytical rationale. These errors individually and collectively undermine not only the modeling results – which are incapable of informing probable Project impacts – but the credibility of the RDEIS's evaluation of the Project as a whole.

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results). The District did not receive the EDT records in sufficient time to confirm this error. If true, however, the passage survival rates summarized in Table E-10 were likely applied incorrectly and do not accurately represent total survival as traditionally treated in a population model. As a consequence, they are extremely and unreasonably low (in addition to the fact that the component numbers used to calculate them are also unreasonably low, as described further below in this Section II.B). In that case, the population numbers generated by the EDT-LCM analyses are significantly in error and cannot be relied on to judge impacts of Project construction or operation. Additional modeling errors are described below and in Attachment 1.

[40] These temporary inundation periods would be about 33 percent shorter using the District's updated 2025 operations rule sets. *See supra* note 37.

[41] RDEIS at 15.

Other serious technical and analytical flaws undermining the RDEIS's analysis include, but are not limited to, the following:

- The RDEIS concludes, contrary to scientific literature and Ecology's own guidance documents, that the Project will interfere with channel-forming flows and processes downstream because it will reduce the severity of major and catastrophic flood flows.[42] This fundamental misunderstanding of river geomorphology ignores that the channel-forming flows in the Chehalis River system, like most river systems, occur at much lower and more frequent flows than those that produce major flooding.[43] Indeed, the RDEIS even analyzes this point and determines that lower flows "do the most 'work' over the long term at controlling and maintaining channel form."[44] The Project does not regulate and has no effect on such flows, and so will not interrupt channel forming processes. Yet, in the Earth Discipline Report and in several others, Ecology incorrectly concludes that the Project will interrupt such processes and thereby create adverse impacts to the river, fish, wetlands, and wildlife, with corresponding tribal and cultural impacts.[45] All of these impacts are incorrect, stemming from this wrong assumption.

- The RDEIS also fundamentally misunderstands wetland hydrology. It concludes, based on the Project preventing certain wetlands from being inundated in major and catastrophic floods, that these wetlands will lose habitat function.[46] But, the RDEIS cites commonly accepted authority on wetlands hydrology noting that a water source is only considered a component of wetland hydrology if it is present, on average, once every two years.[47] Major and catastrophic floods are rarer than that, currently inundating such wetlands only once in seven years. Even with the effects of climate change, such floods are not predicted to occur every two years. As a result, the

[42] *Id.* at 79.
[43] *See* Attachment 1, Comment 355. Ecology's own ordinary high water mark literature suggests that the most effective channel-forming flows are usually no greater than the two-year flood flows. Ecology, Determining the Ordinary High Water Mark for Shoreline Management Act Compliance in Washington State, No. 16-06-029, at 33 (Oct. 2016). Ecology's expertise on this subject lends credence to the RDEIS's own analysis that lower-than-major-flood flows are channel-forming in the upper Chehalis River, as they are in most gravel-bedded river systems. RDEIS, App. F, at 55, 57. Yet, the RDEIS disregards that evidence to conclude that the Project will interrupt channel forming flows by regulating less-frequent, less-geomorphologically important major flows.
[44] RDEIS, App. F, at 57.
[45] *See, e.g., id.*, App. F, at vi (finding significant geomorphological impacts as a result of "[t]runcation of peak flows during periods of impoundment affecting channel-forming flow processes"); *id.* at 71 ("During FRE flood operations, streamflows necessary for most channel-forming processes are reduced. This reduction in peak flows, and corresponding reduction in large wood and sediment transport, would directly impact creation of habitats that depend on those channel-forming processes.").
[46] RDEIS, App. O, at 41-42.
[47] *Id.*, App. O, at 54.

hydrology of these wetlands is not (and will not be) dependent on major or catastrophic floods, and reducing such floods through operation of the Project will not change their function.[48] The RDEIS's basic failures to understand the subject matter being analyzed, such as the channel-forming and wetland-inundation errors above, do not breed confidence in the remainder of its conclusions.[49]

- The RDEIS presents text and LCM results in tables and figures that conflate the Project's impacts with those from climate change, making the impacts of climate change appear to be effects of the Project. The RDEIS Summary states that the Project will have significant and unavoidable impacts on fish species, but has almost no information about the No Action Alternative's similar impacts.[50] Eighty-nine and ninety-four pages into the document, respectively, a table and graph depict a steep decline for three salmonid species after the Project's construction, such that they are expected to be extirpated from the area between Rainbow Falls and Crim Creek.[51] It is not until 100 pages into the document that one finds a similar graph for the No Action Alternative, which shows an even more precipitous decline of the same species in that area.[52] Because nothing in the RDEIS explicitly states that salmonids are predicted to disappear from this area of the basin irrespective of the Project, a non-expert reader is likely to assume from the first 100 pages that the *Project* creates these impacts. At no point does the RDEIS do the math for the reader to see the impacts attributable solely to the Project, as opposed to climate change. This makes it likely for the public to inappropriately attribute climate change impacts to the Project.[53]

- The RDEIS relies on unscientifically low and unsupported passage survival numbers of 34 percent to 69 percent for upstream adult salmonids, rather than using the 90 percent

[48] *See* Attachment 1, Comment 497. There are other reasons it would not impact these wetlands' function as well, as noted in the other comments surrounding Comment 497.
[49] This is especially true because the RDEIS reverses Ecology's prior conclusion on the same subject. The Wetlands Discipline Report in Ecology's 2020 DEIS analyzed wetlands similarly but found the impact to be minor. DEIS, *supra* note 7, App. O, at O-50 to O-53. The RDEIS undertakes the same analysis and finds *fewer wetlands* to be affected, and yet labels this a *significant* adverse impact. The RDEIS does not articulate a basis for this change, nor could a reasonable justification be produced.
[50] *Cf.* RDEIS at S-9 (discussing the proposed Project's impacts at length) *with id.* at S-8 (saying only that in the No Action Alternative, "climate change will continue to affect resources," as opposed to noting that it will extirpate some important species from the area between Rainbow Falls and Crim Creek).
[51] RDEIS at 89 (Ex. 5.3-2), 94 (Ex. 5.3-4).
[52] *Id.* at 100 (Ex. 5.3-7).
[53] Even once the No Action Alternative results are described, the modeling outputs show that the Integrated Model completely fails to capture the impacts of major and catastrophic flooding on fish populations under the No Action Alternative, which is one of the model's primary purposes. *See* Section II.C, below. This again tends to minimize the No Action Alternative's impacts and exaggerates the Project's impacts.

to 99 percent survival rates from major fish bypass facilities in the Columbia and Snake river basins that follow National Marine Fisheries Service (NMFS) fish passage criteria (which the Project will also follow).[54] By ignoring these proven benchmarks in favor of unsubstantiated and arbitrarily low survival estimates, the RDEIS departs from recognized best practices and undermines its scientific credibility.

- The RDEIS also ignores established standards for juvenile fish passage systems based on NMFS and Washington Department of Fish and Wildlife (WDFW) design criteria that are widely implemented in the Columbia and Snake river basins (which the Project will also follow) and which achieve 90 percent to 99 percent survival rates.[55] Moreover, the RDEIS's estimated downstream juvenile fish passage survival rate of zero percent for all species during flood retention events is unreasonably conservative and greatly overstates biological mortality. Flood retention events are far more likely to result in delay than mortality, and will include periods of downstream passage through pressurized conduits that are well documented at Columbia and Snake river dams to have survival rates for steelhead and Chinook Salmon of 95 percent to 99 percent. Survival numbers in the range of 60 percent to 70 percent for downstream passage during Project flood operations, considering delay, potential mortality associated with a temporary inundation pool, and passage through pressurized conduits, are generally conservative, more appropriate, and are supported by peer-reviewed science. Ecology's analysis should use these alternative survival numbers, not an unsupported value of zero percent survival that is contrary to established science.[56]

- The RDEIS frames adverse effects on cultural resources from the Project in a manner that is not supported by the current record. The permit review process includes an important assessment of Project effects on cultural resources under both state and federal law. Generally, the state process is predicated upon conclusions from the federal process. Here, the federal National Historic Preservation Act (NHPA) process has not progressed to a point where the state analysis can result in conclusions, yet the RDEIS is drafted as if it were so. The effect of the RDEIS's premature impacts conclusion is to short-circuit the critical process under federal law of identifying cultural resources and evaluating adverse effects of the Project. Further, the federal process provides a project proponent an opportunity to minimize and mitigate for any

[54] *See* Attachment 1, Comments 178-79.
[55] *See id.* at Comment 180-81.
[56] *See id.* The 95 percent and 85 percent juvenile downstream survival rates are documented in Appendices A and C of Appendix G to the June 2017 Chehalis Basin Strategy Combined Dam and Fish Passage Design Report.

adverse effects on identified cultural resources. This RDEIS reaches conclusions that are premature and not supported by the record or fact given that this process has not yet occurred. The FEIS must clearly reflect the interconnection and procedural posture of the federal cultural resources process and anticipated efforts to mitigate identified Project effects.

- Ecology previously found that the chance of a large earthquake happening while the reservoir is holding water is just one in 2.5 billion.[57] The risk of the facility failing as a result of those conditions is even less. Notwithstanding these facts, the RDEIS concludes that the impacts of facility failure are "significant and unavoidable,"[58] and that it poses a "significant and disproportionate adverse impact" on communities of color and low-income communities.[59] At the same time, the RDEIS ignores the Project's very real protection of human life, property and the environment – and in particular communities of color and low-income communities. The RDEIS's treatment of facility failure risks is contrary to law. An EIS must analyze "probable" adverse environmental impacts.[60] Ecology's own regulations state that impacts are "probable" only if they are "likely or reasonably likely to occur," and do not include impacts that "merely have a possibility of occurring, but are remote or speculative."[61] The District wants the public to understand all of the Project's inherent risks, but they must be accurately and fairly described. And, they should not be described to the exclusion of more likely, beneficial impacts on the same topic.

- The RDEIS's Fish Species and Habitat Discipline Report and the habitat assumptions that were incorporated into the SEPA EDT model both incorrectly assumed that 100 percent of large woody material (LWM) collected at the Project would be removed and lost to the system during flood events, whether or not the Project is operating for flood reduction.[62] This leads to the RDEIS reaching adverse impact determinations for

[57] DEIS, *supra* note 7, App. C, at C-13. It appears that this low probability language was omitted from the RDEIS's Environmental Health and Safety Discipline Report. *See generally*, RDEIS, App. C.
[58] RDEIS at S-15, 68.
[59] *Id.* at S-15, 168.
[60] RCW 43.21C.031(2)(EIS must analyze "probable adverse environmental impacts which are significant.").
[61] WAC 197-11-782.
[62] *See* RDEIS, App. E, at 139 ("Large wood would not be supplied to the river channel upstream of the FRE facility and large logs … would not pass downstream of the FRE facility, eliminating a primary source of large wood supply to the Chehalis River."). Tables E.2-5 and E.2-6 find that, during winter and summer non-flood conditions, 100 percent of LWM will be lost from above the FRE. *Id.*, App. E, Att. E-2, at 2-23, 2-28. Table E.2-7 finds that, during winter flood conditions, 100 percent of LWM will be lost from above the FRE. RDEIS at 2-34. Tables E.2-5 through E.2-7 summarize the assumptions about changes in habitat that were incorporated into the EDTI model, including large wood assumptions. *See id.*, App. E, at 131 (explaining relevance of tables to EDT model).

downstream fish populations, among other things.[63] The RDEIS claims that the District's RPD calls for removal of all wood within the temporary inundation area during flood events, and accordingly, "all wood was assumed to be removed within the inundation footprint."[64] This is not true. In fact, the RPD refers to a 2021 TM that details the District's long-standing commitment to move LWM collected at the Project to below the FRE for aquatic habitat mitigation.[65] Furthermore, Section 8.4 of the Mitigation Plan explicitly outlines the District's detailed LWM recovery and relocation plans to mitigate the disruption of wood transport both during flood and non-flood operations, including 15 proposed mitigation sites for LWM recruitment and placement.[66] It is impossible to reconcile the 2021 TM and Section 8.4 of the Mitigation Plan with the Fish Species and Habitats Discipline Report's conclusion that the District plans to remove 100 percent of LWM from the system. Notably, both the RDEIS's Air Quality and Greenhouse Gas Discipline Report and Earth Discipline Report recognize that LWM will be managed for reuse,[67] indicating that it was possible to read the RPD and associated documents and understand that the Project will not result in removal of 100 percent of LWM from the system.

- The RDEIS distorts no-impact and positive-impact conclusions by presenting them as adverse impacts. For example, in one sentence, the RDEIS both: (1) correctly concludes that there are no known mussel beds within the FRE footprint; and (2) concludes that any mussel beds that die in the construction area would be permanently lost as a result of the Project.[68] An accurate conclusion would be that, since there are no mussel beds in that location, none will be permanently lost as a result of the Project. Similarly, the RDEIS concludes that the Project's reduction in hazardous waste contamination of floodwaters is a "less than significant adverse impact."[69] However, it is not an adverse

[63] RDEIS, App. E, at 139-40.
[64] *Id.*, App. E, Att. E-2, at 2-23, 2-28.
[65] *See, e.g.,* District, Revised Project Description: Flood Retention Expandable Structure, at 80 (April 2024) (citing HDR, Large Woody Material Downstream Passage and Placement Clarification Technical Memorandum (Jan. 4, 2021) (HDR 2021a) ("LWM would be captured, staged, and sorted for use in downstream habitat enhancement projects as determined by the proposed mitigation program…")).
[66] Mitigation Plan, *supra* note 1, at 18, 185-89 (Large Wood Material Recruitment and Placement Plan).
[67] RDEIS, App. A, at 32 ("Large woody material removed during operations would be managed for reuse—such as placement in habitat features or incorporation into on-site restoration efforts—rather than burned."); *id.*, App. F, at 86 (concluding that large wood measures are, along with other mitigation, "likely to improve fish habitat between the FRE facility and South Fork Chehalis River."); *id.* at 88 ("When the FRE facility is operating, it is anticipated that substantial amounts of large wood material would accumulate on the trash rack. This material would be collected during drawdown and stored on site as a "wood bank" for use in future mitigation and restoration projects downstream of the FRE facility.").
[68] *Id.*, App. E, at 122; *see also id.,* App. E, at 55-57 (presenting 2020 survey data corroborating the conclusion that no mussel beds are found within the FRE footprint).
[69] *Id.*, App. C, at 26.

impact at all. The Project will reduce hazardous waste contamination to below the No Action Alternative levels. This is a positive impact that is improperly characterized as "adverse" (albeit less than significant) in the RDEIS.

- Finally, the overview above of the District's most significant SEPA modeling concerns does not attempt to describe every error in the EDT model's inputs, which appear pervasive. For example, model results for Coho Salmon indicate that adult capacity values were predicted to be 100,000,000,000,000,000 (one hundred quadrillion) for some scenarios without FRE facility operation – an astounding variation from the Project operational scenarios which range from 4,667 to 8,614 Coho Salmon – indicating an issue with the model or that a model artifact (*e.g.*, a placeholder number) was mistakenly left in place.[70] Additionally, the model's baseline condition outputs – which were used in the LCM model – estimated more adult spring Chinook Salmon spawners upstream of Crim Creek compared to downstream. This conflicts with WDFW survey data from 2013 to 2021 demonstrating that subpopulations downstream of Crim Creek have abundance numbers that are an order of magnitude greater than upstream subpopulations.[71] Beyond the baseline, the model's predictions also suggest there will be more spring- and fall-run Chinook Salmon spawners upstream of the Project compared to downstream, when in fact the majority of Chinook spawning upstream of the Newaukum River confluence occurs below the Project site.[72] The model also appears to underestimate habitat conditions that are adversely affecting salmonids under existing conditions, including bed scour, side channel and pool habitat, and embeddedness.[73] Using unvalidated parameters appears to be resulting in higher estimates of productivity and capacity than is supported by recent field surveys, which were presented to Ecology and other agencies in 2025.[74] These types of pervasive errors call into question the reliability of not only the SEPA EDT model outputs but the LCM and Integrated Model which rely on those outputs. Ecology should undertake a

[70] *See* Attachment 1, Comment 251.
[71] *See id*. at Comments 154, 173.
[72] *See id*. at Comment 154. Based on 2018 redd data, 81 percent of spring-run Chinook Salmon redds were located below the FRE site and 57 percent of fall-run Chinook Salmon redds were located below the FRE site.
[73] *Id*. See Section II.C, below, for an explanation of how these factors may result in the SEPA LCM model configuration completely failing to capture the effects of major or catastrophic floods on fish populations under the No Action Alternative.
[74] The District presented this information at Interagency Meetings on February 27, 2025 and July 24, 2025. This information was also presented to an OCB technical modeling workgroup on July 24, 2025 with follow-up meetings into the fall of 2025 in which some of the Ecology consultants working on the RDEIS participated, including the EDT modelers. The OCB's modeling workgroup decided to incorporate those data, but it appears that the SEPA EDT team opted not to consider them.

thorough and independent review of the modeling inputs to ensure any other errors are identified and corrected.

A full discussion of the numerous technical and analytical errors contained in the RDEIS can be found in Attachment 1.

B. The RDEIS does not accurately reflect the anticipated flood damage reduction benefits of the Project compared to the alternatives.

The proposed Project will result in significant, demonstrable flood reductions. Although the RDEIS describes and maps the Project's flood reductions, it fails to adequately analyze the beneficial environmental impacts that attend them. In some circumstances, Ecology may have discretion to discuss or evaluate beneficial environmental impacts.[75] However, in the context of this Project, Ecology cannot properly describe the Project's probable significant adverse effects – or those of the No Action and Local Action alternatives – without analyzing these benefits.[76]

The reason for this is twofold. First, the Project's greatest effects occur during times of major or catastrophic flooding, when the No Action and Local Actions alternatives would each have significant environmental impacts as a result of unregulated flooding. One cannot properly compare the Project's impacts to these alternatives without discussing how the Project would reduce some of the alternatives' most significant adverse impacts. Second, some of the beneficial environmental impacts of the Project affect the same resources that are expected to experience negative environmental impacts as a result of the Project. One cannot accurately describe the Project's probable adverse impacts on these resources without considering both the positive and negative potential impacts on the same resource.

On the first issue, the RDEIS frequently analyzes the impacts of the proposed Project's flood operations in comparison to a hypothetical world in which major or catastrophic flooding is not occurring. For example:

- The Earth Discipline Report (and elsewhere in the RDEIS, relying on this report's conclusions) discusses landslide risk from the Project's temporary inundation pool, without noting that a major or catastrophic flood would create comparable

[75] WAC 197-11-402(1) permits, but does not require, beneficial impacts to be discussed.
[76] The RDEIS must evaluate the probable adverse impacts of the no-action and local-actions alternatives "at a roughly comparable level of detail, sufficient to evaluate their comparative merits…." *Id.* at 197-11-442(2).

landslide risks in the absence of the Project, as well as potentially extreme scour downstream.[77]

- The Wildlife Species and Habitats Discipline Report discusses the risk that the temporary inundation pool will kill small and less-mobile terrestrial wildlife, without noting that a major or catastrophic flood – or the landslides that historically have attended such floods – would also likely kill such wildlife in the riparian vicinity.[78]
- The Fish Species and Habitats Discipline Report analyzes the risk of redd suffocation in the temporary inundation area, without noting that redds in the same area are likely to be eliminated in their entirety by scour from major or catastrophic flood flows, or that such flows strand fish far from waterways.[79]
- The Cultural Resources Discipline Report analyzes the risk to cultural sites in the temporary inundation area, again without noting that such sites have endured and will endure comparable risks from major or catastrophic floods, and the landslides that have historically attended them, regardless of whether the Project is built.[80]

The noted impacts above would occur in the No Action and Local Actions alternatives, which the RDEIS sometimes acknowledges. No comparison of these impacts for the Project versus those alternatives is made, however. If the Project is built, these impacts will be *reduced* downstream of the Project in times of major and catastrophic flooding. Reduced turbidity, scour, landslide risk, wildlife risk, redd destruction, and risk to cultural sites during these flood events in the areas downstream of the Project is an important point of comparison between the alternatives for decisionmakers and the public. The RDEIS should systematically analyze, not minimize,[81] the flood and flow impacts in the No Action and Local Action alternatives, and note how the proposed Project would reduce those impacts.

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[77] *Compare* RDEIS, App. F, at 30-31, 36 (finding significant and unavoidable geological landslide impacts) *with id*. at 39 (not mentioning landslide impacts of the No Action Alternative) *despite id*. at 7-8 (discussing background landslide geology in the absence of the Project). *And compare id*. at 74-78 (finding significant landslide risks and analyzing erosion and surface landslides in great detail) *with id*. at 95 (mentioning landslides and erosion in one paragraph) *despite id*. at 43, 50-51, 53 (discussing landslides resulting from major and catastrophic floods).

[78] *See* RDEIS, App. P, at 89, 112 (not comparing the inundation risk to small animals from the Project's flood operations with the No Action Alternative's admitted flood risk to wildlife species).

[79] *Compare id.*, App. E, at 133 *with id*. at 204-06 (showing no or little effect on three of four species from recurring flood scenarios consisting of major or catastrophic floods in three consecutive years) *despite id*. at 63 (acknowledging that high flows should scour redds and disrupt salmon spawning behaviors).

[80] *Compare id.*, App. B, at 30 (noting such Project impacts) *with id*. at 38 (downplaying such impacts for the No Action Alternative as "naturally occurring events rather than human-caused alteration") despite the acknowledgement throughout the RDEIS that human-caused climate change is increasing flood flows and scour and landslide risks.

[81] *See, e.g., supra* note 50.

In addition to failing to qualitatively identify and analyze the flood impacts of the No Action and Local Actions alternatives, the RDEIS's modeling fails to capture these impacts quantitatively. Notably, the modeling *tries* to capture these impacts: the Fish Species and Habitats Discipline Report says climate change impacts were included in the No Action Alternative modeling,[82] recognizing that high flood flows due to climate change are predicted to harm salmon abundance through increased scour and disruption of salmon spawning, rearing and migration.[83] The EDT and LCM models attempt to capture these effects through increased flow predictions, even considering three major-or-larger floods in three consecutive years, called a "recurring flood" period.[84] But, when the model outputs are presented for the No Action Alternative, the fish abundance results for recurring floods are utterly indistinguishable from when recurring floods do not occur.[85] This is true for all species, in all areas, in all climate scenarios. As shown by the figure below,[86] even Spring Chinook (which spawn only in the mainstem) for the late-century maximum climate scenario (where the predicted floods would be the biggest) show no population impact whatsoever from three consecutive major or larger floods in three years.

Figure from RDEIS Appendix E p. 185, with red markup

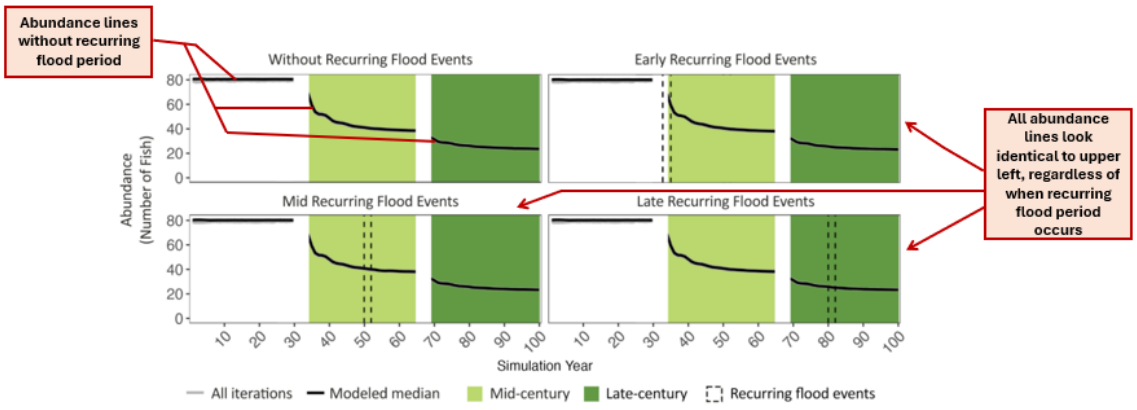

Figure E-35. LCM Results for Spring Chinook Salmon Above Crim Creek Under No Action Alternative, Maximum Climate Change Scenario

Note: Changes in abundance are the result of implementation of the activities described under the No Action Alternative and climate change for mid- and late-century time periods.

[82] REDIS, App. E, at 179 (referencing sections 2.23 and 2.4.2.1).
[83] *Id.* at 63.
[84] *Id.* at 78 and 181.
[85] *See id.* at 183-201 (depicting fish abundance declines without such repeat flooding versus with such repeat flooding in early, mid, and late century windows; all the results in each figure are identical). However, these model changes did not include hydraulic or hydrologic modeling above the proposed Project, *id.* at 79-80, and that lack of data shows in the Integrated Model results.
[86] The figure is copied from the RDEIS (App. E, at 185), with markup inserted by the District to show how the black abundance lines shown when no recurring flood is modeled are identical to the black abundance lines shown when a recurring flood period happens in early, mid, and late centuries. Basically, the SEPA integrated model shows three huge floods in three years having no effect on fish populations.

The lack of change to the black abundance lines around the recurring flood event lines is bewildering. Predicting no population effect from such massive flooding flies in the face of the principle the RDEIS articulates that large floods hurt salmon abundance, as well as observed results of large floods. For example, WDFW has publicly stated that the recent Skagit County flooding will severely impact salmon returns for three years due to scour and suffocation.[87]

These results suggest that, as configured for the RDEIS, the SEPA Integrated Model is broken: it does not capture the negative impacts to fish from increased flood flows due to climate change, which the RDEIS writers intended it to do. It therefore cannot correspondingly show the benefits of the Project in reducing such impacts to inform a comparison between the alternatives. This modeling both under-informs the public and decisionmakers about the potential impacts of the No Action and Local Actions alternatives and, as described below, overstates the adverse impacts of the Project. The FEIS must correct these material inadequacies.

The second issue builds upon the first: when the Project would have both beneficial and negative potential impacts on the same resource, the RDEIS must look at both to correctly describe its probable adverse impacts. As noted above, WDFW has publicly stated that the recent Skagit County flooding would severely impact salmon returns for three years due to scour and suffocation. These are the very same types of impacts that the RDEIS ascribes solely to the proposed Project, *but not to the No Action or Local Actions alternatives*. In a future in which major or catastrophic flooding potentially occurs on average every three years (the same length of time WDFW estimated major flooding to negatively impact salmon returns), the impact of the No Action or Local Actions alternatives on salmon may result in their extirpation in the uppermost Chehalis Basin. If so, the Project's shielding of productive spawning gravels downstream near Pe Ell may enable mitigation to preserve Chinook Salmon – a population recovery option that would not be available in the absence of the Project due to frequent high flows.[88] The RDEIS cannot fully describe the Project's probable adverse impacts on salmon populations without considering both the potential negative effects of temporary inundation events and the potential positive effects of

[87] A WDFW spokesman commented that "This record-setting flood event will likely have severe impacts on salmon, particularly eggs laid earlier this fall, many of which will be lost due to scour from floodwaters or buried under heavy sediment. As a result, there will be affects [sic] to salmon returns in 2027-2029." *See* https://nwsportsmanmag.com/severe-impacts-on-salmon-anticipated-from-record-setting-washington-floods-wdfw/. Such statements are not new; OCB Board members have publicly commented on hearing similar assessments of flood damage to fish populations in prior floods.

[88] Notably, in the last comprehensive survey of spawning redds upstream and downstream of the Project site (Ronne et al. 2018 survey), a large majority of Chinook Salmon spawning redds were downstream of the proposed facility, and so could receive protection from high flood flows under the Project alternative.

protecting downstream redds, as these two effects *together* comprise the Project's impact on salmon.

The same is true of water quality. The RDEIS analyzes turbidity and temperature impacts of the proposed Project. But, turbidity also arises from huge floods under the No Action and Local Actions alternatives: photographs of the 2007 flood show wide swaths of opaque, muddy water that left thick mud and silt slicks within flooded areas.[89] Moreover, in the absence of the Project, major or catastrophic floods result in landslides, infrastructure, debris, cars, equipment, sewage, trash, gasoline, and chemicals running off into the Chehalis River. The Project will reduce the flows that contribute to scour and landslides downstream of the Project, and it reduces the severity and area in which floodwaters can absorb pollutants before receding into the river. These are water quality benefits that offset some of the Project's potential water quality impacts from operations. Both must be analyzed to determine the Project's probable adverse impact on water quality.

Finally, the impacts to transportation, public services, environmental health and Environmental Justice cannot be complete without analyzing the Project's reduction in flood damage. Roads and bridges are destroyed in flooding. Emergency responders' call volumes soar, while simultaneously the flood interferes with their ability to provide prompt assistance. Electricity, sewer, and water services can be damaged or disrupted. Floodwaters contaminate homes. And, it is often the poorest residents whose homes are in the areas of greatest risk and who have the least means to protect themselves or relocate to prevent damage. The Project lowers flooding from Pe Ell to Cosmopolis along 100 miles of river, reducing all of these impacts and providing a significant benefit over the No Action and Local Actions alternatives. This important point is discussed little in the RDEIS. It is especially telling that the RDEIS concludes that the proposed Project will have a significant adverse unavoidable impact on Environmental Justice following its failure to consider the benefits above. That conclusion is highly misleading, and derives from failing to consider both the positive and negative effects when determining what impacts are adverse or probable.

Accordingly, the FEIS must more rigorously analyze the impacts of the No Action and Local Actions alternative from high flows and flooding. It should consider the environmental benefits of the proposed Project from reducing those impacts, and it should use that information both to inform the choice between the listed alternatives and to accurately delineate the significant probable adverse impacts of the Project, weighing its positive and negative effects on the same resources. Further examples of the RDEIS's failure to consider

[89] Chronicle Photo Gallery - "Flooding", *available at* https://photos.chronline.com/gallery/21325471/.

the Project's beneficial impacts or failure to analyze the flood impacts of alternatives can be found in Attachment 1.

D. Ecology failed to timely provide supporting analyses and modeling that are necessary to understand the RDEIS's analyses and conclusions.

Many of the RDEIS's most important conclusions regarding Project impacts are based on key technical analyses and modeling information not contained in the RDEIS or its appendices, whose results are merely summarized (sometimes opaquely) in the RDEIS. A SEPA document must contain sufficient information to allow its conclusions to be generally understood or, where it relies on supporting analyses, studies, or technical reports, those materials "shall be readily available to agencies and the public during the comment period."[90]

For example, to understand conclusions in the RDEIS that are premised on the water quality and hydrodynamic model called CE-QUAL-W2, one must have access to the model input and output files for water temperature, dissolved oxygen, and turbidity, as well as documentation of all assumptions and metadata/data dictionaries. Similar underlying files and data are necessary to understand the RDEIS's use of EDT, LCM, Hydrologic Engineering Center's River Analysis System (HEC-RAS), Water Erosion Prediction Program and Physical Habitat Simulation System (PHABSIM) models in reaching conclusions regarding probable Project impacts on water, fish and other resources. In addition, fully understanding the RDEIS's hydrology and river hydraulics analyses requires access to their associated data, including temperature and precipitation time series data, flow data and flood frequency analyses (for hydrology) and river configuration, terrain, depth grid rasters or floodplain extents data, floodplain structure inventory and/or other spatial data (for river hydraulics).

Recognizing Ecology's obligation to provide such materials, the District reached out to Ecology staff in the weeks leading up to the anticipated release of the RDEIS to determine the best way to obtain this information from Ecology. During an in-person meeting on November 14, 2025, Ecology staff indicated to District staff that a formal request from the District would not be necessary and that Ecology would provide these materials in support

[90] WAC 197-11-440(7); *id.* at 197-11-030(2)(c) (SEPA reviews must be "supported by evidence that the necessary environmental analyses have been made."); *id.* at 197-11-090 (any background or supporting analyses, studies, or technical reports "shall be considered part of the agency's record of compliance with SEPA" so long as it complies with requirements for incorporation by reference); *id.* at 197-11-635 (material incorporated by reference "(a) shall be cited, its location identified, and its relevant content briefly described; and (b) shall be made available for public review during applicable comment periods.").

of the RDEIS review.[91] However, the RDEIS was subsequently issued on November 20, 2025 *without* those materials.

Upon realizing that these materials were not contained within or released with the RDEIS, District staff made follow-up requests to Ecology inquiring about the missing information on November 25, 2025 and December 1, 2025.[92] On December 2, 2025, Ecology staff directed the District to request this information instead from the OCB, which is housed within Ecology and implements the Chehalis Basin Strategy, and to submit a formal Public Records Act (PRA) request if needed for any remaining information.[93] Over the next six days, District staff coordinated with OCB staff to determine the best way to obtain the requested information, only to learn from OCB staff on December 8, 2025, that OCB did not have the great majority of the information the District had requested from Ecology.[94]

Accordingly, on December 8, 2025 the District submitted a formal PRA request to Ecology for the majority of the originally-requested information.[95] In the interest of time, the District made this request despite Ecology's legal obligation to have provided these technical analyses and modeling information with the RDEIS in the first instance,[96] and notwithstanding that the District is not only the Project proponent, but a quasi-municipal corporation of the State of Washington with whom Ecology could share records in a government-to-government exchange, outside of the PRA request process.

After significant coordination between District and Ecology staff and consulting teams over the ensuing two weeks, the District received installments of requested records on December 22, 23, and 26, 2025, consisting of water quality model and LCM results, a structures database, and hydraulic model results. These records did not include the turbidity portions of the water quality model, the other models requested, the wetlands inventory used in analysis, or the documents setting forth assumptions and methodologies used in such models. Much of that information then came to the District in an installment

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[91] M. Bommarito (Ecology), pers. comm. to K. Burnaman (District) (Nov. 14, 2025).
[92] Email from K. Burnaman to M. Bommarito (Nov. 25, 2025); email from K. Burnaman to M. Bommarito (Dec. 1, 2025).
[93] Email from M. Bommarito to K. Burnaman (Dec. 2, 2025).
[94] Email from K. Burnaman to Nat Kale (OCB) (Dec. 3, 2025); email from N. Kale to K. Burnaman (Dec. 8, 2025). Following this exchange, District staff sent multiple additional emails on December 8, 2025 to confirm that Ecology would in fact require a PRA request to obtain the great majority of the analyses and information relied upon in the RDEIS. *See* email from Eric Eisenberg (District) to and between M. Bommarito and N. Kale (Dec. 8, 2025). It was at this point that the District realized that there was no plan to disseminate all of the modeling information through the OCB, despite Ecology directing the District to obtain that information from OCB. The OCB did promptly share, through its contractor ICF, the limited EDT-related information it had, on December 11 and 12, 2025.
[95] E. Eisenberg, Request for Public Records to Ecology (Dec. 8, 2025) (submitted via Ecology online public records request center).
[96] *See supra* note 90 and associated text.

on January 15, 2026, more than two-thirds of the way through the comment period. Still, it did not include key information about juvenile fish modeling used in the LCM, nor did it include the turbidity modeling. The latter was produced on January 29, 2026, six days before comments on the RDEIS were due.[97]

Ecology's public records' staff's worked hard to provide a large quantity of materials in steady installments over the winter holidays. That work is appreciated by the District, and the District likewise worked hard to narrow its request when appropriate to facilitate Ecology's prompt response.[98] However, the District should not have had to obtain these supporting records through the slow and laborious PRA request process in the first instance. The District alerted Ecology to its desire to review the materials well before the RDEIS's release, and Ecology had a duty to release this supporting information coincident with its release of the RDEIS.[99]

To be clear, the requested materials are consequential to the RDEIS's impacts analyses, which rely almost exclusively on models that unintentionally obscure the source of its analysis and conclusions to find that the Project will have significant adverse environmental impacts on a host of resources. In most instances, the District's experts have been unable to determine the source of these purported impacts from the text of the RDEIS alone. The models, inputs and other requested analyses are necessary to understand and provide meaningful and constructive feedback on the RDEIS's conclusions.

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[97] Ecology produced a 2019 memo about turbidity and noted that it had not done additional turbidity modeling for the RDEIS. Email from M. Bommarito to E. Eisenberg (Jan. 29, 2025). This was surprising considering statements in the Water Discipline Report that a "combination of CE-QUAL-W2, HEC-RAS, and Water Erosion Prediction Project (WEPP) models were used to evaluate the different deposition and resuspension mechanisms for major and catastrophic floods; model details are documented in the Reservoir Water Quality Report (Anchor QEA 2019a)." RDEIS, App. N, at 56. Because the RDEIS used updated CE-QUAL-W2 and WEPP modeling, it seemed that the Anchor 2019a citation was merely a reference to methodology for an updated turbidity analysis. However, it seems there was no updated turbidity analysis, and the Anchor 2019a memo *was* the turbidity analysis. Turbidity is an important driver of outcomes in fish abundance modeling. This already-existing analysis should have been provided to the District and the public at large when the RDEIS was released.

[98] For example, after hearing from Ecology's subconsultant for hydraulic and hydrological analysis that producing the underlying data for the RDEIS's hydrology and river hydraulics analyses would be time-consuming and unwieldy, the District narrowed its request for such data to only the outputs of the hydraulic (RiverFlow2D) model. This compromise did reduce the value of the information ultimately produced to inform the RDEIS's hydrology and river hydraulics analyses, but the District nevertheless made this compromise in the interests of time.

[99] WAC 197-11-440(7) (supporting analyses, studies or technical reports relied upon in an EIS "shall be readily available to agencies and the public during the comment period."); *see also, supra* note 90 and associated text.

The District's time and ability to meaningfully review, interpret, understand and develop comments on key analyses and conclusions in the RDEIS consistent with the requirements of SEPA and Ecology's regulations has been materially frustrated by the unnecessary and significant delays caused by Ecology: (1) initially indicating that materials would be provided with the RDEIS – a commitment that the District relied upon to its detriment for several weeks; (2) failing to acknowledge that the materials had not been so provided, causing District staff to spend approximately one week looking for those materials among the RDEIS's 22 electronic files and 2,261 pages; (3) instructing the District to obtain requested records from the OCB that the OCB, with one exception, did not have; (4) insisting that the District submit a PRA request in contravention of Ecology's obligation to provide supporting materials with the RDEIS for public review and comment; and (5) releasing a significant portion of the requested records nearly *two months* into the two-and-a-half month comment period.

While the District now has most of the originally-requested materials, they were not provided in time for the District's engineering and scientific consulting team to conduct the necessary in-depth review to then: (a) use that information to better understand the RDEIS's most radical and extreme conclusions sufficiently and; (b) prepare comments on those conclusions. As Ecology must be aware, a project proponent does not prepare its comments on a 2,261-page RDEIS and its supporting documents in the final days of the comment period. This is why Ecology's own regulations require that supporting documents be made available for public review during the comment period – not merely at the end of a comment period.[100]

Ecology's failure to timely provide the requested records has materially interfered with the District's ability to understand and comment on critical aspects of the RDEIS during the comment period provided.[101] Accordingly, the District intends to continue reviewing those materials and will submit follow-up comments, as appropriate, for Ecology to consider in preparing its FEIS.

[100] *See supra* note 90 and associated text. The District's experts noted that the they did not have time to analyze the WEPP or PHABSIM models, nor the turbidity modeling memo from 2019, because of their late delivery. Given the RDEIS's incorrect modeling assumptions and configurations outlined in section II.B, above, it was important to vet the assumptions and configurations of these models to see how they produced any results reported in the RDEIS. The District could not do so in the time provided.

[101] District staff inquired with Ecology staff regarding the potential for an extension of the comment period to accommodate our need to review the late-provided materials. Ecology staff was adamant that no extension would be provided. M. Bommarito, pers. comm. to K. Burnaman (Jan. 6, 2026).

E. The Project has been refined to further avoid and minimize identified Project impacts and these refinements must be considered in the FEIS.

The District provided its RPD and revised Mitigation Plan to Ecology – which forms the basis for the RDEIS's description of the Project – in April and July 2024, respectively. Ecology requested some additional information and minor technical edits to both documents, which were submitted on December 2, 2024. At that point, Ecology requested that the District submit no revisions to the Project description while the RDEIS was being prepared. However, the District is continuously evaluating ways to further avoid, minimize and mitigate for potential Project impacts while maintaining the Project's critical flood damage reduction benefits. Moreover, federal regulatory proceedings have necessitated the District's development of more detailed Project information and refinements, particularly with regard to fish passage.[102] Accordingly, in the intervening 14 months since December 2024, the District has made certain material Project refinements that reduce anticipated impacts, improve Project mitigation, and meet flood reduction objectives.

The District's refinement process began with addressing the facility's flood operations, one aspect of which is debris management during floods. Specifically, the District worked with its experts to: (1) identify locations lower in the temporary inundation area to store woody debris during floods; and (2) reduce the overall time spent collecting woody debris.[103] In addition to subjecting fewer trees to temporary inundation – thus resulting in a reduction in impacts to vegetation – these changes will allow the temporary inundation area to be evacuated much more quickly, materially reducing the time during which salmon and steelhead redds above the FRE will be impacted by the temporary inundation of flood water.

Next, the District refined its "reservoir operations" (Res-Ops)[104] analysis to examine precisely when and how the temporary inundation pool will be evacuated in the hours, days and sometimes weeks after a major or catastrophic flood.[105] The goal of refining these operations, together with the debris management work above, was to allow water to be

[102] Specifically, the USACE is in the process of preparing its own EIS pursuant to the National Environmental Policy Act. 42 U.S.C. § 4321, *et seq*. Additionally, USACE has instructed the District to prepare a Biological Assessment to inform USACE's Endangered Species Act section 7 consultation with NMFS and USFWS. 16 U.S.C. § 1536(a)(2).
[103] *See* Attachment 2 at Section 4.0 and Att. 1 (Debris Management During Flood Retention Report (Draft)).
[104] The term "reservoir operations" is an engineering term used to describe management of water behind a structure. The District is not proposing a permanent reservoir. For this project, Res-Ops involves managing the filling and drainage of the Project's temporary inundation pool following a major or catastrophic flood event. *See id.*, Att. 2 (Reservoir Operations Analysis (Draft) TM).
[105] *See id.* at Section 5.0 and Att. 2 (Reservoir Operations Analysis (Draft) TM).

released sooner, thus reducing the impact of the temporary inundation area on salmon and steelhead redds above the FRE, while continuing to meet flood damage reduction goals.

Refined debris management locations and sizes as well as Res-Ops changes that reduce the frequency and duration of temporary inundation pools were then used, in turn, to examine how the change in temporary inundation levels would reduce impacts to salmonid redds upstream of the facility.[106] The District also updated the RPD's Vegetation Management Plan (VMP) analysis regarding vegetation mortality from temporary inundation, which showed a decreased impact on trees.[107] Finally, the District analyzed the tree canopy implications of these data and updated its water temperature model, which showed that planned mitigation will result in cooler temperatures downstream of the FRE than previously predicted.[108] In the future, the updated debris management, reservoir operations, redd inundation, vegetation management, and temperature data will all feed into updated Mitigation EDT modeling and life cycle analyses to demonstrate potential reductions in environmental impacts compared to Ecology's 2020 DEIS and the RDEIS.

Separately from the work above, since submission of the RPD in 2024, the District has been working with NMFS's assigned fish passage engineer at the direction of USACE. The purpose of this work is to ensure that the Project's fish passage facilities meet or exceed NMFS criteria, including NMFS guidance for incorporating climate change into the fish passage design. After several months of such interactive meetings, the District has refined the fish outlet works to improve fish passage even under increased future flow conditions.[109] Specifically, while the FRE's primary conduits will continue to provide downstream fish passage and serve as a secondary upstream passage route, primary upstream fish passage will now be provided through the addition of two dedicated upstream fishways designed in consultation with NMFS. These dedicated upstream fishways will pass through the facility like the primary conduits and will meet established state and federal fish passage design guidance for fishways. They consist of two types of fish ladders frequently used in Washington, except that they are designed with much smaller drops in water surface from pool to pool to be far more manageable for juvenile fish and resident fish species than most adult fish ladders.[110]

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[106] *See id.* at Section 6.0 and Att. 3 (Inundation Analysis with 2024 Project Design and 2025 (O4P2) Operational Scenario TM).
[107] *Id*.
[108] *See id.* at Section 7.0 and Att. 4 (Riparian Shade Temperature Model with 2024 Project Design and 2025 (O4P2) Operations TM).
[109] *See* Attachment 3 (Fish Passage Design Report to Inform SEPA).
[110] See *id.* at 20 (Section 5.1.1, depicting the fishway layout and the water level from one end to the other, showing a very gradual change in elevation of only about 12 to 13 feet overall).

Finally, the District has refined its analysis of the water needed for construction of the Project. Based on information the District previously provided, the RDEIS estimates that 3.7 cubic feet per second (cfs) of water will be consumed continuously throughout the construction period.[111] Since 2024, however, the District has conducted an updated water demand assessment including the evaluation of the peak and average water demand anticipated throughout construction, with reference to specific construction activities' estimated water usage and schedule.[112] The result is a much lower average estimated monthly water use than 3.7 cfs: the lowest monthly average demand (January) is 0.43 cfs, and the highest monthly average demand (July) is 0.88 cfs. Adding a 20 percent buffer to each estimate yields monthly average continuous water demands of 0.52 to 1.06 cfs.[113] This is less than a third of the water usage the RDEIS analyzes, and this reduction in water needs will help avoid and minimize water-quantity and water-rights impacts noted therein. The District will continue to refine its construction water demand estimates as part of a plan to determine sources of construction water supply and associated mitigation for water use.

To aid Ecology in considering each of these Project refinements in its FEIS, the District is attaching the following information to these comments as Attachments 2 through 4:

Attachment 2: Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum

Att. 1: Debris Management During Flood Retention Report (Draft)

Att. 2: Reservoir Operations Analysis (Draft) TM

Att. 3: Inundation Analysis with 2024 Project Design and 2025 (O4P2) Operational Scenario TM

Att. 4: Riparian Shade Temperature Model with 2024 Project Design and 2025 (O4P2) Operations TM

Attachment 3: Fish Passage Design Report to Inform SEPA

Attachment 4: Water Demand During Construction (Draft) TM

[111] RDEIS, App. N. at 65.
[112] *See* Attachment 4 (Water Demand During Construction (Draft) TM).
[113] *Id*.

Finally, the District is continuously evaluating ways to further avoid, minimize and mitigate for potential Project impacts and meet the Project's critical flood damage reduction objectives. Additional improvements to the VMP and Project EDT analysis are likely in the coming months; other mitigation may result from discussions with the OCB or its partner entities and participating Tribes. As noted above, this will result in more Project mitigation, not less. Moreover, the NHPA Section 106 process is ongoing and is likely to result in additional mitigation. The District is also in the process of developing refinements to the Chehalis-Centralia Airport levee design that involve the addition of a floodwall on the east side of Interstate 5 in the area of the airport. This floodwall would be similar – but with fewer impacts – to one proposed in the Local Actions Alternative and evaluated in the RDEIS.[114] The District will provide Project refinements to Ecology as soon as possible to inform the FEIS, as appropriate.

III. Conclusion

As described in this letter and the attached detailed comments (Attachment 1), the RDEIS contains significant misstatements, errors and legal failings. Ecology must correct these errors in its FEIS so that the public and governmental decisionmakers may trust in its findings and rely on its conclusions regarding the Project's impacts, alternatives and mitigation measures.

Most critically, the FEIS must be substantially revised to consider the District's planned mitigation and include that mitigation when making Project impact determinations, and it must correct the misrepresentations and voluminous technical and analytical errors contained in the RDEIS that undermine its accuracy, credibility, and ability to inform the public and government decisionmakers. Finally, the FEIS must consider the Project refinements described above and in the attachments, which materially reduce and mitigate for the Project's anticipated impacts.

The District appreciates Ecology's consideration of these comments and the information provided, and requests that these comments and all attachments be appended to the FEIS without modification.[115] Moreover, because of the significant and substantive nature of these comments, the District requests that Ecology take the time necessary to address

[114] The floodwall would be in a similar location to, though slightly east of, the Local Actions Alternative's floodwall depicted in the RDEIS at 31 and App. 1, at 60 (Fig. 1-15), the impacts of which are described in Section 5.2.3 of the RDEIS at 82. However, the District's proposed floodwall would be: (1) on or closer to Interstate 5 and therefore located in a previously disturbed area; and (2) a shorter "I" wall that will have fewer construction impacts compared to the taller "T" wall construction that the District understands would be required for the Local Actions Alternative's floodwall.

[115] *See* WAC 197-11-560(2).

them, and that it do so in a comprehensive FEIS and not in an addendum to the RDEIS.[116] Finally, as explained in Section II.D, above, the District will continue to provide comments, as appropriate, resulting from its review of supporting documents.

Thank you for your attention to these comments. Should you have any questions, please contact Kathy Burnaman at kathy.burnaman@lewiscountywa.gov.

Sincerely,

Ryan Barrett
District Administrator

On behalf of:

Chehalis River Basin Flood Control Zone District Board of Supervisors
Scott Brummer, Chair
Lindsey Pollock, Vice Chair
Sean Swope, Member

Enclosures: Attachment 1: Detailed Comments on Proposed Chehalis River Basin Flood Damage Reduction Project
Attachment 2: Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum
Attachment 3: Fish Passage Design Report to Inform SEPA
Attachment 4: Water Demand During Construction (Draft) TM

[116] *Id.* at 197-11-560(5) allows agencies to use an addendum to the DEIS as an FEIS only when changes in response to comments are "minor" and "largely confined" to factual corrections or "do not warrant further agency response." The comments provided by the District are not minor, and warrant substantial revisions that cannot be accomplished in an addendum.

Attachment 1:

Detailed Comments on Proposed Chehalis River Basin Flood Damage Reduction Project

Chehalis River Basin Flood Control Zone District

February 4, 2026

Comment #	Revised Draft EIS Component	Main Body or Appendix Section	Location (page, paragraph, sentence, table, bullet)	Comment
SUMMARY				
1	SUMMARY	S-13, S-16		The RDEIS mistakenly says that the FRE is inconsistent with the site's FRL zoning designation or forest resource land designation in Lewis County's comprehensive plan. Those designations are consistent with governmental services. LCC 17.42.020 Table 2. Therefore, the use is lawful in the zone. The RDEIS is also mistaken about lack of compliance with the Lewis County Shoreline Master Program, which has provisions for flood hazard management facilities (SMP 4.05). These are allowed in rural conservancy environments under the plan (SMP 4.05.02.G, SMP 6.01.01 Table 6-1). The FEIS should correct these errors.
2	SUMMARY	S-14 to -19		In numerous instances, the RDEIS finds impacts significant and unavoidable unless mitigation is feasible. However, the RDEIS declines to determine whether mitigation is feasible because of uncertainty, delegating that to later permit processes. This essentially causes the RDEIS to find numerous significant and unavoidable project impacts by discounting all avoidance, minimization, and mitigation aspects of the project. This is despite the fact that the RDEIS identifies numerous mitigation measures proposed by the applicant and the permits by which the project would be required to implement mitigation successfully, or else it could not proceed. Moreover, an EIS must include evaluation of mitigation proposed by an applicant. In short, the RDEIS does not address the project's probable impacts, as it is extremely improbable / impossible that the project could proceed without implementing successful mitigation. The RDEIS instead addresses the project's hypothetical worst-case-scenario impacts in the unlikely or impossible event that it could proceed without mitigation or permit requirements. This is especially bewildering because, in some discipline reports, the RDEIS concludes that the proposed mitigation would offset the proposed Project's impacts. Yes, the RDEIS concludes these impacts are "unavoidable" anyways.
3	SUMMARY	What Would Be Impacted by the Proposed Project?	Page S-9, second paragraph	The summary states that there would be significant impacts to Tribal resources and cultural resources, and also that determinations of impacts and mitigation for these resources will be made in Government-to-Government consultation with state and federal governments and through the federal National Historic Preservation Act Section 106 process, which is currently in progress. Appendix B (Cultural) does not clearly demonstrate significant adverse impacts based on this ongoing process. The FEIS should defer to that process and wait for effects to be determined.
4	SUMMARY	Significant Impacts from Proposed Action	Page S-13, Exhibit S-5	The write up of cultural is a bit misleading since the analysis is relying on Section 106. Under the Section 106 process, if archaeological resources are not eligible for the NRHP, they are not assessed for effects. Effects to the one NRHP-eligible site are being minimized by relocation of the project and are still currently being determined through the Section 106 process. The resources have not yet been fully described, so discussing effects to them is not yet warranted. Mitigation for any identified effects would follow from the Section 106

Comment #	Revised Draft EIS Component	Main Body or Appendix Section	Location (page, paragraph, sentence, table, bullet)	Comment
				process. Recommend updating the narrative on the graphic to reflect comments/edits in Appendix B (Cultural).
5	SUMMARY	Significant Adverse Environmental Impacts and Proposed Mitigation Summary	Page S-14, Exhibit S-6	Row 1 is misleading. Given that the analysis is relying on Section 106, if archaeological resources are not eligible for the NRHP, they are not assessed for effects. Effects to the one NRHP-eligible site are being minimized by relocation of the project and are still currently being determined through the Section 106 process. The resources have not yet been fully described, so discussing effects to them is not yet warranted. Mitigation for any identified effects would follow from the Section 106 process. The language in Row 1 should be updated for accuracy in-line with the comments/edits to Appendix B (Cultural).
MAIN BODY: SECTIONS 1-11				
6	MAIN BODY	1-11	Key Findings of the Environmental Health and Safet Analysis	RDEIS states 'While unlikely, if ground shaking from a large earthquake damaged the FRE structure while the inundation pool is holding water, the impact would be significant and unavoidable. The FRE will be designed to accommodate seismic forces when the inundation pool is impounded such that the risk of an uncontrolled release of the inundation pool is minimized and so unlikely as to be considered negligible. RPDR Section 3.3 of Appendix F outlines industry design guidance and the risk-informed approach which will serve as the basis for design. The risk-informed design framework considers a range of hazard levels (return periods) in combination with the anticipated severity of consequences with each. These are compared against the limited risk tolerance described in USACE, USBR, and FEMA public protection guidelines. Mitigation is proposed through design approach making the impact avoidable.
7	MAIN BODY: SECTIONS 1-11	2.3.1		Description is correct but fails to mention the change that only one of the sites will be selected for development once further characterization of the quarries is completed.
8	MAIN BODY: SECTIONS 1-11	2.3.3	Page 13, paragraph 3	The statement "The Applicant has proposed to assess and update Pe Ell's water supply to avoid impacts to the water supply." Additionally, Appendix 1 Section 3.2.3 states the project includes maintaining an uninterrupted water supply to the town of Pe Ell. It appears this aspect of the project has not been considered appropriately in the determination of impact. See also Comment #379
9	MAIN BODY: SECTIONS 1-11	2.3.3		High level summary is generally correct. Note: It would take a significant redesign to pass the pipe through the FRE structure and providing adequate valving and head controls could be significant, particularly if the water supply pipeline requires operation during periods when the facility is in flood operations which could put head of over 200 feet onto the intake, pipeline, and discharge facilities.
10	MAIN BODY: SECTIONS 1-11	2.3.3.1		Drilling rigs are used for more than blasting and will be used for blasting (quarry and FRE structure), instrumentation installation, target explorations, grouting/treatment. Quarry pre- and post-stockpile locations are not discussed here nor conveyors and intermediate transfer stations and general stockpiles.
11	MAIN BODY: SECTIONS 1-11	2.3.3.1		The concrete production facility description is very general and incomplete and should be expanded to include the cement and all possible supplemental cementitious material (SCM)

Comment #	Revised Draft EIS Component	Main Body or Appendix Section	Location (page, paragraph, sentence, table, bullet)	Comment
				descriptions such as fly ash, slag, natural pozzolans that might be used. Proper storage facilities for these materials will be provided as part of the concrete production facilities.
12	MAIN BODY: SECTIONS 1-11	2.3.5	Page 23, paragraph 1	States an anchored log boom would capture large wood floating. This was further developed since the RPDR. Based on the draft Debris Management During Flood Retention Report (Attachment 1 to Attachment 2: Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum), multiple anchored log booms, log broncs, and work boats will operate to capture the large wood floating.
13	MAIN BODY: SECTIONS 1-11	2.3.6	Page 24 paragraph 2	SEIS states there is only one debris collection area. This was further developed since the RPDR. In the draft Debris Management During Flood Retention Report (Attachment 1 to Attachment 2: Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum), there are two proposed debris storage areas.
14	MAIN BODY: SECTIONS 1-11	3.1	2nd paragraph	Text states: "This EIS uses a more updated flow rate, which includes data from the past 40 years..." The document is dated November 2025, so it can be inferred that data from 1985-2024 is being used. Completing a Bulletin 17C analysis with data from this date range yields a 100-year flow of ~90,350 cfs. However, on the next page (Exhibit 3-1) the 100-year flow is stated as 75,100 cfs. Also, on Table N-6, there is a footnote talking about data being used from 1970 to 2015. Completing a Bulletin 17C analysis of this date range yields a 100-year flow of ~87,000 cfs. So, it is not possible to recreate the 100-year flow with the given information in the documentation.
15	MAIN BODY: SECTIONS 1-11	5.1	Key Finding and Water Analysis summary	The summary is overly critical and pessimistic. The write-up in the section paints a more detailed view showing that impacts are manageable and not significant. This is not the case in the summary section. Please correct the summary section to summarize the results detailed in the section.
16	MAIN BODY: SECTIONS 1-11	5.1	Key Finding and Water Analysis summary	The stated impacts include impacts farther downstream, outside of the construction area, due to reduced shade and cover. How is it possible to have impacts in a segment of stream that has not been modified?
17	MAIN BODY: SECTIONS 1-11	5.1	Key Finding and Water Analysis summary	The area upstream of the inundation pool is no different than a pool-riffle region of the natural river. Why is this accounted for as significant when it is similar to natural riverine system?
18	MAIN BODY: SECTIONS 1-11	5.1	Key Finding and Water Analysis summary	It is unclear if the RDEIS accounted for areas within the conduits and endsill that increase the DO accounted for. This analysis should be included in the key findings.
19	MAIN BODY: SECTIONS 1-11	5.1	Page 47, paragraph 1 of Key Findings of Water Analysis	The District has conducted modeling of project-related effects on stream temperature based on shade losses from facility construction, and mitigating factors including VMP implementation. The values summarized herein are outdated and do not reflect the Mitigation Plan actions. Please refer to comments on Appendix N (Water) for more information on project effects on stream temperature.

Comment #	Revised Draft EIS Component	Main Body or Appendix Section	Location (page, paragraph, sentence, table, bullet)	Comment
20	MAIN BODY: SECTIONS 1-11	5.1	Page 48, paragraph 1	The RDEIS assumes up to 2 million gallons of water would be withdrawn from the Chehalis River for construction use, equivalent to approximately 3.7 cfs per day. The District has refined the construction water needs analysis since the Revised Project Description. Over each construction year, the weighted average peak use of water is approximately 0.63 cfs, or 407,000 gallons per day. This quantity is well below the amount assumed in the RDEIS, and upon which a “less than significant” determination was made for changes in habitat over most months. Please see Attachment 4: Water Demand During Construction (Draft) Technical Memorandum to these comments. The FEIS should incorporate this refinement into its analysis.
21	MAIN BODY: SECTIONS 1-11	5.1 (Water)	Page 48	The EIS analyzes 2 million gpd water needs during construction based on information available at the time of its analysis, from the Revised Project Description. However, the District has conducted a more refined construction water supply analysis, attached as the Construction Water Demand TM, which estimates actual construction water needs to be much less. The highest average monthly construction water demand would be 0.88 cfs (in July, at the height of construction season), with a lower average demand in other months. This figure weights in peak demand more heavily than it would likely occur, and so it is conservative. Even adding an additional conservative buffer of 20% above this 0.88 cfs, the projected maximum average monthly demand would be 1.06 cfs. That means that the highest-demand month would, on average, use less than a third of the water previously proposed. The average annual demand is predicted to be even lower, at 0.63 cfs. The FEIS should incorporate this updated water estimate into its analysis.
22	MAIN BODY: SECTIONS 1-11	5.1.2.1	Page 51, paragraph 1	Please explain the causal mechanism for statements claiming construction will negatively affect dissolved oxygen and stream temperatures. These statements are made with no foundation or support for the effects. Effects on dissolved oxygen from construction are dismissed as "negligible" in the last paragraph of this page, and effects on temperature are stated to be "within the allowable range pursuant to water quality standards."
23	MAIN BODY: SECTIONS 1-11	5.1.2.1	Page 53, paragraph 1	The following statement is incorrect and should be changed. The original statement reads as follows; "This water diversion would temporarily block and change the natural flow and bed of the river channel." This sentence should be changed to the following; "This water diversion would change the natural flow and bed of the river channel." The project doesn't "block” but does change.
24	MAIN BODY: SECTIONS 1-11	5.1.2.1	Page 53, paragraph 2	"Because the Proposed Action would use, divert, obstruct, and change the…" The project doesn't "obstruct" normal river flows. It doesn't retain flood flows. Please change this sentence and remove "obstruct."
25	MAIN BODY: SECTIONS 1-11	5.1.2.2	Page 56, paragraph 3, sentence 3	These frequencies are relatively similar to those under 04P1 and P2 operations for future climate.
26	MAIN BODY: SECTIONS 1-11	5.1.2.2	Page 57, paragraph 1	Operational refinements have reduced the number of inundation days. See detailed comments on operations in Appendix N (Water).

Comment #	Revised Draft EIS Component	Main Body or Appendix Section	Location (page, paragraph, sentence, table, bullet)	Comment
27	MAIN BODY: SECTIONS 1-11	5.1.2.2	Page 57, paragraph 1, sentence 1	The REIS does not reflect updates to Project operations. The District has refined the operational scenarios since the Revised Project Description was issued. Under refined operational scenarios, temporary pool drawdown rates would be increased to 20 feet per day for areas below elevations of 500 feet. These areas have low landslide risk and will result in a faster pool drawdown, and less days of temporary inundation upstream of the facility during flood events.
28	MAIN BODY: SECTIONS 1-11	5.1.2.2	Page 57, paragraph 5	See District's updated modeling results for stream temperature in the Mitigation Plan prepared for the project and submitted to Ecology in 2024. As this section addresses operations, any increase in temperature assumed in this EIS during the November to March period when flood would occur is less than significant with regard to effects on water quality.
29	MAIN BODY: SECTIONS 1-11	5.1.2.2	Page 62, Exhibit 5.1-5	This table should be updated to reflect refined operational scenarios.
30	MAIN BODY: SECTIONS 1-11	5.2	Key Findings of Earth Analysis	The key findings and impact statements in this section related to the consequence of FRE structure failure appear to be based on postulated events that far exceed typical design criteria for large, high hazard dams to which the facility will be designed. The document would be much improved by including and/or expanding the context for these impact statements. For example, considering that the risks associated with credible potential dam failure modes will be mitigated to meet public protection guidelines of the USACE, USBR, and FEMA, the impact analysis findings would warrant a significant reduction in the stated impacts.
31	MAIN BODY: SECTIONS 1-11	5.2	Page 68, Key Findings of the Earth Analysis:	RDEIS states the large woody material would be removed from the river system and be a significant and unavoidable adverse impact. The statement does not provide what the impact to the system is. The District has a long-standing commitment to move LWM collected at the Project, including LWM remaining in the temporary inundation area, to below the FRE for aquatic habitat mitigation. See, e.g., RPDR page 80, HDR, Large Woody Material Downstream Passage and Placement Clarification Technical Memorandum (Jan. 4, 2021). That document states “LWM would be captured, staged, and sorted for use in downstream habitat enhancement projects as determined by the proposed mitigation program…”. Furthermore, Section 8.4 of the Mitigation Plan explicitly outlines the District’s detailed LWM recovery and relocation plans to mitigate the disruption of wood transport both during flood and non-flood operations, including 15 proposed mitigation sites for LWM recruitment and placement. Mitigation Plan pages 18 and 185-89 (Large Wood Material Recruitment and Placement Plan). The RDEIS ignores this aspect of the proposed project. The FEIS should correct this error.
32	MAIN BODY: SECTIONS 1-11	5.2	Page 68, paragraph 2	The District has provided detailed comments on the effects of the Project on Earth resources in Appendix F. This section should be updated to reflect the District's comments and refined analyses.

Comment #	Revised Draft EIS Component	Main Body or Appendix Section	Location (page, paragraph, sentence, table, bullet)	Comment
33	MAIN BODY: SECTIONS 1-11	5.2	Page 68, paragraph 3 under Key Findings of the Earth Analysis	Global comment regarding statements about the Mitigation Plan's potential infeasibility. Actions proposed under the Mitigation Plan are part of the Project and will be requirements of any authorizations issued by regulatory entities. Funding of the Mitigation Plan, including long-term monitoring and adaptive management, is an incumbent component of this public project and all mitigation work will be funded as part of the Project. The District will be coordinating funding on a parallel track with construction and operational funding.
34	MAIN BODY: SECTIONS 1-11	5.2 (Key Findings)		The FRE retention structure and related outlet (including fish passage conduits), and spillway will be designed to modern dam safety standards. The current design provides stability of the FRE structure under normal, flood, or post-earthquake conditions assuming all sections of the FRE structure are stable under “gravity loading conditions.” The design does not consider the potential for development of arch action (due to curvature of the FRE structure) that would transfer some of the FRE structure gravity loads to the abutments under inundation pool storage (flood) and earthquake loading conditions. Further, if any loading such as a flood, earthquake or seiche wave were to induce some differential deformation between monoliths within the FRE structure, the resulting “damage state” condition would not result in a large release of a inundation pool, but a more limited release through damaged monolith joints that would result in downstream damages that are significant less than assigned in the environmental analysis. Hence the current design is judged to have a significant level of surplus stability capacity, and consequences associated with damage to the FRE structure during extreme loadings would be relatively small. Future preliminary design analyses will include development of a full 3D structural analysis model that will quantify the structural capacity and expected behavior of the FRE structure under all critical design loading conditions. The potential for failure of the FRE structure will be evaluated with a full quantitative risk analysis, and results will demonstrate that risk of failure of all credible potential failure modes (PFMs) including earthquake, flood and seiche waves due to landslides will be well below risk tolerance guidelines of the USACE/USBR/FEMA.
35	MAIN BODY: SECTIONS 1-11	5.2 (Key Findings)		The FRE will be a concrete gravity structure that will be capable of withstanding overtopping events that may occur. While a specific and large overtopping event has not been postulated and evaluated with stability/structural response models, such an event would be judged highly unlikely, and the FRE structure will be designed to withstand such an event. Such a potential failure mode will be included in a formal risk analysis that will be performed as part of preliminary design to verify that the facility would meet the risk guidelines of the USACE/USBR/FEMA. On a related note, the FRE structure will be designed to have freeboard capable of safely routing a full probable flood event (PMF). This freeboard, as well as additional freeboard that would be available as the inundation pool is drawn down following a flood retention event would be capable of mitigating landslide induced seiche wave events.
36	MAIN BODY: SECTIONS 1-11	5.2 (Key Findings)		The report states that during the 2007 flood, an estimated 5.7 to 8.7 tons of sediment entered the river upstream of the proposed FRE facility. The basis for these numbers is not supported in the RDEIS nor in the literature. In addition, the numbers appear to reflect yield

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				throughout the entire upper Chehalis River basin, not all of which would influence habitat or geomorphology within the Project reach. See also Comment #325.
37	MAIN BODY: SECTIONS 1-11	5.2.2.1	Earthquake Risk subheading, 1st paragraph	The "Earthquake Risk" text indicates that the Cascadia Subduction Zone can trigger large, "damaging" earthquakes in or close to the Chehalis Basin. The use of the term "damaging" in this context is subjective and should be removed. The damage potential of an earthquake is based on the type and design of the structure of interest; it is not a property of the earthquake itself.
38	MAIN BODY: SECTIONS 1-11	5.2.2.1	Page 74, paragraph 3	The refined operations plan includes drawdowns of up to 20 feet per day at elevations below 500 feet where landslides are unlikely to occur with proposed stabilization measures as part of the Project.
39	MAIN BODY: SECTIONS 1-11	5.2.2.1	Page 77, paragraph 1	This assessment does not reflect the District's analysis. Please review the District's Mitigation Plan, Appendix A, for an analysis of sediment transport through the facility.
40	MAIN BODY: SECTIONS 1-11	5.2.2.1	Page 77, paragraph 2	Please clarify this statement: Current levels of large wood are low in the Chehalis River; a large amount entered the river during the 2007 flood but has since been removed.
41	MAIN BODY: SECTIONS 1-11	5.3.2	Page 87 (for entire section under **Findings for the Proposed Project**)	The District has made comments on expected impacts on fish and aquatic resources in Appendix E (Fish). Please refer to those comments for this section.
42	MAIN BODY: SECTIONS 1-11	5.3.2.1	Page 88, first full sentence on page	The REIS questions whether BMPs for noise and vibration from construction would fully minimize effects on aquatic species. The primary impact minimization measure for in-water work and associated effects of noise or vibration is to conduct such work "in the dry," in isolation from aquatic habitat. Conducting work in the dry is a standard practice and permit requirement to minimize effects on aquatic species. Thus, there is no uncertainty that this measure will reduce or eliminate effects from noise or vibration, and the EIS should state this explicitly and remove the ambiguity.
43	MAIN BODY: SECTIONS 1-11	5.3.2.1	Page 89, Construction Impacts on Salmonids	The District has requested the model inputs used to derive the estimated changes in salmonid abundance reported in the SEPA revised draft EIS. However, the estimates do not consider baseline conditions for passage, which would be mimicked in the construction bypass. There is no spawning habitat in the construction reach, and the number of spring Chinook Salmon spawning upstream of Crim Creek has varied from zero to a few fish, with a maximum of two redds reported by WDFW during redd surveys conducted from 2013 to 2019. See Ronne et al. (2020) and Ashcraft (2018).
44	MAIN BODY: SECTIONS 1-11	5.3.2.1	Page 90, paragraph 2 under Operation Impacts on Aquatic Habitats	The REIS suggests reduced fish passage to areas upstream of the facility could impact aquatic habitat upstream of the temporary inundation area over the long term because salmon carcasses would no longer contribute nutrients to the system. This determination ignores the operation and function of the FFPF. During operations, the FFPF will collect upstream migrating fish. Collected adult salmonids and Pacific Lamprey would be released upstream of the temporary pool to continue to spawning areas. During normal (non-flood) operational periods, the dedicated fishways will provide access to upstream habitats. The

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				fishways will be designed to meet NOAA Fisheries and WDFW passage criteria. Thus, access to habitats upstream of the facility will be maintained. Any statements implying "impacts" to habitats upstream from reduced nutrient loading should be removed from this EIS.
45	MAIN BODY: SECTIONS 1-11	5.3.2.1	Page 90, paragraph 3 under Operation Impacts on Aquatic Habitats	See District comments on Appendix E (Fish). Operation of the facility would reduce bed scour compared to flood conditions without the facility.
46	MAIN BODY: SECTIONS 1-11	5.3.2.1	Page 91, paragraph 2	See the District's comments on Appendix E (Fish). While formation of a temporary pool will likely result in some mortality of salmonid eggs, the primary spawning areas within the temporary inundation area are between Big Creek and Fisk Falls. Under the District's refined operational scenario, this reach will be inundated under flood waters for a few days, and some survival is expected. Complete elimination of spawning or rearing habitat will not occur, and fine sediment transport will move fines out of the temporary inundation area within two months of each event.
47	MAIN BODY: SECTIONS 1-11	5.3.2.1	Page 91, paragraph 3	The District's proposed Mitigation Plan includes ongoing measures to pass large wood, and supplement downstream areas with large wood over time to address project-related changes in channel geomorphology. This analysis assumes no mitigation actions will be implemented and should be revised to reflect the District's plan, which must be implemented to comply with expected conditions of future permits.
48	MAIN BODY: SECTIONS 1-11	5.3.2.1	Page 92, paragraph 1 under Operation Impacts on Salmonids	The effects of climate change on salmonids without the project (i.e., future baseline conditions) must be considered. The effects of the project must be compared to those future baseline conditions/effects over time.
49	MAIN BODY: SECTIONS 1-11	5.3.2.1	Page 92, paragraph 1 under **Operation Impacts on Salmonids**, sentence 3	While a "worst case" scenario may predict one outcome that reflects an unlikely scenario, the most likely operational effect should be analyzed considering facility operations will span decades. Using the "worst case" scenario to quantify impacts does not present the likely outcome and overestimates the Project's probable impacts to a level with catastrophic outcomes. The analysis should be focused on describing the Project's probable impacts, not unlikely, worst case scenarios.
50	MAIN BODY: SECTIONS 1-11	5.3.2.1	Page 92, paragraph 2	Because most floods that would trigger operations will occur from November through March, the potential overlap with steelhead spawners (and kelts) is limited temporally because they typically do not begin spawning until February. This periodicity and likely overlap with steelhead adult spawners, and subsequent kelt life history, should be explained and captured in this REIS. As currently stated, this impact assessment is overly conservative and inaccurate because it does not portray what is reasonably likely to occur (i.e., most steelhead will spawn later in the spring, after the typical period when flood operations are expected to be necessary).

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51	MAIN BODY: SECTIONS 1-11	5.3.2.1	Page 92, paragraph 3	See comments on Appendix E (Fish) related to expected fish passage performance for the dedicated fishways through the facility and the FFPF structure.
52	MAIN BODY: SECTIONS 1-11	5.3.2.1	Page 93, paragraph 2 under Chehalis Basin Perspective on Salmonid Impacts	Spawning reach identification for arguments appears to presume high use of spring Chinook Salmon spawning upstream of the FRE. Please define where the reaches of these primary spawning areas are located. During redd surveys conducted by WDFW from 2013 through 2019, only a handful of spring Chinook redds were reported upstream of the proposed FRE site.
53	MAIN BODY: SECTIONS 1-11	5.3.2.1	Page 93, paragraph 3, both bullet points under **Chehalis Basin Perspective on Salmonid Impacts**	Please calculate the percentages of each species that contribute to overall Chehalis Basin populations from spawning use of the temporary inundation area only. Significant spawning occurs in tributaries and upstream of the temporary inundation area, and habitat in those areas will not be affected by the Proposed Action.
54	MAIN BODY: SECTIONS 1-11	5.3.2.1	Page 94, Exhibit 5.3-3	Misleading title of Exhibit 5.3-3. Estimated Abundance of Salmon and Steelhead Above Crim Creek. The caption for this figure is misleading and should make clear tributaries and mainstem habitats upstream of the modeled temporary pool are included in these estimates. In addition, please provide the source of abundance estimates. WDFW redd survey data does not indicate such high numbers of spring Chinook. Fall Chinook numbers are also high, and reflect peak spawning years (2018, for example), but do not provide mean estimates using redd count data that was made available to the District from WDFW.
55	MAIN BODY: SECTIONS 1-11	5.3.2.1	Page 95, paragraph 1	Following construction, during "normal" periods when the facility is not operating for flood damage reduction, there will be no effect on creek hydrology. During low flow periods, flow would be directed into one or both of the dedicated fishways to provide passage, but no flow would be removed from the system. Accordingly, the Project will not "worsen" summer flows following construction. There is no spawning habitat for Pacific Lamprey in the FRE footprint and operations will not reduce or eliminate spawning areas downstream to Elk Creek. These statements are speculative and not supported by citations or evidence. In the absence of the facility, major floods will scour spawning substrates downstream and reduce survival and productivity for cohorts spawned prior to the flood event.
56	MAIN BODY: SECTIONS 1-11	5.3.2.1	Page 95, paragraph 2	During flood operations, the outflow will be reduced to 300 cfs as the facility conduits close and the temporary pool forms upstream of the facility. This minimum outflow was determined in coordination with a technical subcommittee for fish and aquatic resource protection and is higher than winter baseflows. Mussels are expected to be established in deeper areas of the river channel, in stable substrates that are typically watered year-round. Facility operations are highly unlikely to dewater occupied habitats from late fall through spring, when precipitation will also

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				contribute to consistent hydrology along stream margins that will be rewatered after a few days of flood retention. The rationale for this effect is oversimplified, and the effect is overstated, and lacks context and consideration of mitigating variables, including the wet-season timing of flood events.
57	MAIN BODY: SECTIONS 1-11	5.4.2.1	Page 103, paragraph 1	This conservative approach to tree mortality (and subsequent effects on wildlife habitats) should be revisited with operational refinements that will reduce the duration and depth of inundation, particularly in upstream portions of the temporary pool that will be drawdown within days of flood retention operations.
58	MAIN BODY: SECTIONS 1-11	5.4.2.1	Page 103, paragraph 2	The VMP planting palette was selected to include species that can endure prolonged inundation. This statement is speculative and includes no evidence or support.
59	MAIN BODY: SECTIONS 1-11	5.4.2.1	Page 103, paragraph 4	Portions of the Mitigation Plan that address forested habitat conversion and long-term complex forest conservation are feasible and an integral part of the action. The benefits of these actions should be included in this section, particularly as related to marbled murrelet habitat retention and improvement over the long-term compared to baseline conditions. The reader should be reminded that, under existing conditions, habitat within the temporary inundation area consists of managed forests with homogenous tree stands harvested every 40-50 years. Such forests do not typically support trees that meet minimum size requirements or contain nesting platforms necessary to support marbled murrelets. The District has committed to a pre-construction nesting habitat suitability survey of trees to determine the quantity and quality of suitable marbled murrelet nesting habitat, and this survey will better inform BMPs for tree removal. The District's proposed Mitigation Plan is expected to more than offset losses of suitable nesting trees over the long term, through preservation and protection of conifers from future harvest.
60	MAIN BODY: SECTIONS 1-11	5.4.2.1	Page 104, paragraph 2	The reader should be made aware of the findings in Appendix P (Wildlife), which indicate little, if any, use of trees within the study area by nesting marbled murrelets.
61	MAIN BODY: SECTIONS 1-11	5.4.2.1	Page 105, paragraph 1, first full sentence on page	Loss of habitat from quarry use is misleading. Please provide the calculations used to arrive at this acreage estimate. Only one of the three quarries is likely to be used and failure to reiterate this is misleading.
62	MAIN BODY: SECTIONS 1-11	5.4.2.1	Page 106, paragraph 2	Please refer to comments on floodplain inundation in Appendix P (Wildlife).
63	MAIN BODY: SECTIONS 1-11	5.6	Page 120	Should be updated based on the comments/edits in Appendix L (Tribal).
64	MAIN BODY: SECTIONS 1-11	5.6.2.1	Page 122, second paragraph bullet list, and third paragraph bullet list	Impact discussion would benefit from explanation of current access.

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65	MAIN BODY: SECTIONS 1-11	5.6.2.2	Page 127, last paragraph	This section is inconsistent with Appendix B, which states that the levee overlaps certain sites. Additionally, the rationale for listing these archaeological sites under the Tribal section is unclear. Please clarify whether these sites are tribally affiliated.
66	MAIN BODY: SECTIONS 1-11	5.7.2.1	Page 133, third paragraph	The RDEIS is mistaken in asserting that the proposed Project would conflict with Lewis County land use policies. The Project site is defined as Forest land in the Lewis County Comprehensive Plan is zoned as Forest Resource Land. *See* Lewis County Comprehensive Plan at 28, *available at* https://lewiscountywa.gov/media/documents/Volume1_CompPlan_ysRfkKW.pdf; LCC 17.30.430. Such land allows "rural government services" with an administrative approval, LCC 17.42.020, which means "those governmental services historically and typically delivered at an intensity usually found in rural areas" of Lewis County, LCC 17.10.180. Lewis County's rural area already has two large traditional dams operated by a government entity for many decades (the Mayfield and Mossyrock Dams, operated by Tacoma Power). Therefore, this Project is a use permissible within the zoning. The FEIS should withdraw this significant adverse impact finding.
67	MAIN BODY: SECTIONS 1-11	5.7.2.1	Page 133, sixth paragraph	The RDEIS is mistaken in asserting that the proposed Project would conflict with Lewis County Shoreline Master Program (SMP) policies. The SMP includes flood hazard prevention as one of its goals. Lewis County SMP 2.09. An entire section of the SMP is dedicated to flood hazard management policies and regulations. SMP 4.05. New structural flood hazard management measures are permittable as shoreline modifications. SMP 4.05.02.G. In-water shoreline modification structures are permittable as conditional uses in Rural Conservancy shoreline areas, which is the Project site's designation, SMP 6.01.01 Table 6-1, and there is a specific set of regulations for structural hazard flood reduction measures. SMP 6.08. In short, the Lewis County SMP has many provisions that allow and regulate facilities like the Proposed Project, which the project will simply follow in the permitting process. The RDEIS's reliance on other reports to conclude that such a permit would be impossible to obtain is misplaced as those other reports decline to credit the project's mitigation plans, leaving such details to permitting. Here, the RDEIS has identified the necessary permits and constraints they would place on the project to mitigate its impacts. The permit requirements are not uncertain; the FEIS should analyze them as it does for Best Management Practices (BMPs) and other permit requirements, conclude that they would mitigate the project or else it cannot be built, and withdraw this significant impact finding.
68	MAIN BODY: SECTIONS 1-11	5.9	Page 149, Key Findings of the Cultural Resources Analysis	List all consulting Tribes, not just a few.
69	MAIN BODY: SECTIONS 1-11	5.9	Page 149, Key Findings of the Cultural Resources Analysis	Use terminology consistent with NHPA Section 106 as the analysis is relying on the Section 106 process.

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70	MAIN BODY: SECTIONS 1-11	5.9	Page 149	Should be updated based on the comments/edits in Appendix B (Cultural).
71	MAIN BODY: SECTIONS 1-11	5.9.2.2	Page 151	Section 5.9.2.2 states that impacts will be reviewed; however, elsewhere the document states that there are significant adverse effects on TCPs. These conflicting statements should be reconciled and revised.
72	MAIN BODY: SECTIONS 1-11	5.9.2.6	Page 153	Section 5.9.2.6 states that no determination of impacts has been made because the Section 106 process is ongoing. However, other sections state a significant adverse impact. The analysis needs to be consistent throughout the document and Appendix B. The RDEIS may not reasonably conclude that there are significant and unavoidable impacts while simultaneously acknowledging that no determination of impacts has occurred.
73	MAIN BODY: SECTIONS 1-11	Exhibit S-6 5.2.2.1 5.2.2.4 5.6.2.1 5.10.2.4 5.12.2.1		The joint probability of a breach occurring due to an earthquake at the same time as a flood that initiates water being impounded is so low that we do not consider this type of joint probability during a Potential Failure Mode Analysis (PFMA) for a dam safety study. This is outside the standard dam safety practice and should be removed. The joint probability of two remote events occurring at the same time is improbable. The probability of two such remote occurrences happening at once is so unlikely that it does not advance the purposes of SEPA to describe them in this manner.
74	MAIN BODY: SECTIONS 1-11	5.10		The FRE will be designed to accommodate seismic forces when the inundation pool is impounded such that the risk of an uncontrolled release of the inundation pool is minimized and so unlikely as to be considered negligible. RPDR Section 3.3 of Appendix F outlines industry design guidance and the risk-informed approach which will serve as the basis for design. The risk-informed design framework considers a range of hazard levels (return periods) in combination with the anticipated severity of consequences with each. These are compared against the limited risk tolerance described in USACE, USBR, and FEMA public protection guidelines. Mitigation is proposed through the design approach.
75	MAIN BODY: SECTIONS 1-11	5.12		The design criteria for the FRE structure present all populations and infrastructure downstream of the proposed facility with the same levels of protection as other high hazard dams across the U.S. while providing significant flood reduction benefits.
76	MAIN BODY: SECTIONS 1-11	5.15.2.1	Page 194, paragraph 4	The REIS states there is one debris management storage area previously operated by Weyerhaeuser and it will be accessed by the FR 1000 route. This has been further developed since the RPDR. The draft Debris Management During Flood Retention Report (Attachment 1 to Attachment 2: Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum), states there are two debris storage areas in different locations than the previously chosen Weyerhaeuser operated area.
77	MAIN BODY: SECTIONS 1-11	10		The scale of the maps is too great to see any discernible differences in floodplain extents and depths reported. Major and minor roads are shown, but many of them do not have labels which makes them difficult for understanding locations.

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APPENDIX 1: PROJECT DESCRIPTION – ALTERNATIVES				
78	APPENDIX 1: PROJECT DESCRIPTION - ALTERNATIVES	Whole Appendix	Whole Appendix	As discussed in Section II.E. of the Detailed Comments to which this table is attached, the Project Description has been materially updated to further avoid, minimize and mitigate for potential Project impacts identified in the RDEIS. These updates must be reflected in the FEIS's Project Description, environmental impact analyses and probably adverse impact findings. Specifically, please update the FEIS to reflect the information provided in the following: • Attachment 2: Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum • Attachment 1: Debris Management During Flood Retention Report (Draft) • Attachment 2: Reservoir Operations Analysis (Draft) Technical Memorandum • Attachment 3: Inundation Analysis with 2024 Project Design and 2025 (O4P2) Operational Scenario Technical Memorandum • Attachment 4: Riparian Shade Temperature Model with 2024 Project Design and 2025 (O4P2) Operations Technical Memorandum • Attachment 3: Fish Passage Design Report to Inform SEPA • Attachment 4: Water Demand During Construction (Draft) Technical Memorandum
79	APPENDIX 1: PROJECT DESCRIPTION - ALTERNATIVES	Whole Appendix	Whole Appendix	At many points in this Appendix, the RDEIS correctly references the proposed Project's Mitigation Plan as part of its revised project description submissions. Yet, the RDEIS treats the mitigation plan differently than the rest of the project description in terms of analysis, declining to consider the mitigation actions' effects on probable environmental impacts due to uncertainty regarding feasibility or economic practicability. As noted in the cover letter, this is incorrect, and the mitigation should be considered. Conceptually, it is also nonsensical: the proposed Project itself is a very large public work that, due to cost and many other factors, also faces uncertainty regarding feasibility and economic practicability, and yet the RDEIS analyzes its probable impacts. It is anomalous to use uncertainty as a bar to analysis for one half of the project but not the other. Finally, even if the mitigation were distinct and need not be analyzed, the proposed Project contains a number of avoidance and minimization measures designed to reduce potential adverse environmental impacts that are not mitigation; they are baked into the project design as avoidance mechanisms. These include, among other things, (1) a phased construction plan in which construction occurs mostly in the dry; (2) a construction bypass designed to mimic the natural river hydraulics, allowing volitional fish passage for nearly the entire construction period without resort to trap and transport or a tunnel; (3) a fish outlet works allowing volitional fish passage during the facility's normal, flow-through operations (which has now been improved through consultation with the National Marine Fisheries Services on improved fish passage); (4) an operations plan that minimizes impacts to fish from flood operations (which has now been improved to reduce the period and impacts of temporary inundation); and (5) a vegetation management plan that avoids and minimizes loss of vegetation due to temporary inundation, thereby minimizing wildlife, temperature, and water quality impacts. By declining to analyze these measures fully on the theory that

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				feasibility and economic practicability will be determined in permitting, the RDEIS fails to analyze the probable significant adverse impacts of the proposed Project, not the mitigation—because these avoidance measures are aspects of the project design itself.
80	APPENDIX 1: PROJECT DESCRIPTION - ALTERNATIVES	3, 3.2.4.1, 3.3, 3.3.4, 3.3.5	Page 17, para. 3; Page 35, para. 2; Page 41, key elements box and para. 1; Page 45, sec. 3.3. 4; Page 46, fig. 1-11	The RDEIS states in several places that there will be one debris sorting area and that removal of large woody material (LWM) will take up to 14 days, thus slowing the drawdown rate of the temporary inundation area. This description and the discussion of environmental impacts that flows from that description are no longer accurate. As described in the attached Debris Management During Flood Retention Report, the District is proposing two debris storage areas as well as multiple anchored log booms, log broncs, and work boats to capture the floating LWM. Through these changes, the time to clear the LVM from a 100-year flood is reduced from up to 14 days to up to just 5 days. Additionally, the two log storage areas are located lower in elevation and closer to the FRE structure, resulting in a shorter duration of inundation for most instances of flood operations. The results of the change in operation are described in the attached Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Operations technical memorandum. The FEIS should incorporate these refinements through revisions to the Project Description and its analysis throughout the FEIS.
81	APPENDIX 1: PROJECT DESCRIPTION - ALTERNATIVES	3.1.1.3	Page 23	The design of the proposed outlet works have been refined since issuance of the Revised Project Description Report that is used to define the Proposed Action in this SEPA RDEIS. The refinements to the outlet works further avoid and minimize impacts during normal flow-through operation of the proposed project. Refinements include the addition of two dedicated fishways running parallel to the conduits located to the left and right of the conduits and conduit stilling basin. The fishways provide a substantive improvement in fish passage survival as the fishways improve the reliability of the passage routes, provide more passage routes, and provide better fish passage performance through the FRE structure. In addition to the fishways, an additional primary conduit has been added and the size and number of secondary and evacuation conduits have been refined to improve the open channel flow capacity of the conduits, provide finer control of and more fish-friendly discharge of flows during flood retention operation, and improve sediment transport through the FRE structure and sediment continuity in the Chehalis River system. Details of these refinements to avoid and minimize impacts are included in the Attachment 3: Fish Passage Design Report to Inform SEPA and the appendices and attachments thereto.
82	APPENDIX 1: PROJECT DESCRIPTION - ALTERNATIVES	3.3	Page 41	Proposed debris management during flood retention events and operating rules for flood retention events have been refined by the District since issuance of the Revised Project Description Report that is used to define the Proposed Action in this SEPA RDEIS. Refinement of proposed debris management and flood retention operation allowed for additional refinement of the Vegetation Management Plan. Refinement of these three portions of the proposed project resulted substantive decreases in proposed future river water temperatures and, together with reductions in future water temperature, in avoidance and minimization that substantially reduced the environmental impact of the proposed project. Refinements to these portions of the proposed project, how these refinements built on each other to further avoid and minimize impacts, and the estimated future fish

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				populations resulting from these refinements are attached to these comments in the Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Operations technical memorandum and the attachments thereto.
APPENDIX 2: CUMULATIVE IMPACTS				
83	APPENDIX 2: CUMULATIVE IMPACTS	3.2.1		The RDEIS mistakenly discounts proposed avoidance, minimization, and mitigation due to uncertainty: "During construction, sediment could be delivered to the river due to erosion of excavation surfaces … Mitigation is proposed to reduce erosion and design for slope stability and may reduce some of these impacts; however, there is currently uncertainty regarding whether such mitigation measures are technically feasible or economically practicable." As described in the cover letter to which these comments are attached, the FEIS must consider the proposed mitigation when determining the proposed Project's probable impacts.
84	APPENDIX 2: CUMULATIVE IMPACTS	3.3.1	Page 19, bullets 2 & 3	These bullets incorrectly state that the Project will have significant adverse impacts on fish during construction due to degraded habitat and passage. As described in Appendix D-3 of the 2024 Revised Project Description, the construction bypass will support passage conditions similar to those under baseline through the reference reach and is expected to have no adverse impact on migratory fish.
85	APPENDIX 2: CUMULATIVE IMPACTS	3.3.1	Page 19, bullets 2 &3	These bullets incorrectly conclude that construction noise will have a significant adverse effect on fish. In-water work noise, including pile driving and blasting, that could affect fish, will occur in isolation from the active flow. By constructing the facility in the dry, noise and vibration is not expected to affect fish behavior or degrade habitat near the construction area. This is a fundamental Project construction design feature that the RDEIS misunderstands, resulting in findings of adverse impacts that are incorrect. This must be corrected throughout the document's descriptions, analyses and findings.
86	APPENDIX 2: CUMULATIVE IMPACTS	3.5.1	Page 22, bullet 6	The statement that the Project would have significant adverse effects on downstream wetlands and waterbodies is inaccurate. When the facility is not operating to reduce downstream flooding, it will have no effect on downstream hydrology and floodplain connectivity. During flood retention periods - lasting approximately 30 days and occurring, on average, every 2-3 years under future climate scenarios, flows would be temporarily reduced. These periods overlap with plant senescence periods, or are outside of peak growing periods, in the rainy season from November through March. These brief periods of operation in the wet season should not alter the condition or function of wetlands or waterbodies downstream. Indeed, the wetlands in question cannot be hydrologically dependent on major or catastrophic flood inundation because such inundation occurs too infrequently (less often than the 2-year flow) to impact wetland hydrology under accepted scientific guidance. This description and the incorrect analyses and Project impact findings that flow from this fundamental misunderstanding of the Project must be corrected throughout the document.

Comment #	Revised Draft EIS Component	Main Body or Appendix Section	Location (page, paragraph, sentence, table, bullet)	Comment
APPENDIX A: AIR				
87	APPENDIX A: AIR	2.4.1, 3.2.2.1.1	Page 17, bullet 1; Page 29 paragraph 2	It states there is one debris management sorting area, but this has been further developed since the RPDR. In the draft Debris Management During Flood Retention Report (attached to Attachment 2: Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum) there are two debris storage areas.
APPENDIX B: CULTURAL				
88	APPENDIX B: CULTURAL	Summary	Page iv, first paragraph.	The terminology is confusing in this Appendix, which conflates and mixes terms. Historic properties are those cultural resources that are eligible or listed in the NRHP. These include archaeological and built environment resources and TCPs. It seems that the term 'historic properties' is being used herein to mean historic built environment resources (e.g., buildings, structures, and objects). The District recommends using the term 'historic built environment resources' for built resources so that the terms 'historic properties' and 'historic property' are retained for usage consistent with 36 CFR Part 800 and inclusive of all resource types that are listed in or eligible for the NRHP. This will make the FEIS consistent with Section 106 practice, which it should follow in this case.
89	APPENDIX B: CULTURAL	Summary	Page iv, last paragraph	This paragraph is not accurate. If adverse effects on NRHP eligible properties are determined to be a result of the project, then the Section 106 consulting parties will consult to resolve adverse effects on those properties. Mitigation measures are agreed upon during Section 106 consultation and a Programmatic Agreement or Memorandum of Agreement that includes the agreed-upon mitigation measures is executed. The FEIS should credit this process and conclude that it will mitigate for any potential adverse effects.
90	APPENDIX B: CULTURAL	1.1	Page 1, first paragraph	This Discipline report is misguided, since the analysis is relying on Section 106 of the National Historic Preservation Act (NHPA). Under the Section 106 process, if archaeological resources are not eligible for the National Register of Historic Places (NRHP), they are not assessed for effects. Effects to the one NRHP-eligible site are being minimized by relocation of the project and are still currently being determined through the Section 106 process. The resources have not yet been fully described, so discussing effects to them is not yet warranted. Mitigation for any identified effects would follow from the Section 106 process. The FEIS should employ the effects determination from that process.
91	APPENDIX B: CULTURAL	1.1	Page 1, third paragraph	This terminology (i.e., historic property) is imprecise and conflates terms within the Section 106 process. Suggest use of 'historic built environment resources' when referring to built environment resources that are historic in age. The term historic property means a site, structure, object, building, or district that is determined eligible for or listed in the NRHP.
92	APPENDIX B: CULTURAL	1.1	Page 1, fourth paragraph	This is the first reference of the NRHP. The analysis should introduce the register for all resources, not just Traditional Cultural Places (TCP). The NRHP includes eligible buildings, structures, objects, sites, and districts that are archaeological and historic built environment

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				too, not just TCPs. This unclear use of technical language is part of a broader pattern in which the RDEIS does not adequately reflect the totality of the cultural resources analysis. Potential project effects on cultural resources may include effects to nontribal cultural resources as well as tribal cultural resources. The FEIS should more clearly distinguish the general cultural resources and tribal analyses.
93	APPENDIX B: CULTURAL	1.1	Page 1, last paragraph	This sentence is confusing. Recommend striking it entirely. A "recommendation" is not part of the Section 106 evaluation process - only those resources that are determined eligible or formally listed are subject to regulation. Unevaluated resources are often said to be 'treated as eligible' under Section 106 until either they can be evaluated or assessed for effects like an eligible resource. It is unclear what is intended when the RDEIS uses the term “recommendation.”
94	APPENDIX B: CULTURAL	1.1	Page 2, first paragraph	This statement is not entirely accurate because a permit may still be needed in the Area of Potential Effects (APE) depending on the resource. This cannot be determined until the APE is established and the identification stage of the evaluation process is completed.
95	APPENDIX B: CULTURAL	1.2	Page 5, third paragraph	The FEIS needs to clarify the verification process referenced in this paragraph. Add citation because it is not stated in EO 21-02 yet this paragraph is drafted as if it is included in the Executive Order. EO 21-02 states: 1. Agencies shall consult with DAHP and affected tribes on the potential effects of projects on cultural resources proposed in state-funded construction or acquisition projects that will not undergo Section 106 review under the National Historic Preservation Act of 1966 (Section 106), including grant or pass-through funding that culminates in construction or land acquisitions, to determine potential effects to cultural resources.
96	APPENDIX B: CULTURAL	2.2	Page 6, second paragraph	Cultural resources analysis should be based on the Proposed Project’s effect on the current condition of the resource. The FEIS must clarify whether this reference to a catastrophic flood is natural or the result of the project.
97	APPENDIX B: CULTURAL	2.4	Page 21, last paragraph	Section 2.4 addresses methodology but fails to clarify whether the flood scenarios are due to the FRE. This section should be reworked to clearly reflect the project nexus to project effects on cultural resources.
98	APPENDIX B: CULTURAL	2.4	Page 23, second paragraph	Section 2.4 addresses 2 of 8 archaeological sites but does not address the remaining 6. The FEIS should indicate the outcome of the remaining 6 sites.
99	APPENDIX B: CULTURAL	2.4	Page 24, Figure B-5	This Study Area extends far outside the area covered by surveys yet the RDEIS includes no explanation as to why there were no surveys conducted in the whole area. There should be some justification or explanation why surveys were not needed in the entire study area. The project effects analysis must reflect a nexus to the proposed project and have data supporting the same. Notably, although the Study Area may be the same as for other disciplines that consider the full extent of the project’s flood-reduction capability, in this Discipline report that study area makes little sense. There is no reason offered, nor reason to believe, that the proposed project poses specific effects to cultural resource in so great an expanse. The Section 106 process is currently identifying relevant resources. The FEIS

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				should decline to use such a large unsupported study area and conform to the Section 106 conclusions.
100	APPENDIX B: CULTURAL	3.4	Page 38, final three paragraphs	The RDEIS analyzes how, in the no-action alternative, catastrophic and major floods may bury, inundate, scour, or otherwise impact historic and cultural resources, but it minimizes or discounts those effects because they are ostensibly natural and have long been part of the landscape. This analysis is flawed because it artificially exaggerates the adverse impacts of the proposed Project: the inundation or potential burial of historic or cultural properties in the temporary inundation pool (give those resources' locations based on archaeological work cited in the RDEIS) is comparable to, and perhaps less destructive than, the inundation from major or catastrophic flood flows and the landslides that they have historically engendered. It is not appropriate to count one as an impact but discount the other because it is longstanding. The RDEIS notes that the severity of such flows and their attendant landslide and scour risks is increasing, most likely due to human-caused climate change. These things are not innate to the environment and should not be discounted in the manner the RDEIS discounts them. Further, the proposed Project includes landslide mitigation measures and a temporary pool that might ameliorate scour and landslide risks to these sites upstream of the facility, and its flow regulation downstream would certainly reduce risk to cultural and historic properties downstream. Consider, for example, that the 2007 flood destroyed the historic Tin Bridge, which the proposed Project might have prevented if it had existed at that time. The FEIS should analyze the impacts of major and catastrophic flood flows found in no-action alternative and local action alternatives without bias or discounting of these impacts, and it should consider the ways in which the proposed Project reduces those impacts. The proposed Project's potential adverse effects upon cultural resources cannot be properly analyzed without reference to the positive and negative effects of the project on this same topic. Nor can the public or decision makers properly compare the proposed Project to the alternatives analyzed if the effects of the latter, and the way that the proposed Project might reduce those effects, are not discussed.
101	APPENDIX B: CULTURAL	2.2.1	Page 10, Figure B-3	The study area for cultural resources appears to be the same study area as for the entire RDEIS, but it includes some figures showing a much smaller portion of the area than is shown in many of the other figures. The closeup of the study area depicted in this figure displays a hole in the middle of the study area, without explanation. The FEIS should either correct this figure, if it is not supposed to have such a hole, or it should explain why the study area excludes this small region. Further, this figure should reflect the entirety of the Study Area if the FEIS will include an analysis that exceeds the Section 106 APE.
102	APPENDIX B: CULTURAL	2.2.1	Page 6, second paragraph	The appendix should use consistent terminology for the resources that are analyzed in the appendix, which should be defined from the beginning. For example, Section 2.2.1 mentions "Native American place names;" however, this term was not used prior in the appendix where the types of resources included in the analysis were described.
103	APPENDIX B: CULTURAL	2.2.5	Page 15, Table B-5	The FEIS should identify which of these are in location of physical disturbance versus viewshed or buffer. This information is important to assess project effects on resources. It is

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				understood that the RDEIS does not do this because cultural resources are still be identified in the Section 106 process, and the analysis is relying on the Section 106 process. However, the RDEIS should not have prejudged or presupposed the outcome of that process and the effects.
104	APPENDIX B: CULTURAL	2.2.5	Page 15, Table B-5	This table suggests there are 166 archaeological resources "yet to be determined." However, neither the table nor the accompanying narrative states explain what "not yet determined" means in terms of the analysis or if there is project nexus to potential impacts on these resources. The FEIS should clarify. Or, better yet, it should narrow its study area to those areas that might potentially be affected, as identified in the Section 106 process.
105	APPENDIX B: CULTURAL	2.2.5.1	Page 16, first paragraph	The RDEIS's description of "known" archaeological resources that "would be impacted" by the proposed Project effects is mistaken. To be precise, since the analysis is using the Section 106 process, it must follow that process. These resources have not been determined eligible by the lead federal agency yet, and SHPO concurrence has not yet been obtained for these determinations of eligibility. Therefore, it is entirely predeterminate and presumptive to make conclusions on project effects. The applicant's archaeological team identified many of these archaeological resources in prior survey work and recommended that only some of them were eligible. DAHP is included in the NHPA Section 106 consultation process in which this work was presented for comment over a period of several months, and DAHP did not suggest any changes to those recommendations, nor have the consulting tribes suggested changes to date. It is too ungenerous to state that this is merely the applicant's recommendation with no concurrence from other Section 106 participants. The FEIS should include additional information generated through Section 106 consultation, which will evaluate which resources are determined eligible.
106	APPENDIX B: CULTURAL	2.2.5.1	Page 16, first paragraph	The RDEIS uses 'vicinity', an undefined term throughout Appendix B. Generally, cultural resources are described in proximity to the Section 106 APE (i.e., within the APE). Project effects are then assessed within the APE, not in a 'vicinity. Reliance on the term "vicinity" is ambiguous and should be replaced to more appropriately indicate whether there are the archaeological resources are within the APE as established in the Section 106 process.
107	APPENDIX B: CULTURAL	2.2.6	Page 16, first paragraph	The RDEIS uses the term "historic properties" when in fact "historic built environment resources" might be the subject of this section. Recommend that the FEIS uses terminology consistent with Section 106 because the State's analysis will depend upon the determinations of eligibility that are being completed as part of the Section 106 process.
108	APPENDIX B: CULTURAL	2.2.6	Page 16, first paragraph	The final sentence, in bold font, is a conclusion lacking any supporting analysis. There is no indication whether potentially existent archaeological sites would incur any project effects. It is improper to make a conclusion of project effects with no analysis.
109	APPENDIX B: CULTURAL	2.2.6	Page 17, Table B-6	The description herein is too high level to understand where the potentially impacted resources are located. It is important to identify what is in the project footprint and what will incur project effects.
110	APPENDIX B: CULTURAL	2.2.6.1	Page 18, first paragraph	This resource (the Tin Bridge) is no longer within the FRE facility site, and it should be made clear that it is no longer extant and thus, does not need to be considered herein. The

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				reference to the Pe Ell Water system's historic features is imprecise, as well. Although those features of the water system were recorded as a built environment resource, the District's archaeological firm recommended that the proposed Project would only potentially impact the non-contributing components of that system, and so would not adversely affect the historic property. (Ostrander and Scott 2022; Ostrander 2025). The U.S. Army Corps agreed with this finding.
111	APPENDIX B: CULTURAL	2.2.7	Page 18, second paragraph	The statement about historic-era cemeteries needs more context. The FEIS should indicate the number of cemeteries that were relocated and should indicate whether they relocated into the Study Area and the area where project effects will occur (i.e., the Section 106 APE).
112	APPENDIX B: CULTURAL	2.2.7	Page 18, Table B-7	Specify whether these recorded cemeteries are within the footprint and Section 106 APE. This is important to know for impacts analysis and the data lacking any nexus to the proposed project does not offer context.
113	APPENDIX B: CULTURAL	2.2.8	Page 20, first paragraph	This paragraph is confusing because it indicates the following list is not related to either this RDEIS study area or project reviewed by this RDEIS. It is confusing to have a list of 6 general statements untethered to this proposed project. Further, several of the itemized elements lack source data and appear to be conclusions without supporting analysis. If the RDEIS lacks meaningful information to substantiate its analysis, the FEIS should await the outcome of the Section 106 process for a better understanding of identified resources and APE.
114	APPENDIX B: CULTURAL	3.2.1.1.1	Page 26, second paragraph of section	This is unclear whether there is a reference to impacts here rather than effects. Under Section 106, effects are not assessed on all resources; effects are assessed on resources that are eligible for or listed in the NRHP (i.e., historic properties). Because this analysis relies on the Section 106 process, it would be prudent to use consistent terminology.
115	APPENDIX B: CULTURAL	3.2.1.1.1	Page 27, first paragraph	If determined eligible, the NRHP-eligible sites will be assessed for effects, and if those effects are determined to be adverse, the USACE will determine appropriate mitigation in consultation with the Section 106 parties.
116	APPENDIX B: CULTURAL	3.2.1.1.1	Page 27, fifth paragraph	Terminology is confusing in this context. "Historic property" means an eligible or listed site, building, structure, object, or district. The RDEIS should stay consistent with NHPA Section 106 terminology as this analysis is relying on the Section 106 process. However, the conclusion that there would be no adverse effects to the Pe Ell Water System is correct,
117	APPENDIX B: CULTURAL	3.2.1.1.1	Page 27, sixth paragraph	This same statement about an Inadvertent Discovery Plan (IDP) should be included above for archaeological resources.
118	APPENDIX B: CULTURAL	3.2.1.1.1	Page 27, seventh paragraph	Project activities should be described above as these are common for all resource types, not just TCPs. Here, documented TCPs should be described and assessed for impacts.
119	APPENDIX B: CULTURAL	3.2.1.1.1	Page 28, third paragraph	It is unclear what TCPs are discussed herein. These are not described and thus, the analysis is not verifiable. The lack of details derives from these potential TCPs being identified and evaluated in the Section 106 process; the FEIS should await the evaluation

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				and determination of potential effects from that process rather than prematurely presuming effects or impacts here.
120	APPENDIX B: CULTURAL	3.2.1.1.1	Page 28, fourth paragraph	Concluding that significant adverse impacts would occur to unrecorded archaeological resources is not substantiated and potentially predeterminate. Significant adverse impacts occur if significant (or eligible) sites are impacted to the extent they can no longer convey their significance. It is presumptive to conclude that any unrecorded site would be significant. Moreover, these impacts are not adequately compared to impacts in the absence of the project due to major or catastrophic flooding. If the proposed facility does not meaningfully increase the disruption such flooding will cause the sites, it is not a significant impact.
121	APPENDIX B: CULTURAL	3.2.1.1.1	Page 28, fourth paragraph	It is premature to conclude that the impacts to archaeological sites will be significant when such sites are still being evaluated in the Section 106 process, in which DAHP is participating and may concur with the USACE's. The FEIS should consider the impacts and mitigation analysis that arises from further information generated in the Section 106 process.
122	APPENDIX B: CULTURAL	3.2.1.2	Page 29, third paragraph	Discussion of archaeological resources should be moved to the archaeological sites and isolates paragraph above. Additionally, an IDP would be needed for archaeology as well, not just human remains.
123	APPENDIX B: CULTURAL	3.2.2.1.1	Page 30, second paragraph	The accumulation rate anticipated during time when the water is being stored may be relevant in this analysis. Burial may take longer than the short-term storage event. Moreover, effects from operations must be compared against the effects of major or catastrophic flood flows under the No Action Alternative and the landslides that have historically attended such floods, which could also inundate, erode, bury, or destroy such sites.
124	APPENDIX B: CULTURAL	3.2.2.1.1	Page 30, second paragraph	There is an undefined reference to increased wet/dry cycles. There should be some analysis whether the proposed project increases those over natural conditions, especially for any sites that are in the floodplain already (or in light of the high quantity of precipitation such sites naturally endure).
125	APPENDIX B: CULTURAL	3.2.2.1.1	Page 31, first paragraph	Under Section 106, adverse effects have to be avoided, minimized, or mitigated. If adverse effects cannot be avoided or minimized, then they are mitigated. The Section 106 consulting parties identify appropriate mitigation, which is included in an agreement document. The FEIS should clearly reflect the Section 106 process.
126	APPENDIX B: CULTURAL	3.2.2.1.1	Page 31, third paragraph	Archaeological resources should be discussed in the Archaeological Sites and Isolates section above, not here in the Human Remains and Cemeteries section.
127	APPENDIX B: CULTURAL	3.2.2.1.1	Page 31, third paragraph	An IDP applies to archaeological resources, not just human remains. The IDP should include archaeological resources as well.
128	APPENDIX B: CULTURAL	3.2.2.1.1	Page 31, fifth paragraph	Same comment applies here as in Section 3.2.1.1.1, which states: Concluding that significant adverse impacts would occur to unrecorded archaeological resources is not substantiated. Significant adverse impacts occur if significant (or eligible) sites are impacted

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				to the extent they can no longer convey their significance. It is presumptive to conclude that any unrecorded site would be significant.
129	APPENDIX B: CULTURAL	3.2.2.1.1	Page 31, fifth paragraph	Notably, the proposed Project has attempted to minimize impacts on the site noted in the RDEIS. The Section 106 process to fully evaluate the resource for eligibility, determine potential effects, and determine any mitigation is ongoing, and it is premature to determine significant impacts before that process concludes. The FEIS should follow the outcomes of the Section 106 process.
130	APPENDIX B: CULTURAL	3.2.2.3	Page 33, first full paragraph	The cross reference to the Fish report is misplaced because, as noted dozens of times in the comments to that Appendix, the adverse impacts noted in the RDEIS are overstated and conflate climate change impacts with the project impacts. The proposed Project's mitigation plan includes measures that would reduce river temperatures downstream of the facility. The increased temperatures and lower flows shown in the RDEIS's modeling, which affect the culturally significant Lamprey, result from climate change in the No Action Alternative, not the proposed Project. As such, the cultural implications of such fish impacts are not impacts of the proposed Project. The FEIS should correct the Fish report and cross-references to its incorrect conclusions through the document.
131	APPENDIX B: CULTURAL	3.2.3	Page 33, second paragraph of section	This is not accurate. If adverse effects on NRHP eligible properties are determined to be a result of the project, then the Section 106 consulting parties will consult to resolve adverse effects on those properties. Mitigation measures are agreed upon during Section 106 consultation and a Programmatic Agreement or Memorandum of Agreement that includes the agreed-upon mitigation measures is executed. The FEIS should credit this process and conclude that it will mitigate for adverse effects.
132	APPENDIX B: CULTURAL	3.2.3	Page 34, first paragraph	IDPs also include the process to follow in the event human remains are inadvertently discovered.
133	APPENDIX B: CULTURAL	3.2.4	Page 34, bullet list	These first two bullets are not appropriate mitigation measures - they are identification efforts.
134	APPENDIX B: CULTURAL	3.2.4	Page 34, bullet list	An IDP is not considered a mitigation measure under Section 106 and typically under the DAHP standards. An IDP is a best management practice (BMP) and is a tool to avoid or minimize potential effects. An IDP is similar to BMPs in other permitting contexts that are discussed in the RDEIS mitigation sections.
135	APPENDIX B: CULTURAL	3.2.4	Page 34, first paragraph	The FEIS should reflect there would be an agreement document - that is standard practice when adverse effects cannot be avoided or minimized.
136	APPENDIX B: CULTURAL	3.2.4	Page 34, third paragraph	Mitigation would include measures that benefit the Tribes, the public, and professional understanding, as typical in Section 106 and DAHP processes. The DAHP website provides some guidance on mitigation: https://dahp.wa.gov/project-review/mitigation-ideas. The FEIS should credit and follow the Section 106.
137	APPENDIX B: CULTURAL	3.3.1.1	Page 35, second paragraph of section	There is no support or content for how this analysis can assert that all impacts could be avoided. For example, there is no analysis concerning what archaeological sites or isolates

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				may be in the footprint or APEs of such local actions, in part because such actions are nonspecific and not yet proposed or identified. Here is one example of a potential local action, however: an airport levee improvement built without the reduction in inundation from the District's proposed Project would likely need to be a ring levee. Construction of new levee components to complete the ring, outside of the current levee footprint west of Interstate-5 in the airport vicinity, would pass through areas that are denoted in the statewide predictive model on the public side of WISAARD as having a high risk of containing archaeological resources. Before a survey is conducted of the area, it is premature to conclude whether any resources would be present and whether they would be affected, let alone whether such effects could be avoided or mitigated. To be similar to the treatment of the proposed Project, rather than concluding that such impacts would be avoided or mitigated, the FEIS should note that such impacts are indeterminate, and could potentially be significant and unavoidable, unless mitigated.
138	APPENDIX B: CULTURAL	3.3.1.1	Page 36, first paragraph	It is unclear how construction could cause impacts. Would historic buildings and structures be demolished? The appendix needs to explain and analyze further to support this conclusion so that the level of effort is commiserate with the analysis for the proposed Project. This is not to say that the District disagrees with the conclusion; daylighting China Creek would include modifications through the heart of historic Centralia, including City Hall and Centralia College, among other historic buildings. It is only that the FEIS should provide more analysis to put the alternatives on equal footing to the proposed Project.
139	APPENDIX B: CULTURAL	3.3.1.2	Page 36, first paragraph of section	This analysis does not assess indirect impacts as defined in Section 2.1, which states: A direct effect occurs at the same time and place with no intervening cause and includes visual, physical, or auditory effects. Indirect effects to historic and cultural resources are those caused later in time or that are farther removed in distance but still reasonably foreseeable. Indirect effects include regulatory or policy changes that would change cultural resources review processes or increase public access to locations that would otherwise be inaccessible, resulting in damage to or looting of cultural resources. This analysis confuses the definition of direct and indirect impacts from how those are defined in Section 2.1. It is prudent to be consistent in applying definitions throughout the entire analysis. This is not to say that the District disagrees that local actions such as daylighting China Creek could have indirect effects on historic properties. For example, changes in land use related to the daylighted corridor could, ultimately, cause development or redevelopment of historic properties or those adjacent to them, which could affect the nature of those properties or their cultural significance. The District encourages the FEIS to include more analysis of the alternatives to put them on equal footing with the proposed Project.

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APPENDIX C: ENVIRONMENTAL HEALTH & SAFETY				
140	APPENDIX C: ENVIRONMENTAL HEALTH & SAFETY	3.2.2.1.1; 3.2.5	Page 19, 2nd paragraph, and Page 35	This section makes a significant adverse impact determination based on the potential for a large enough earthquake to occur while the temporary inundation pool is full, leading to catastrophic failure having downstream effects. It also mentions how as design progresses it would be subject to Ecology's DSO which would ultimately determine if the FRE structure design were safe enough and approve construction. Such approval would require seismic compliance to withstand an extremely rare earthquake (1 in 10,000-year quake), which would have to occur in the very small percentage of time when the temporary pool is full; the net result of these two unlikely scenarios is a shrinkingly small risk that these potential adverse effects would occur. DSO permit requirements are not uncertain or infeasible. The FEIS should credit these requirements as mitigating this risk such that it is no longer a significant *probable* adverse impact. The RDEIS currently analyzes this impact as if it were probable, when it is not probable under current industry guidelines, this risk of failure is so low that it would not be considered a credible risk. If the purpose for discussing this non-credible risk is to address public comments on the 2020 DEIS, the FEIS should note that this is the purpose of the discussion, and that the impacts addressed on this point are not probable.
141	APPENDIX C: ENVIRONMENTAL HEALTH & SAFETY	3.2.2.1.3	Page 23 3rd paragraph; Page 26, 5th paragraph	This section of the Discipline Report and the corresponding section of the main SEPA RDEIS both reference the benefits of the facility during times of major or catastrophic flooding through reductions in needs for emergency services, improved emergency service response (by safeguarding road access), and reduced public exposure to harmful contaminants. Yet, the stand-alone summary RDEIS document and the similar summary at the outset of the RDEIS contain no reference to these benefits; only the very unlikely catastrophic earthquake impacts are mentioned there, in the same table and in essentially the same format as probable significant adverse impacts. Fronting the adverse impacts over the much-more-likely beneficial impacts of the project is misleading, requiring the public to read hundreds of pages of materials to see the likely project impacts. The FEIS should include both positive and negative impacts in its summary to provide the public with a fair assessment of the proposed Project's probable impacts.
142	APPENDIX C: ENVIRONMENTAL HEALTH & SAFETY	3.2.2.1.3	Page 26, 5th paragraph	This section correctly analyzes how the proposed Project will reduce inundation levels and therefore reduce the number of inundated hazardous materials sites that would mobilize contaminants. The section's conclusion that the project results in "less than significant adverse impacts" understates that the Project has positive environmental impacts in this regard. The analysis also understates the benefit the facility would create in several respects. First, it considers only hazardous materials sites. Many homes and businesses have household hazardous waste that can be mobilized into floodwaters if they are sufficiently inundated. By reducing or eliminating inundation levels in these structures, the proposed Project reduces a diffuse and widely dispersed release of chemicals into the environment. Second, many inundated structures contain trash or other *nonhazardous* materials that can nevertheless leach harmful chemicals into floodwaters and, ultimately, surface and groundwater. Reducing or preventing inundation reduces such leachate. Third, the analysis fails to consider flood impacts on public services, particularly the risk that

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				flooding impacts public water supplies, sewer or septic systems, or electricity service. Reducing the severity of flooding, on the margins, reduces drinking water contamination and sewer or septic leachate (particularly from septic systems dependent on electric pumps). Fourth, the analysis considers only the release of chemicals into the environment generally, without noting the environmental health implications of such chemicals (or fecal coliform, offal, mud, other unhealthy contaminants) washing and soaking into homes and businesses. Reducing inundation reduces these contaminants' lingering presence in occupied structures, as well as reducing mold or other moisture-related health risks in those structures. All these items result in a far greater environmental health benefit than this section analyzes. The FEIS should consider these environmental health benefits in this Discipline Report as well as in the discipline reports analyzing aquatic species outcomes and water quality, since the reduction in mobilization of the above-described contaminants affects those reports' analysis of probable significant adverse impacts.
143	APPENDIX C: ENVIRONMENTAL HEALTH & SAFETY	3.2.4.1	General comment for section	Although this Discipline Report discusses DSO review of the design and safety standards necessary for the proposed Project to be permitted and constructed, the RDEIS does not include such design review and approval as a permit-required mitigation measure. The FEIS should note this important mitigation measure because it addresses the very impact that this Discipline Report most often highlights: the earthquake risk. DSO design requirements will require the proposed Project to meet rigorous seismic standards that make the earthquake mentioned in the RDEIS extremely unlikely. Indeed, this earthquake risk, mentioned several times in the RDEIS, is far, far less likely than any of the mitigation measures the RDEIS declines to analyze due to "uncertainty", demonstrating that the RDEIS easily could have analyzed those mitigation measures despite the uncertainty.
APPENDIX D: ENVIRONMENTAL JUSTICE				
144	APPENDIX D: ENVIRONMENTAL JUSTICE	2.3	Page 15, 3rd-5th bullets	(CEQ 1997), (USEPA 1998), and (NEPA Committee and EJ IWG 2016) are referenced in body text, but are not listed in references section of the appendix. The FEIS should identify these sources.
145	APPENDIX D: ENVIRONMENTAL JUSTICE	3.2.1	Page 20, paragraph 1	The RDEIS states there is one debris management storage area, but this has been further developed since the2024 Revised Project Description. In the draft Debris Management During Flood Retention Report (Attachment 1 to Attachment 2: Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum), there are two debris storage areas. The FEIS should reflect the project update.
146	APPENDIX D: ENVIRONMENTAL JUSTICE	3.2.1	Page 20, 3rd bullet	This section incorrectly states that three quarry sites will be developed. The project is exploring three quarry sites, but no more than 2 quarries are proposed for disturbance as correctly stated in the SEPA RDEIS main document section 2.3.3.1, pg. 16 and Appendix 1 section 3.2.6 pg. 37. Additionally, Section 7.4 of the RPDR (2024) states that ultimately one quarry will be selected as the primary quarry keeping a second option permitted in the case there are issues with the first site. Revise the RDEIS and revise its findings accordingly such that the FEIS correctly characterizes the project.

Comment #	Revised Draft EIS Component	Main Body or Appendix Section	Location (page, paragraph, sentence, table, bullet)	Comment
147	APPENDIX D: ENVIRONMENTAL JUSTICE	3.2.2.1	General comment for section	Direct Impacts of the Local Action and No Action alternative on communities of color and low-income populations should be directly compared with the reduced flood damage associated with the FRE. This section is focused wholly on the very unlikely occurrence of FRE structure failure and ignores the disproportionate effects existing today, and exacerbated with climate change, on vulnerable populations in the basin.
148	APPENDIX D: ENVIRONMENTAL JUSTICE	3.2.2.1	Page 26, 1st bullet	In the Environmental Health and Safety report the FRE structure failure probability was not included in the RDEIS but was included in the 2020 DEIS. That probability was stated as 1 in 2.5 billion in 2020 and unless otherwise further analyzed, should be stated for the pubic to see the very small likelihood of that impact.
149	APPENDIX D: ENVIRONMENTAL JUSTICE	3.2.3.1	General comment for section	This section should refer to the rigorous design and approval process for a structure of this type. This includes an independent panel of dam safety experts who will review and comment on the design to ensure the structure meets or exceeds all applicable dam safety criteria.
150	APPENDIX D: ENVIRONMENTAL JUSTICE	3.2.3.2	General comment for section	This section should refer to the rigorous design and approval process for a structure of this type. This includes an independent panel of dam safety experts who will review and comment on the design to ensure the structure meets or exceeds all applicable dam safety criteria.
151	APPENDIX D: ENVIRONMENTAL JUSTICE	3.4	Page 38, 3rd and 5th bullets	In this section there are estimates for losses of structures and environmental health contamination from flooding under the No Action Alternative. The RDEIS's conclusion that "Some changes may affect communities of color and low-income populations" is anemic and inconsistent with the analysis elsewhere in the Discipline Report. The FEIS should clearly categorize these losses as disproportionate to EJ communities. This Discipline Report already identifies these communities in the study area as being disproportionately impacted by flooding; the No Action Alternative's future flood projections are greater than current flooding risks, which will lead to even greater EJ impacts. The FEIS should systematically analyze, not minimize, the No Action Alternative's adverse environmental impacts and should describe when the proposed Project would reduce those impacts, to allow the public and decisionmakers to meaningfully compare the alternatives.
APPENDIX E: FISH				
152	APPENDIX E: FISH	Summary	Pages i-iv	Summary tables are misleading. | The title of Table E-1 indicates that this table presents a summary of Significant Adverse Impacts. The format of this table lists columns that, when read left to right are Impact, Impact Finding, Mitigation Proposed, and Significant and Unavoidable Adverse Impact. This implies to the reader that the determination of Significance presented (yes or no) considered all of the information provided in the cells to the left, when in fact they did not. For example, the Water Discipline Report (page 90, Appendix N) states: "...the Applicant is proposing a Surface Water Quality Management Plan that would provide sufficient shade for mitigation." Yet, in the fish summary table (and the water summary table), the RDEIS states that water temperature effects are Significant and Unavoidable. This presentation can lead the reader to a mistaken conclusion and in

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				that way, lacks transparency, and does not meet Ecology's obligation to identify the Project's probable impacts for the public and local and state decision makers.
153	APPENDIX E: FISH	Summary	Page 31	Inconsistencies in abundance between Table E-7 and text and identified sources. | Several of the values for adult salmon and steelhead abundance upstream of Crim Creek that are presented in Table E-7 are inconsistent with those presented in the identified source Ronne et al. (2020) and are also inconsistent with the text that follows in Sections 2.2.2.1.1, 2.2.2.1.2, 2.2.2,1.3, and 2.2.2.1.4. Average values for 2013-2018 from Table 2 in Ronne et al. (2020) for spring Chinook Salmon, fall Chinook Salmon, Coho Salmon and Steelhead are 23, 320, 858, and 1142, respectively, while averages presented in table E-7 are 20, 363, 1070, and 1214. These numbers and the associated affected environment descriptions should represent the data available for the system. If additional data were used to update those numbers, then additional citations should be provided to support the estimates. Further, the text that follows Table E-7 and describes these subpopulations inconsistently relies on either the Ronne et al. (2020) numbers or the numbers from Table E-7 but no additional citation is provided. For example, average abundance for spring Chinook Salmon and Steelhead are the same as in Table E-7, while averages presented for fall Chinook and Coho salmon were taken from Ronne et al. (2020) and are considerably different than the averages presented in the table. These inconsistencies are not only confusing to the reader but also make it hard to understand how existing conditions are or are not consistent with models used to evaluate impacts to these subpopulations. The FEIS must explain whether other sources were used to support these averages and, if so, how the data from the two sources were used together and how they informed impact modeling.
154	APPENDIX E: FISH		General	The evaluation of potential impact is not consistent across Project-related actions, nor does it compare the Project Actions to the No Action Alternative to allow for a transparent determination of probable Project-related impacts. | 1. While only negative impacts are discussed for the FRE facility, benefits and negative impacts are discussed for the Local Actions alternative. One interpretation of this could be that the FRE facility would have no potential benefits, but that is not the case. For example, one potential benefit of the FRE facility would be the reduction in bed scour that would result from holding back a major or catastrophic flood. Reducing bed scour could in turn result in increased survival of eggs and embryos that are in the gravels in both the reach upstream of Crim Creek and the reach from Rainbow Falls to Crim Creek. SEPA requires an objective and impartial evaluation of probable impacts. Presenting only negative impacts of one alternative, while presenting potential benefits of other alternatives, is not consistent, impartial, or transparent. 2. While the Life-Cycle Model appears to have considered both future Project impacts and future No Action conditions, the results are not presented in a way that facilitates this comparison. Instead, both graphic and written descriptions of model results compare the future with the Project against a more current baseline condition and, in doing so, misleadingly conflate the impact of future conditions (i.e., climate change) with the Project's impacts, making it appear that the Project is causing impacts related to climate change.

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				The FEIS must transparently compare the Project to the No Action alternative so that the Project's probable impacts are clear, and the impacts of climate change are not ascribed to the Project. 3. The models used to predict potential impacts related to the Project in the SEPA analysis are not in alignment with current conditions nor smolt to adult returns that have been observed in the upper river over the past decade. Thus, they were not configured to perform in a reliable way. The EDT model's 2-year average flow scenario was developed to reflect a baseline condition that would then be changed to capture future conditions that would support specific levels of productivity and capacity of each modeled scenario. Unfortunately, the modeled SEPA EDT baseline condition does not represent the patterns of abundances that have been observed in the upper river in the past decade. The data available from WDFW surveys between 2013 and 2021 demonstrate that Chinook Salmon upstream Crim Creek subpopulations have fewer fish than the subpopulations between Rainbow Falls and Crim Creek. The difference for spring-run Chinook salmon is dramatic with recent WDFW abundance estimates an order of magnitude greater downstream as compared to upstream of Crim Creek; yet the SEPA EDT outputs for baseline conditions were estimated as slightly more adult Spring Chinook spawners upstream of Crim Creek as compared to downstream. These outputs are then used in the SEPA Life-Cycle Model to predict future conditions. While the District has not had the time to review and compare all input files used in the SEPA EDT model, we have identified several that look to be dissimilar to current conditions and would warrant further consideration and modification. For example, the model appears to be underestimating habitat conditions that are currently affecting the salmon populations including, for example, bed scour, area of side channel and pool habitat, and embeddedness within the FRE footprint. Using unvalidated parameters appears to be resulting in higher estimates of productivity and capacity than exists based on recent field surveys. It is worth noting that the District collected data on habitat conditions from 2022-2025 and presented both the methods and potential for inconsistencies with previous EDT ratings to the agencies in the spring of 2025. While the technical committee advising on the OCB EDT considered and agreed to incorporate relevant data to that model, it appears that the SEPA team opted not to consider these data when updating their EDT. This undermines the validity of the SEPA EDT results. There may be other habitat parameters of the model that are causing it to perform poorly in predicting baseline populations; additional testing of the model would be required to understand where it could be improved to reflect current conditions. In its current configuration, using the EDT abundance estimates as initial model abundance estimates for the SEPA Life-Cycle Model also calls into question the reliability of the outputs of that model. Overall, the model, as parameterized, does not align with empirical data collected by WDFW and others. For example, the model predicts more spring and fall-run Chinook spawners upstream of the FRE facility as compared to downstream of the facility, but in reality, the majority of spawning by Chinook salmon upstream of Newaukum occurs below the FRE. Based on 2018 redd data, 81% of spring-run Chinook salmon redds were located

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				below the FRE and 57% of fall-run Chinook salmon redds were located below the FRE. Results from the EDT model suggest that 60% of the fall-run Chinook spawners utilize the area upstream of the FRE and 52% of the spring-run Chinook spawners utilize the area upstream of the FRE. This suggests the model is parameterized incorrectly given the disparity between empirical and predicted data. Page 78 of Appendix E suggests the EDT model was validated with fish escapement numbers, but this does not appear to be the case, raising questions regarding the reliability of the model results and associated Project impact analyses.
155	APPENDIX E: FISH		General (page iii)	Inadequate impacts analysis of Local Actions alternative | On page iii, the RDEIS discusses the Local Actions alternative and suggests purchase of at-risk properties in the floodplain. In the Chehalis River basin, most of the at-risk property that is in the historical floodplain consists of farms/agriculture, raising questions regarding the legitimacy of this suggestion. No Land use impact was attributed to this proposed loss of agricultural resource land; that impact should have been addressed. Moreover, the Local Actions alternative was not evaluated via EDT/LCM while all other actions/alternatives were evaluated. This erroneously assumes that the Local Actions alternative would have no fish impacts, which is untrue: at a minimum, it would have the same fish impacts as the No Action alternative (which included the extirpation of some salmon species from Rainbow Falls to Crim Creek and which should also include fish impacts in the uppermost basin from major and catastrophic flooding that the RDEIS is currently not capturing in its modeling). Beyond that, some local actions under consideration in the upper Chehalis include levees that would likely have adverse impacts. The FEIS should analyze the impacts of all alternatives, not merely the proposed Project.
156	APPENDIX E: FISH	1 Introduction	Page 40	Based on Figure E-6b, EDT model assumption for fall-run Chinook salmon spawning distribution does not accurately reflect existing or historic spawning information. | As is evident from Figure E-6b, fall-run Chinook Salmon have been documented spawning in four tributaries that were not included in the modeled fish distribution - the East Fork, Thrash, Crim and Lester Creeks. By excluding the contribution of spawning in these tributaries from the EDT model for this subpopulation, the model would underestimate the contribution of these fish that would not be impacted by the inundation pool and would overestimate impacts to this subpopulation as a whole. Using 2018 WDFW redd data provides an estimate of the proportion of the fall-run Chinook salmon spawning habitat and population excluded from the SEPA EDT and LCM models. While survey efforts were not the same every year, the 2018 data is considered the most comprehensive spawning survey data and thus represents the best recent data for salmon distributions in the upper Chehalis River. In 2018, no fish were observed spawning in Thrash Creek, but the combined proportion of spawners in Crim Creek, Lester Creek, and the East Fork would have been approximately 5% of the total run that year. By not including this portion of the subpopulation, EDT and LCM model results potentially overestimate impacts to this subpopulation.
157	APPENDIX E: FISH	1 Introduction	Page 59	Substantial effects of flooding on macroinvertebrates would occur in No Action, changes to these would need to be considered under FRE. | As described in Section 2.2.2.4 of

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				Appendix E, under the current condition, flooding and especially major or greater floods may be causing impacts to macroinvertebrates that require years for populations to recover. As described in Section 2.2.3, these floods are anticipated to occur with more intensity and more frequency based on future climate predictions, suggesting that this impact would be even greater under the No Action Alternative. High-flow events, including major and catastrophic floods, present suboptimal in-channel conditions for rearing salmonids (Jeffres et al. 2008) and increase risk of mortality from sources like stranding (Junk et al. 1989). Given this information, any potential risks to juvenile salmonids associated with FRE operation should be interpreted in the context of risks faced during high flow events under No Action conditions which includes more frequent and intense flooding, and increased channel degradation in the upper Chehalis River. By not making that comparison, the potential impacts associated with the future FRE facility are inappropriately inflated.
158	APPENDIX E: FISH	2 Methodology	General Comment	Lack of transparency and consistency in model assumptions. | Jorgensen et al. (2021) modeled the Chehalis Basin using the HARP model; within that model was a juvenile salmonid redistribution model. Within the salmon redistribution model, all movements are in the downstream direction. Proportions of fish moving downstream were guided by the Chehalis Basin Scientific Review Team. The downstream movement text is at odds with text regarding upstream movement within this section. Furthermore, based on Jorgensen et al. (2021), only 5% of young of year Coho Salmon would move downstream to the mainstem which is substantially less than what the modeling presented. As written, the RDEIS incorrectly suggests that all, or nearly all, Coho Salmon upstream of the FRE are impacted by FRE operations by eliminating their ability to move downstream.
159	APPENDIX E: FISH	2 Methodology	Page 73	Lack of clarity and inconsistency in describing Proposed Action assumption for EDT modeling make it difficult to determine if the model accounted for potential future habitat changes as described for No Action. | On this page, it is stated that the analysis of the FRE "facility incorporated changes over time in salmonid habitat potential due to projected effects of a changing environmental baseline" and specifies hydrology, temperature, and "several other factors" that appear to be consistent with the assumptions for the No Action. The reader is then referred to Attachments E-2 and E-3. In Attachment E-2, the No Action Modeling Assumptions section clearly lists specific assumptions for land use degradation, culvert actions, ASRP early actions, and tree growth. We were unable to identify anywhere in the Proposed Action (FRE) Modeling Assumptions that similar assumptions were made resulting in habitat rating changes when modeling the FRE. If these future habitat conditions were included, specifics should be provided in this section of Attachment E-2. If they were not and an additional model run is not planned, then the text should be revised to be clear in the Methods section. However, upon review of model assumptions in Attachment E-2, where the assumptions for the No Action are clearly identified in a footnote to Table E. 2-1, this footnote appears to only apply to the No Action Timeline not the FRE Facility Timeline model scenarios.

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160	APPENDIX E: FISH	2 Methodology	Page 73	The statement "…potential of a major or larger flood occurring during construction and backwater effects that could temporarily inundate area upstream of the diversion dam" is inaccurate. A diversion dam is not proposed as part of the project. Additionally, flow through the project site is conveyed in the existing river channel, the bypass river channel, and through the proposed FRE conduits during the different phases of construction. Backwater upstream of the project site would only occur when the river is flowing through the FRE conduits and the flood flows exceed the open channel capacity of the conduits (9,500 cfs in the project description; 13,700 cfs in the current design.
161	APPENDIX E: FISH	2 Methodology	Page 78	Annual Ocean Productivity changes with model scenarios and lacks transparency. | In Section 2.4.2.1.3, it states "Annual ocean productivity in the LCM is treated as a density-independent function, where there is no limit in capacity and productivity is held constant among the flood scenarios modeled." Yet, upon review of the LCM files, we noted that for some scenarios for spring-run Chinook Salmon (mostly under the proposed action scenarios) the ocean survival and capacity was not density-independent. This may be moot and may have no impact on LCM; however, the input files provided show density dependence in marine survival and capacity for spring-run Chinook. If this is how the model was run it would be incorrect and inconsistent with general knowledge of marine ecology. Clarification and, perhaps correction, to the density-dependent marine survival and capacity assumptions is needed.
162	APPENDIX E: FISH	2.1	Page 7, 3rd paragraph	Pre-supposing conclusion | "...extending from approximately 6 miles upstream of the proposed FRE facility to RM 5 east of Cosmopolis, where the effects on fish would be most noticeable." This is the Methods section, and it is inappropriate to reach a conclusion here that effects would be "noticeable." In fact, as set forth elsewhere in these comments, the RDEIS overestimates the potential impacts of the proposed Project by declining to analyze the reduction in impacts from mitigation and required permitting processes, by not clearly delineating the effects of the proposed Project from those of baseline future conditions due to climate change, and by relying on models that make inappropriate assumptions or otherwise fail to represent the conditions they propose to represent. To the extent that the proposed Project's fish effects are noticeable in portions of the study area, such as the area by Cosmopolis, it is because these are actually effects of the No Action alternative that are being incorrectly attributed to the proposed Project. Meanwhile, the No-Action and Local Actions alternatives' adverse fish impacts due to increased flooding are minimized, as is the proposed Project's reduction of those negative effects. The result is that the effects of the proposed Project that the RDEIS find noticeable are highly exaggerated.
163	APPENDIX E: FISH	2.2.1	Page 12, last paragraph	Insufficient information, Unsupported statement/conclusion. Please revise the analysis for the FEIS per the following: 1. "Solar heating is the primary driver of water temperatures…" This statement ignores importance of air temperatures as a primary driver and does not distinguish seasonal effects; for example, with climate change, summer water temperatures are predicted to increase with air temperature. Following the EIS' logic, solar heating would be the primary driver that causes the predicted increases of climate change, which is clearly incorrect. 2. "The water frequently exceeds maximum temperature thresholds in summer that salmon

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				and steelhead prefer" This is an overly generalized statement and not technically correct with respect to inferring impacts. For example, a temperature may not be in the range preferred by fish but is not stressful, so it cannot be automatically concluded that fish are being impacted.
164	APPENDIX E: FISH	2.2.1	Page 18, last paragraph	Insufficient information, Unsupported statement/conclusion | The statement ending with "...throughout the Chehalis Basin have resulted in a stream channel that is more simplified (predominantly a single-thread channel) compared to historical conditions" is overly generalized. It is unlikely to be true in the upper Chehalis River upstream of the South Fork, where the channel is predominantly entrenched and confined by bedrock.
165	APPENDIX E: FISH	2.2.1.1	Page 20, last paragraph	Inaccurate citation and interpretation | "The mainstem Chehalis River is more linear and simplified compared to historical conditions, particularly downstream of Crim Creek (RM 108) (Beechie et al. 2021)." Beechie et al. (2021) did not identify Crim Creek as a transition point. Moreover, given the river is mostly confined and entrenched with negligible bankfull channel migration down to above the South Fork, it is not clear how it can be more linear now compared to historic conditions.
166	APPENDIX E: FISH	2.2.1.1	Page 21, first paragraph	Insufficient information provided | Regarding landslides, the associated harvest practices involved are no longer occurring. The writing ignores that current forest practices rules protect against landslides too.
167	APPENDIX E: FISH	2.2.2.1.1	Page 33	Not considering best available information | Appendix B of the Revised Mitigation Plan provides important information on distribution of Chinook spawning habitat that provides important context for evaluating significance of effects; that information was not considered. For example, WDFW data indicates the proportion of spring run Chinook Salmon spawning in the upper Chehalis river is minor compared to spawning numbers in the major tributaries, and that most spawning in the upper Chehalis occurs downstream of Pe Ell.
168	APPENDIX E: FISH	2.4.2.1.4	Pages 79-80	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | The bullets on these two pages comprise a large number of sources of uncertainty, but the inherent uncertainty within each does not appear to have been estimated explicitly and evaluated in the LCM modeling, either directly through error propagation or through prior distributions if Bayesian modeling was performed. In addition, the uncertainty around assumptions presented in Attachment E-2 is limited and does not address all the uncertainty associated with using hypotheses to predict future environmental parameters such as bed scour, percent fines, wood, etc. To help facilitate the use of this model to inform decisions regarding flood control in the Chehalis River basin, the SEPA DEIS should identify all of the model parameters used and provide a level of uncertainty with that. Where appropriate, they should indicate how and where uncertainty increases. For example, how uncertain is the bed scour input that is generated from a calculator based on six parameters, most of which also have some level of uncertainty associated with them. In this way, the DEIS can provide transparency about their models. Based on the available documentation, it appears that the only way stochasticity was integrated in the modeling was by a form of Monte Carlo modeling where the sequence of

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				flows each year was selected randomly 100 times; it is furthermore unclear what distribution was assumed in the random selection of flows.
169	APPENDIX E: FISH	2.4.2.1.4	Pages 79-80	Model assumptions do not appear to match model input data, nor proposed FRE facility operation | As described in the last bullet that begins on page 78, the EDT modeled specific, representative floods such that, "if a flood event occurred in January, that timing affects the salmon and steelhead in the LCM" and "if floods occur at a different time of the year than was modeled," then different impacts could result. Later in the DEIS (page 146), it states that because no downstream passage would be provided during an FRE facility closure, it was conservatively assumed ... that juveniles attempting to pass during a major or catastrophic flood would not survive." As described in Attachment E-2, the 2009 "major" flood occurred in January and the 1996 flood occurred in February, so those months should define the FRE operating periods for FRE facility scenario models. However, when reviewing the EDT model inputs provided by Ecology, we noticed a significant inconsistency with what is described in Appendix E and Attachment E-2. The obstruction input dataset for SEPA EDT model runs with FRE facility showed that the FRE would be 100% impassible to juvenile salmon for 6 months, October through March, not just "conservatively" for the month when the facility would be operating. This is an inaccurate representation of the FRE operation and impact. There has been no model developed that predicted such extended operation of the FRE. Consequently, the condition modeled by the SEPA DEIS does not reflect the proposed, nor anticipated need for FRE operation. Instead, the SEPA DEIS presents unrealistic FRE modeling scenarios that artificially inflate the negative impacts of the FRE operation.
170	APPENDIX E: FISH	2.4.2.2	Pages 80-82	Insufficient information provided, incomplete analysis of effect and justification of assumptions, and not considering best available information likely affecting conclusions | Caldwell et al. (2004) PHABSIM upper Chehalis River study site was located above a long bedrock chute below Big Creek, where the District's spawning habitat mapping indicates some of the more extensive wetted gravel riffles and pools are located within the temporary impoundment reach. The site does not appear to be generally representative of most of the habitat in that reach and is also not representative of habitat-flow relations downstream of Crim Creek and the FRE facility location to Pe Ell. Therefore, the RDEIS incorrectly interprets analysis of Caldwell et al.'s site data as being appropriate for representing habitat in the rest of the river.
171	APPENDIX E: FISH	2.4.2.2	Page 81, Table E-9	Insufficient information provided | 1. Bass are not found in the impounded reach and are unlikely to be introduced upstream of Elk Creek in the future. 2. The resulting WUA-flow curves are not presented, and this is critical for interpreting the results that are tabularized in Section 3. Without this information, neither the District nor other interested parties or members of the public can provide meaningful comments on the RDEIS's analysis. Also see Comment #245 that describe how the manner in which WUA has been used to infer an impact constitutes a circular argument, and that thus the analyses involving WUA cannot be used to infer impacts of FRE facility construction and operation.

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172	APPENDIX E: FISH	3 Technical Analysis and Results	Page 88	Assumes fish would reside in temporary pool, would not leave and would perish. | The RDEIS expressly assumes that "juvenile and adult salmonids and other fishes migrating downstream would reside in the temporary inundation pool for up to 35 days." Assuming that all fish that remain in the temporary inundation pool and eventually will perish is not a reasonable assumption. Some fish are expected to choose to leave the inundation pool and move upstream to the riverine section of the mainstem or tributaries. The behavior of fish movements in inundation pools has been well documented throughout the Pacific Northwest and includes fish moving upstream as well as remaining along the shallow edges of the inundation pool. This is an important distinction to characterize because variability in fish behavior would likely include avoidance of deep-water habitats and therefore reduce exposure of these individuals to less suitable habitat conditions. The RDEIS's assumption that all fish remain in the temporary inundation pool until the die is not consistent with the best available science and leads to analyses and impact determinations that are inaccurate and unscientific. These errors must be corrected in the FEIS, which must recognize that fish behavior is flexible and fish are adaptable; therefore, fish would be expected to use edge habitats to move upstream to riverine habitats that would be available for rearing until the riverine condition is restored.
173	APPENDIX E: FISH	3 Technical Analysis and Results	Pages 204-206	LCM results for future No Action scenario are compared to median population abundances simulated for year 2035, with no explanation of how this was simulated. | This is the only mention of a simulation of median initial population abundances for fish populations in simulation year 2035. No further information is available about how these estimates were simulated or if they were validated against past escapement estimates. When comparing the median initial population abundances for the Life-Cycle Model (presented in Section 3.2.2 by subpopulation) to the WDFW survey estimates presented in Section 2.2.2.1 of the DEIS, the abundances for fall-run Chinook Salmon and Coho seem reasonable approximations of field estimates. In contrast, abundances for spring-run Chinook Salmon and steelhead appear to be inconsistent with WDFW escapements. Chinook are four times higher than the WDFW average from 2013 to 2018 and would be 10 times higher or even more if that average were to include the additional survey years from 2018 to 2024 (Number of spring-run Chinook redds upstream of the FRE by year: 2015 = 1; 2016 = 2; 2017 = 3; 2018 = 1; 2020 = 7; escapement 2.5, 5, 7.5, 17.5; average 8, thus 10 times higher). Yet, given how low the recent spring-run Chinook Salmon escapement to the upper Chehalis River has been, it is reasonable to assume that with some better water years, recent runs could increase on average to something greater than 20 fish. That said, an increase from an average of 20 to 80 would be unrealistically high given the median initial population abundance was simulated for 10 years in the future and predictions are for drier, not wetter, and warmer summer conditions that would be expected to further reduce migrating and spawning habitat suitability with respect to temperature and depth. In addition, the simulated median abundance for the steelhead subpopulation upstream of Crim Creek showed a different pattern than the other species and represented considerable fewer steelhead, approximately 42% of the WDFW average escapement. This steelhead median initial abundance is problematic as a more robust initial population could be

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				expected to perform differently within the Life-Cycle Model. One might expect a population of 1,214 steelhead to be more robust than a population of 514, and impacts to that population may be less under future model scenarios. In addition, these medians are the same numbers as EDT Equilibrium Abundance outputs. If these simulated median abundances are in fact SEPA EDT outputs from a 2035 2-year average condition model, it raises the question of whether the SEPA EDT overestimated habitat capacity/productivity for spring-run Chinook Salmon and underestimated habitat capacity/productivity for steelhead, because the simulated median initial abundances are considerably more and less, respectively, than estimated escapement for these subpopulations in the upper Chehalis. The simulated median initial population sizes for Rainbow Falls to Crim Creek subpopulations also appear to vary considerably from WDFW escapement estimates. As reported by Ronne et al. 2020, comparable peak supplement surveys in 2018 documented an order of magnitude more redds for spring-run Chinook Salmon downstream of the proposed FRE facility, 39 as compared to 1 upstream; whereas the numbers of fall-run Chinook Salmon redds downstream of the FRE facility were 3.45 times those upstream. In contrast, the median initial population abundances for these two subpopulations downstream of the FRE facility were both smaller than those used for modeling the upstream Chinook subpopulations. If inaccurate, these initial population abundances would affect the output of the LCM such that the model would predict more dramatic reductions to these population than if validated initial population abundances had been used.
174	APPENDIX E: FISH	3.2.1	Page 85, Table E-10	The Draft SEPA EIS presents construction-phase fish-passage survival estimates as low as 34% yet provides no traceable scientific or technical basis for these values. On Page 86, section 3.2.1 it is stated that anecdotal discussions "were used qualitatively to assess fish passage impacts." The EIS does not identify the underlying empirical studies or expert-judgment parameters used to derive these survivability estimates. Without such documentation, reviewers cannot determine whether these numbers reflect best available science, outdated assumptions, or are simply placeholders.
175	APPENDIX E: FISH	3.2.1	Page 85-86, Table E-10	Faulty logic used to estimate passage survivals adversely affects validity of EDT-LCM modeling predictions | See comment Comments #255 for Attachment E-3, p.3-11, Table E.3-2. It is not described in the RDEIS whether the EDT model is retaining the fish that do not attempt passage and allows them to survive or treats the survival numbers in Table E-10 as a multiplier to all fish arriving at the project site, which then effectively 'kills' those fish that do not make the attempt. The RDEIS's text and tables imply that they are simulated to simply die. In which case, the passage "survivals" summarized in Table E-10 would have been applied incorrectly and do not accurately represent total survival as traditionally treated in a population model and are as a consequence extremely and unreasonably low (irrespective of the observation that the component numbers used to calculate them are also unreasonably low). Accordingly, the population numbers generated by the EDT-LCM analyses are likely to be significantly in error and are inappropriate for inferring impacts of the FRE facility construction and operation. This appears to be a serious error in the RDEIS's analysis that would undermine its assessment of probable Project impacts. This

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				should be transparently corrected with an explanation for the error and modification in the FEIS.
176	APPENDIX E: FISH	3.2.1	Page 86, Table E-10	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | Multiple survival numbers provided in Table E-10 are unsupported by citations and references and so contrary to well-established and widely recognized, peer-reviewed science as to make their inclusion in the RDEIS and the RDEIS's reliance on them inappropriate. Accordingly, the RDEIS's reliance on numbers that are contrary to evidence results in an RDEIS that does not provide a credible, reliable assessment of the Project's probable adverse environmental impacts. Specifically: 1. See comments on Tables E-3.2 through E-3.8 and E-10 in Attachment E-3 regarding individual numbers in the columns likely being too low in general, and what happens to overall survival estimates for upper Chehalis River fish if the same numbers are applied to other passage obstacles downstream and upstream of the FRE facility 2. Of special note, the 0% survival for juvenile downstream passage in the flood retention scenario is not justified. For example, using that number implies there should be no anadromous runs of salmonids and Pacific Lamprey in the Columbia River basin above the first dam encountered. 3. In general, FRE operations are likely to occur more frequently over the winter and early spring, before downstream migration of smolts occurs. This does not appear to have been considered. 4. Justification for the numbers for Cutthroat Trout is not provided. They appear low, and significantly low in the construction scenario. 5. Justification for the numbers for lamprey is not provided. In addition, ammocoetes reside in fine sediments with a specific grain size distribution that would likely be thoroughly scoured out during the floods requiring FRE facility operation. 6. The survival numbers in this table fail to compare fish passage survival to baseline conditions. For example, identify the locations immediately downstream of the project that are impassable to specific species and juvenile fish during low-flow conditions in the Chehalis River, such as summer flows, and revise survival numbers in this table so they compare with baseline (current pre-project) conditions. 7. Table E-10 must be replaced with survival numbers that are based on credible science. Attachment 3: Fish Passage Design Report to Inform SEPA provides a table titled Estimated Percentage of Fish Passing the FRE Facility / Construction Location and Surviving Beyond the FRE Facility Location for the Construction and Operation of the FRE Facility. This table is similar to E-10 in the RDEIS with survival numbers that more appropriately reflect the Proposed Action. Citations and reasoning supporting the numbers in the table are provided in the attached Fish Passage Design Report to Inform SEPA. The Applicant requests Ecology use the numbers provided in the attachment instead of those in table E-10 of the RDEIS, in the context in which they are provided and that Ecology account for the timing, displacement, and productivity of species and life stages not addressed in this table rather than assume complete loss of those individuals and their productivity as currently appears to be done in the RDEIS.

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177	APPENDIX E: FISH	3.2.1	Page 85-86, Table E-10, Paragraph 7	Additional explanation and justification for the listed fish passage survival rates is requested. The statement says these rates were used to qualitatively assess passage impacts. Were these survival rates applied to the EDT-LCM modeling, which yielded quantitative results?
178	APPENDIX E: FISH	3.2.1	Table E-10	The construction-phase bypass design follows NMFS (2011) and WDFW (2000; 2009) criteria, which govern nearly all major fish bypass facilities in the Columbia and Snake River basins. These systems consistently achieve survival rates between 90 and 99 percent, far exceeding the 34 percent figure used in the Draft EIS. Research demonstrates this performance across multiple facilities. Muir et al. (2001) reported survival rates of 95 to 99 percent for yearling Chinook and 93 to 98 percent for steelhead at Snake River bypass systems. Ferguson et al. (2007) documented approximately 95 percent survival through the modified Bonneville Powerhouse 2 juvenile bypass. Adams and Evans (USGS 2011) found survival rates ranging from 90 to 98 percent through surface weirs and non-turbine passage routes at McNary Dam. NOAA's Federal Columbia River Power System standards further reinforce these expectations, requiring 96 percent survival for spring migrants and 93 percent for summer migrants at each dam. Collectively, these results form the scientific foundation for modern NMFS design criteria, which have been adopted for the Chehalis construction-phase system. The estimates in Table E-10 are also outdated as they were based on a decade-old design; therefore, survival estimates should be updated based on the new project design. The Applicant requests that Ecology utilize the survival values provided in the table titled Estimated Percentage of Fish Passing the FRE Facility / Construction Location and Surviving Beyond the FRE Facility Location for the Construction and Operation of the FRE Facility in the Attachment 3: Fish Passage Design Report to Inform SEPA instead of 0% survival listed in table E-10 of the RDEIS.
179	APPENDIX E: FISH	3.2.1	Table E-10	The State Environmental Policy Act (SEPA) obligates agencies to ground environmental impact analyses in the best available science and to fully disclose assumptions, uncertainties, and methodological limitations. The Revised Draft EIS does not meet this standard when it relies on a single pessimistic survivability estimate (e.g., 34%) without transparent justification or supporting evidence. If Ecology intends for this low value to represent a conservative approach, SEPA practice requires a sensitivity analysis that evaluates a range of plausible outcomes (e.g., low, medium, and high scenarios). This approach ensures decision-makers and the public understand how results vary under different assumptions. Embedding a single pessimistic point estimate, particularly one that is inconsistent with regional performance of comparable NMFS/WDFW-compliant trap and transport systems, fails to provide the transparency and scientific rigor SEPA mandates.
180	APPENDIX E: FISH	3.2.1	Table E-10	NMFS and WDFW have established design criteria for juvenile fish passage systems that are widely implemented in the Columbia and Snake River basins. These standards are based on decades of research and operational experience and aim to achieve survival rates that consistently exceed 90 percent, often approaching 95 to 99 percent. NMFS criteria specify hydraulic conditions, approach velocities, and structural features designed to minimize injury and delay, while WDFW criteria provide state-level standards to ensure compliance with biological performance goals. Observed performance in systems built to

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				these standards is well documented in peer-reviewed studies, such as Muir et al. (2001) and Ferguson et al. (2007), which report survival rates consistent with these benchmarks. By ignoring these established standards and substituting an unsubstantiated low survival estimate, the analysis departs from recognized best practices and undermines its scientific credibility. SEPA expects agencies to rely on these proven benchmarks when evaluating impacts, not arbitrary figures that conflict with decades of empirical data.
181	APPENDIX E: FISH	3.2.1	Table E-10	The event based passage survival rates in Table E10 appear unreasonably conservative and likely overstate biological mortality, particularly under flood retention operations where several entries show 0% downstream survival across species and life stages. Because the Revised Draft EIS describes the FRE as a flowthrough facility most of the time, with gates closed only during major/catastrophic floods, interpreting these 0% survival values as representative of seasonal outcomes, without credit for delayed passage post closure, operational timing, or mitigation (e.g., trap-and-haul, bypass flows, salvage), is not well documented or supported in the discipline report narrative and risks inflating modeled mortality beyond realistic exposure windows. Table E-10 is not transparent regarding (a) whether Table E10 values reflect instantaneous event survival versus seasonal survival, (b) the fraction of migrants expected to encounter closures by timing window, and (c) the routing and mitigation assumptions used to derive 0% survival entries; regardless, the assumptions stated and implied withing the RDEIS are inconsistent with the project's stated operating regime and with basin lifecycle modeling practices that treat passage and survival probabilistically across multiple routes, attempts, and time steps rather than as complete loss during a single operational state. Performance inefficiency does not equate to mortality and attempting to having a direct tie via the modeling for performance x survival = remaining fish is a flawed approach. Many outcomes other than mortality occur if a fish is delayed, falls, back or is displaced. Rather the analyses could indicate whether an individual is affected (some degree of impact from additional energetic investment up to mortality) could be characterized, but a definitive outcome of mortality based on performance is flawed. The assumption of 0% downstream survival during flood retention events should be revised to reflect the short duration (~4 weeks or less) and infrequent occurrence (once every 5 to about > once per year) when a temporary pool is held upstream of the FRE structure and the high performance of the pressurized conduits when the pool depth is below the fish sounding depth (less than 1 atmosphere). Paired-release PIT-tag experiments in the Columbia–Snake system document survival of 95.3–99.4% for yearling Chinook and steelhead passing through pressurized bypass routes (Muir et al., 2001; Ploskey et al., 2011). NOAA and PNNL analyses further report dam-passage survival near or above 96–98% across multiple years (Ploskey et al., 2011). However, data is less readily available for mortality due to short-duration holding in temporary pools. Upon assessing the hydraulic modeling of the proposed project under multiple scenarios, a critical review was undertaken relative to standard passage criteria (NOAA 2023a-c), past design experience and outcomes, along with project-specific understanding. The result of that review led to

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				prescribed downstream survival rates in the 60% to 70% range based on the compilation of existing information and professional judgement. The rates provided do not fall outside of other research and findings within the literature but provide an incrementally improved and tailored assessment specific to the project. The Applicant requests that Ecology utilize the survival values provided in the table titled Estimated Percentage of Fish Passing the FRE Facility / Construction Location and Surviving Beyond the FRE Facility Location for the Construction and Operation of the FRE Facility in the Attachment 3: Fish Passage Design Report to Inform SEPA instead of 0% survival listed in table E-10 of the RDEIS.
182	APPENDIX E: FISH	3.2.1.2, 3.2.1.3	Pages 87-89	Fish behavior changes during high flow events. Fish find velocity refugia and slower moving parts of rivers and streams to wait until river flows decrease below flood levels. This natural behavior is the basis for state and federal definitions for fish passage design flows. The statement that near-field hydraulics could create velocity barriers within the FRE conduits is inaccurate because fish movement upstream must be occurring in order for there to be a barrier to passage. No evidence has been provided in the RDEIS indicating a potential for velocity barriers would exist. The RDEIS later confirms in Section 3.2.4.2.1.1 that fish are expected to reside below the facility until flow subsides and passage conditions improve. Separately, as discussed elsewhere in these comments and their attached associated technical memoranda, the fish passage design has been improved since the RDEIS stopped receiving new information. The updated design reflects consultation with the National Marine Fisheries Services to improve upstream fish passage through dedicated fishways that meet standard passage criteria. Meeting these criteria improves passage for all species at all life stages. The FEIS should be updated to correct the misstatements and consider the improved design.
183	APPENDIX E: FISH	3.2.1.3	Page 88, last bullet	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | The EIS does not consider what the annual recurrence interval of the 35-day figure is, and what the corresponding days of inundation-frequency curve looks like at the FRE facility location; i.e., in how many years out of 100 does the pool inundation last 35 days, 30 days, 25 days, etc. This needs to be considered with respect to how biological implications would change and how they would compare to some biologic criteria, which are also missing.
184	APPENDIX E: FISH	3.2.2	Page 89	Relative change in abundance between current and future conditions is the wrong metric for evaluating the No Action versus Action Alternative. | Although not transparent in Appendix E, it appears that the relative change in abundance was evaluated for current and future conditions using the EDT model (this is also presented in Attachment E-2 on page 2-1, last paragraph). While this is an appropriate approach for an EDT evaluating change over time, it is not the appropriate approach for evaluating impacts of the FRE facility because the future condition scenarios would include changes to habitat and salmon population that would be expected from other factors independent of the FRE, such as climate effects. This confusion is increased by the presentation of EDT results as discussed below. The appropriate comparison for understanding potential future impacts of the FRE facility is to compare the FRE facility in the future time period against a No Action condition in the same future time period, which was modeled and shows impacts from climate

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				change when compared to the baseline condition. The RDEIS's overt exclusion of direct comparisons between the future No Action and Proposed Action in Appendix E while presenting the comparison in Attachment E-2 is unfair to the Project and calls the RDEIS's analysis and conclusions into sharp question. When comparisons between equilibrium population levels of the No Action and Proposed Action for the same climate model and timeframe are made, it is clear that operation of the FRE has *reduced impact* on the spawning populations below the facility (spring- and fall-run Chinook). The main driver of population decline is climate change for this reach as currently modeled. Above the FRE, equilibrium numbers are more disparate and the RDEIS's modeling gives the appearance that the FRE has a much larger impact than it would. Given this, the RDEIS's use of higher upstream equilibrium numbers for Chinook upstream of the FRE versus downstream do not reflect empirical data. By modeling a larger percentage of the population as being upstream of the FRE, the RDEIS gives the misimpression that the FRE would have a greater sub-population level impact. Also, when looking at relative change and drawing conclusions, it assumes similar level of parameter value uncertainty under both sets of conditions being compared, and that the difference between the two scenarios is outside of the prediction errors of each scenario. That has not been demonstrated.
185	APPENDIX E: FISH	3.2.2	Page 89-90, 5th paragraph	Insufficient information, Unsupported statement/conclusion | The statement, "If the construction period were longer, it is expected that integrated model and EDT model results would converge, similar to the operations modeled" is unsupported and illogical. First, the RDEIS does not refer to specific EDT model results making it unclear which results could support this conclusion. Second, EDT model results were input to the LCM as part of the integrated modeling approach, thus the statement implies that, over the long term, the LCM predictions should not matter and would effectively give the same results as EDT alone. This is illogical because they are two different modeling frameworks with different parameters and algorithms. The statement also implies that conditions during construction are similar to conditions with the FRE facility in place, which is not accurate. These errors must be corrected in the FEIS.
186	APPENDIX E: FISH	3.2.2	Pages 92, 97, 102, 107	EDT results (Figures E-12, E-17, E-22, E-27) are misleading with respect to what change would result from the FRE versus future habitat changes under a No Action alternative. | Figures E-12, E-17, E-22, and E-27 depict changes in salmon and steelhead abundance from EDT modeling of four salmon/steelhead runs under the future FRE facility scenario. What is presented and described in the text is the relative change in subpopulations from the 2-year average (2035 baseline condition) to future FRE facility and then separately. Much later in a different section of the DEIS (starting on page 182), the relative change from the 2-year average to future No Action is presented. A comparison of future No Action to future FRE facility is missing in the DEIS; therefore, the results are misleading with regard to the predicted potential impacts that could result due to the FRE facility operation.

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187	APPENDIX E: FISH	3.2.2	Pages 93-96, 98-101, 103-106, 108-111	LCM results (Figures E-13-E16, E-18-E21, E-20-E23, E-24-E27) are misleading as they show only FRE modeled impacts and do not also provide the No Action alternative's impacts in the same view to allow comparison. | To convey the probable adverse impact of the FRE facility, it is critical that the model results of both the FRE facility and No Action are present in the same figure. If this were done, the reader would be able to interpret the model predictions; for example, it would be made clear that the reduction in spring-run Chinook Salmon for the Rainbow Falls subpopulation occurs in the No Action Alternative and is not further reduced by the FRE where the projected fish abundance is the same between the two model scenarios. Similarly, the Coho Salmon and steelhead Rainbow Falls to Crim Creek subpopulations all are projected to be extirpated under the No Action Alternative; therefore, there would be no additional impact assigned to a future FRE facility for these subpopulations. By presenting only the FRE results without the context of the No Action Alternative, the RDEIS misleads the reader to think all of this impact is attributed to the FRE, and that is not what the model indicates based on written results presented in Section 3.4.3.2.
188	APPENDIX E: FISH	3.2.3	Page 113 (paragraph 5) and 114 (bullet 1)	The RDEIS states that there will be one debris sorting area. This description and the discussion of environmental impacts that flows from that description are no longer accurate. As described in the attached Debris Management During Flood Retention Report, the District is proposing two debris storage areas as well as multiple anchored log booms, log broncs, and work boats to capture the floating large vegetative material. This should be revised throughout the Project Description and wherever it is referenced in the RDEIS.
189	APPENDIX E: FISH	3.2.3	Page 113, paragraph 6	The EIS incorrectly describes the flow capacity of the fish passage channels during construction as 2,200 cfs and creating backwater effects at flows above 2,200 cfs. The river passes through the project site in its existing natural channel in construction Phase 1; in the construction bypass channel in construction Phase2; and via the proposed FRE conduits in construction Phases 3 & 4. The Construction Bypass Hydraulic Modeling TM (Chehalis RPDR Appendix D3 Apr 2024) states the bypass channels are designed to convey up to the 25-yr event (26,800 cfs). Multiple locations in the EIS, including in Appendix E Fish Species and Habitats Discipline Report Section 3.2.4.2.1.1, state the open channel flow capacity of the conduits as 9,500 cfs. Moreover, as provided in Attachment 3: Fish Passage Design Report to Inform SEPA, the District has refined the Project design to allow for 13,700 cfs flow through the conduits. The FEIS must use the correct, refined conduit information to reflect both the 13,700 cfs flow rate and the minimized backwatering, which will only occur at flows above 13,700 cfs.
190	APPENDIX E: FISH	3.2.3.1.1	Page 116, 6th paragraph	Faulty logic and resulting overly conservative estimates likely incorrect; cannot rely on EDT and LCM results accordingly | The RDEIS's fish passage assumptions are fundamentally flawed and scientifically unsupported. The RDEIS's reliance on these numbers for its assessment of Project impacts is inappropriate and unreliable.
191	APPENDIX E: FISH	3.2.3.1.1	Page 117, last paragraph	The RDEIS suggests explosive use for blasting may be washed into the river, resulting in harmful effects on fish. Although the RDEIS acknowledges water quality BMPs required for blasting under state and federal permits may mitigate such effects, the District notes that all

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				blasting will occur in the dry and washdown water will be hauled offsite. Further, prior to construction, the selected contractor will be required to prepare a blast plan with BMPs to address water quality issues following re-watering of isolation reaches after construction.
192	APPENDIX E: FISH	3.2.3.1.1	Pages 118-120	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | The analysis does not define minimum required distance between blasting charge and water, and whether the 7.3 psi criterion of Timothy (2013) would be exceeded by the proposed activities. Empirical analysis methods exist that estimate over-pressure dissipation with distance for a blasting charge in water (e.g., Carlson et al. 2011; Dunlap, K.N. 2009. Field measurements have found that near-surface blasting in ground next to streams resulted in over-pressures that were substantially lower than 2 psi (cf. Rasmussen and Mulcahy 1985. Study of particle velocities and water overpressures as related to construction blasting adjacent to anadromous streams. Alaska Dept of Transportation and Public Facilities, Project F-RF-RS-071-1 (25). Equations exist for estimating overpressure at the rock-water interface based on assuming all explosive energy is transmitted through the rock (cf. Alaska Department of Fish and Game [ADFG] 1991; Wright and Hopky 1998; Carlson, and Johnson 2010. Pacific Northwest National Lab (PNNL) used a spreadsheet developed for the USACE and presented a graph and numeric results that indicated over-pressures in psi dissipate to the -1.2 power of distance. The RDEIS does not take this best available science into consideration and is likely overstating impacts accordingly. In addition, the RDEIS's analysis does not reflect that the District would require the selected contractor to prepare a blasting and debris management plan for agency submittal and approval at least 60 days prior to blasting activities. No blasting will occur within the active river channel (i.e., where there is water flowing); rather, blasting waterward of the OHWM will be conducted behind isolation structures, in the dry. Because water transmits shock waves more effectively than air, isolating blasts from water is an effective means of reducing blasting effects on aquatic resources. The minimum distance between anticipated blasting locations and the wetted channel varies from approximately 100 to 200 feet. To reduce or eliminate potential blast-related effects on fish, or to keep fish out of areas with potentially harmful blasting pressure, the selected contractor will be required to attenuate vibration transference if blasting is proposed within 50 feet of the active Chehalis River flow or its tributaries. Attenuation will include maintaining a dry in-water work area within this zone or potential use of sheetpile isolation structures. Blasting shock waves will also be reduced by selecting the minimum-sized charge and type of explosives required to accomplish the required excavation. The FEIS must reflect these District commitments which are an integral part of the proposed Project.
193	APPENDIX E: FISH	3.2.3.1.1	Page 119, 4th paragraph	Insufficient information provided | The statement, "Sound is also extremely important to fish and is used for communication, prey and predator detection, and navigation" is not supported with relevant citations. We are unaware of evidence of salmonids communicating with sound, using sound to detect prey or predators, or relying on sound for navigation in a turbulent, rough river channel. In the extended sense of salmon spawning relying on vibrational pressure stimuli for gamete release, there does not appear to be any spawning habitat present within the likely range of sounds generated by construction.

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194	APPENDIX E: FISH	3.2.3.2	Page 122, first sentence	Faulty logic regarding potential impact on mussels | The RDEIS states that the loss of mussel beds in the construction area would prevent future colonization as they would be permanently lost, but then says there are no known mussel beds within the FRE facility footprint. The latter statement corroborates 2020 survey data presented in Section 2.2.2.3 and calls into question the RDEIS's conclusion that the Project could impact species that have never been documented in that reach of the Chehalis River.
195	APPENDIX E: FISH	3.2.3.2.1	Page 124, 2nd and 3rd paragraphs	Faulty logic and resulting overly conservative estimates likely incorrect; cannot rely on EDT and LCM results accordingly | In addition, these paragraphs incorrectly imply that the values in Table E-10 and the conclusions in these paragraphs were based on comparing to the existing stream channel within the affected construction footprint only, and on assuming that other natural passage restrictions downstream would be less restrictive at base flows. This implication is incorrect because the bypass channel will afford passage at lower flows where passage is blocked elsewhere in the river. Passage conditions will accordingly be better in the bypass than at various other locations downstream and upstream.
196	APPENDIX E: FISH	3.2.3.2.1	Page 124, paragraph 3	This conclusion is made: "Overall, reduction of fish passage during construction of the FRE facility would have a significant adverse impact on anadromous fish because the FRE facility would permanently change the hydraulic conditions so that conditions would not match the hydraulics of the existing stream channel." This conclusion is incorrect. Section 3.3.1.4 of Appendix I: Fish Passage Design technical memorandum of the Applicant's Revised Project Description Report states "A reference reach design approach (per WDFW's 2013 Water Crossing Design Guidelines) is utilized for… the construction phase Chehalis River and Crim Creek bypass channels." Further, Section 5.4.6, paragraph 1 on page T6-26 of WDFW's 2012 Stream Habitat Restoration Guidelines states "A more conservative approach (to fish passage design) is to develop fish passage (design) standards using the characteristics of the natural channel in reaches adjacent to the project reach… closely matching the profile, cross section, and bed texture of the reference reach usually insures fish passage." This stated position by WDFW that the reference reach approach, if performed according to their guidance documents, such as the 2013 Water Crossing Design Guidelines, is a conservative approach to fish passage and usually ensures fish passage is one of the primary reasons the Applicant selected this design approach for the bypass channels. In addition, the bypass channels will meet all NMFS criteria for fish passage as well, for the same reasons. Bypass channels designed to meet WDFW and NMFS guidelines and standards are included as part of the project as stated in the Applicant's Revised Project Description. The bypass channels should be evaluated as meeting WDFW and NMFS design standards and should reflect highly effective volitional fish passage as stated in WDFW's own guidance. As such, the RDEIS should reflect no impact on fish passage for the bypass channels compared to the No Action alternative.
197	APPENDIX E: FISH	3.2.3.2.2.1	Page 126	Unsubstantiated impact to subpopulation downstream for habitat degradation in the construction area. | This section indicates that a projected decline in both the spring-run and fall-run Chinook Salmon subpopulations downstream would be driven by aquatic

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				habitat degradation within the FRE facility construction area, which is located upstream. However, the RDEIS does not explain which of three types of construction-related habitat degradation identified, including (i) 10 acres of aquatic habitat loss (that includes both riparian and in-channel areas), (ii) in water-work, or (iii) dewatering a stretch of reach upstream, would be responsible, nor does it explain the mechanism (e.g., prey reduction, temperature) by which this degradation could potentially affect fish spawning and rearing downstream of the canyon reach in a manner that would result in a population level response. The RDEIS therefore fails to provide an adequate explanation for the modeled effects of an 11% to 12% decrease in spring-run Chinook Salmon and a 13 to 19% decrease in fall-run Chinook Salmon subpopulations downstream of the FRE. The aquatic habitat within the FRE facility construction area contains rearing and migratory habitat with little to no value to salmon or steelhead spawning, based on only redd ever observed there (WDFW publicly available data showed 1fall Chinook salmon redd observed in 2015). The DEIS does not specifically identify the habitat value of this area, and since rearing, migratory and spawning habitat would not be limiting factors for the subpopulations downstream, it is difficult to understand the level of population effect equated with the loss of 10 acres of aquatic and riparian habitat.
198	APPENDIX E: FISH	3.2.3.2.3	Page 128, 4th paragraph	Contradictory text | Three paragraphs earlier, the RDEIS states that, "No freshwater mussels were found within the FRE facility footprint. The closest known mussel beds to the FRE facility location are 7 miles downstream near the town of Doty." The RDEIS cannot reasonably then conclude, just paragraphs later, that, "Loss of habitat in the footprint ... would create a significant adverse impact on freshwater mussels … by permanently eliminating functional habitat.". Since functioning habitat has not been documented for mussels within the FRE facility footprint, assigning functional value to some potential future condition without any habitat data or analysis is unsubstantiated. This conclusion should be reconsidered.
199	APPENDIX E: FISH	3.2.4	Page 130, 1st paragraph	Inaccurate/faulty statements | 1. The 950 feet and 2,000 feet figures refer to width of the temporary impoundment, not the channel per se. This should be clarified accordingly 2. The statement, "and reduced channel-shaping forces downstream of the FRE facility that would normally occur during a major to catastrophic flood" is based on a flawed analysis in Appendix F, Earth. See respective Comment #329 and #330 regarding faulty basis of assumptions regarding what constitutes a channel-forming flood.
200	APPENDIX E: FISH	3.2.4.1.1	Page 131, 1st paragraph	Insufficient information provided | There is no basis in the RDEIS for the statement, "Fish passage upstream to tributary streams would be impaired." The Project will not impair fish passage upstream to tributaries. See Comment #325 for Appendix F (Earth) regarding faulty argument based on assuming incision.
201	APPENDIX E: FISH	3.2.4.1.1	Page 131, 2nd paragraph	Insufficient information provided | It is unclear how, "sediment deposited in the reservoir area during a flood retention event [would create] a barrier to fish movement." The statement is inconsistent with results and processes described in Appendix A in the District's Revised Mitigation Plan. There is no explanation of the physical process assumed, where a barrier would form, or how it would differ from the No Action alternative's condition.

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				For example, the tributaries are generally steep and high energy and appear to transport large cobble readily downstream to their confluence with the Chehalis River. Any material that deposits within a tributary at the interface with the temporary impoundment would be expected to be distributed over a long reach rather than piled up at one location because the elevation of the impoundment would be continually changing location. As another example, under the No Action condition, the mouth of Big Creek is a steep cobble-boulder fan that is elevated above base flows. Fish passage into Big Creek is likely restricted to times when both Big Creek and the Chehalis River are at higher flows. In addition, the District's sediment transport work demonstrated that the Chehalis River upstream of the proposed Project can mobilize coarse sediment that may deposit at the mouth of a tributary at frequently recurring flows, and that these high probability flows mobilize more coarse sediment overall (due to their frequency) than the rarer major and catastrophic flood flows. The FEIS should credit this conclusion and update its impacts analysis according.
202	APPENDIX E: FISH	3.2.4.1.1	Page 132, 2nd bullet	Incorrect assertion and Contradictory text | The statement that the "Daily maximum temperatures of the Chehalis River could increase by up to 2°C to 3°C in mid- to late summer in the temporary reservoir" is incorrect because the FRE facility is not expected to operate during summer months, so there would be no temporary inundation pool at that time. In addition, the assertion that the FRE facility operation would result in lethal temperatures for some cold-water adapted species is unsubstantiated and contradicts the RDEIS's own analysis of FRE facility mitigation on future water temperatures that is presented in Appendix N. That Water Discipline Report (tasked with formally evaluating water quality, unlike this report) concludes that the proposed Project's mitigation would, if designed and implemented as proposed, offset the temperature impacts of the facility. The Fish Discipline Report in the FEIS should credit this conclusion and analyze the project's *probable* environmental impacts, rather than describing the highly improbable scenario in which the facility is permitted to be constructed without such mitigation.
203	APPENDIX E: FISH	3.2.4.1.1	Page 132, 3rd bullet	Potentially contradictory text and does not consider best available information | It is not clear if the reduction in availability in large wood delivered by landslides to the channel is assumed to be due to landslides being reduced by FRE facility operation (in which case stands in contrast to Appendix F asserting that landslides could increase), or that wood delivered by landslides would be removed as part of flood operations and not be in the channel anymore (which ignores the proposed Project's plan to reuse such wood for habitat purposes). Either way, this bullet point is incorrect. The upper Chehalis is currently a wood-poor system, and the proposed Project, including its plans to collect and use large woody material for habitat purposes, will not result in the impacts described.
204	APPENDIX E: FISH	3.2.4.1.1	Page.133, 1st bullet	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | 1. The RDEIS incorrectly assumes that the habitat quality in the area upstream of the proposed Project is superior to its actual baseline quality. There essentially is no large wood presently preventing scour in the spawning habitats in the temporary inundation area. Bed scour should therefore not be expected to increase over baseline in this manner The FEIS should correct this error.

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				2. The RDEIS also fails to take into account that potentially extreme bed scour would otherwise occur during a major or catastrophic flood event, but the proposed Project's operations would reduce or avoid that scour. This should be accounted for here, as it modifies the probable effects of the Project and would offset the effect in the next bullet (i.e., suffocation of redds is effectively not an impact beyond baseline if those same redds would have been scoured out in the absence of the project). This is part of a larger pattern in which the RDEIS fails to properly analyze the adverse environmental impacts of the No-Actions and Local-Actions alternatives from major or catastrophic flood flows and essentially compares the proposed Project to a hypothetical world in which major or catastrophic flooding is not occurring. In its failure (1) to qualitatively compare the proposed Project's impacts during flood operations to what would be occurring during such a flood in the absence of the project, and (2) to quantitatively consider the adverse impacts of major and catastrophic flood flows, the RDEIS minimizes the No-Action and Local-Actions alternatives' environmental impacts and unfairly exaggerates the proposed Project's impacts by comparison. Moreover, the RDEIS does not consider the proposed Project's reduction of those alternatives' negative impacts. The FEIS must correct these errors to determine the significance of the proposed Project's probable adverse impacts, as their significance cannot be determined without reference to the baseline conditions and the proposed Project's net change (positive and negative) to that baseline.
205	APPENDIX E: FISH	3.2.4.1.1	Page 133, 4th bullet	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | The statement, "This backwatering effect would degrade the habitat more intensively in this area and could create hydraulic conditions that impair fish passage through open FRE facility conduits" is unsupported: it provides no evidence as to why such rare and short backwatering would have any meaningful habitat effect; it has been established in the District's sediment transport analyses that the river has a high capacity for quickly transporting any sediments that might deposit temporarily in the river at frequent flows in which a backwater would not form. It also ignores the RDEIS's conclusion in 3.2.4.2.1.1 that backwater would not affect fish passage overall. See Comment #189 and 253.
206	APPENDIX E: FISH	3.2.4.1.1	Page 133, 5th bullet	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | Significant bed scour that would otherwise occur during a major or catastrophic flood event would be avoided or reduced by operation of the Project, both upstream and downstream. The effect on scour should be accounted for here, as it modifies the probable effects of the Project and would likely offset the effect of the No Action alternative (and of the Local Actions alternative without the FRE facility), where data collected by the District indicate that survival of redds in the temporary impoundment reach would likely be effectively zero because of spatially extensive, deep scour in spawning habitats during floods with a magnitude triggering FRE facility operation. In addition, reduced scour downstream of the facility, where more extensive spawning occurs, would be associated with greater survival with the FRE facility than without. Accordingly, the impact of suffocating some redds is not likely to be associated with a net change in overall outcomes compared to conditions without the FRE facility.

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207	APPENDIX E: FISH	3.2.4.1.1	Page 133, 6th bullet	Relying on flawed assumptions | Regarding likely invalidity of assumptions and modeling presented in Appendix F, Earth concerning deposition and resuspension of sediments, and erosion within vegetated areas of temporary inundation pool. The FEIS should correct its incorrect assumptions in the Earth Discipline Report and carry forward the corrected work into all other disciplines, including this one.
208	APPENDIX E: FISH	3.2.4.1.1	Page.133, 8th bullet (extending onto page 134)	Relying on flawed assumptions, disregarding mitigation plans | The RDEIS notes that because the proposed Project would manage large wood debris that accumulates in the temporary inundation pool during flood events, it would starve the area above the facility of large wood for habitat formation purposes. It also suggests that removal of wood from the trashrack would starve the downstream river of large wood. Both assumptions ignore the proposed mitigation plan to manage this large woody debris with mitigation or restoration as its first/primary potential use. This would restore the best quality large wood debris to the river system for habitat benefit. Moreover, the RDEIS ignores that most of the large woody debris that historically has entered the river system from major and catastrophic flooding ends up on privately-owned riparian banks (often farmland), where it is removed by private landowners and does not contribute to habitat formation. The RDEIS notes that much of the large wood from 2007, for example, was removed, and that the upper Chehalis is currently wood-poor. So, under existing conditions, the influx of large wood does not provide substantial habitat benefit, and the proposed mitigation plans to install this wood for habitat benefit may be an improvement in habitat outcomes over baseline. The FEIS must, here as elsewhere, accurately analyze the baseline in the no-action and local actions alternatives and consider how the proposed Project and its mitigation plans would improve upon those alternatives. These considerations are necessary to determine the probable impacts of the proposed project and their significance, and to allow adequate comparison with the alternatives.
209	APPENDIX E: FISH	3.2.4.1.1	Page 134, 1st bullet	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | Same comment as Comments 226 and 364 concerning fine sediments also applies to turbidity. Moreover, the District could not fully analyze turbidity effects because, despite request, Ecology did not provide its turbidity modeling tool to the District and did not provide its WEPP model to the District until it was too late for the District's environmental scientists to evaluate it.
210	APPENDIX E: FISH	3.2.4.1.1	Page 134, 2nd bullet	Not considering best available information | Statement does not consider sediment transport modeling and analyses described in Appendix A of District's Revised Mitigation Plan, where it is evident that the reported model predictions of changes in storage and grain size may be incorrect, can differ substantially based on the assumptions and parameters specified in the modeling, and accordingly cannot be used to infer impact. Please see Comment 287.
211	APPENDIX E: FISH	3.2.4.1.1	Page 134, 3rd bullet	Insufficient information provided | " The effect of the FRE facility to reduce peak flows would also reduce the geomorphic forces that cause large wood delivery to the channel in reaches downstream…" — this is an overly broad statement lacking context and definition. It is not explained what the "geomorphic forces" they are referring t and how they act at

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				different flood levels. Moreover, it stands at odds with the facts that channel-forming flows recur much more frequently and at much lower flows than the major and catastrophic flood flows in which the proposed Project regulates flow, that much of the riparian zone downstream is degraded in alluvial reaches where wood delivery would otherwise occur, and that large conifers are generally firmly rooted in bedrock and upper banks in entrenched reaches where they are difficult to dislodge by channel-forming flows. Furthermore, the statement effectively assumes that baseline habitat conditions are superior to their actual conditions and thereby exaggerates the proposed Project's impacts by suggesting it will create effects that are already present. The FEIS should consider baseline conditions more accurately when analyzing impacts; it must also correct the Earth Discipline Report's fundamental misunderstanding of the geomorphic processes regarding channel-forming flows in the upper Chehalis River and carry that correction forward into all other disciplines.
212	APPENDIX E: FISH	3.2.4.1.1	Page 134, 7th bullet	Relying on flawed assumptions | See Comment #329 and #330 for Appendix F Earth regarding flawed definition of channel forming floods in EIS. Dominant channel forming flows would not be truncated or effectively attenuated by FRE operations.
213	APPENDIX E: FISH	3.2.4.1.1	Page 135, 3rd & 5th bullets	Inconsistency with other text | Reduced bed scour is treated as an impact here and increased scour is treated as an impact elsewhere in the RDEIS. Increased and reduced scour cannot both be treated as impacts. It is reasonable to infer that increased bed scour increase mortality risk to eggs and would be considered a potential impact to habitat function.
214	APPENDIX E: FISH	3.2.4.1.1	Page 135, 3rd bullet	Not considering best available information | Ignores sediment transport modeling and analyses described in Appendix A of District's Revised Mitigation Plan, where it is demonstrated that the river has more than sufficient capacity to transport substrates downstream when the FRE facility is not being operated.
215	APPENDIX E: FISH	3.2.4.1.1	Page 135, 4th bullet	Relying on flawed assumptions | See Comment #329 and #330 for Appendix F, Earth regarding flawed definition of channel forming floods in EIS. Dominant habitat forming flows would not be truncated or effectively attenuated by FRE operations
216	APPENDIX E: FISH	3.2.4.1.2	Page 135, 2nd paragraph	Relying on flawed assumptions | See Comment #329 and #330 for Appendix F, Earth regarding flawed definition of channel forming floods in EIS. Habitat formation in the upper Chehalis River is not associated primarily with major or larger floods during which the FRE facility would be operated.
217	APPENDIX E: FISH	3.2.4.1.2	Page 136, 2nd, 3rd and 5th paragraphs	Insufficient information provided, relying on flawed assumptions, and not considering best available information | These are overly generalized statements. Note that the references regarding impacts to peak flows and flow variability are with respect to long term effects of regulated flows below dams, which is not representative of the FRE facility. Moreover, see Comment #329 and #330 for Appendix F, Earth regarding flawed definition of channel forming floods in EIS: Dominant channel forming flows would not be truncated or effectively attenuated by FRE operations, and considerable flow variability would remain. The statements also do not consider sediment transport modeling and analyses described in

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				Appendix A of District's Revised Mitigation Plan that demonstrate flows passing through the FRE facility when it is not operated are associated with an order of magnitude greater net transport of coarse sediments that form within-channel bars and islands compared with the FRE facility operation-level floods.
218	APPENDIX E: FISH	3.2.4.1.2	Page 136, 4th paragraph	Insufficient information provided | These are overly generalized statements. No supporting evidence or arguments are given demonstrating that these generalized statements apply to the Chehalis River, and moreover this paragraph ignores hydraulic modeling showing that the paragraph does not apply to entrenched reaches where the 100-year flood is confined to the channel in the upper river under the No Action alternative, and that the active floodplain is still extensively engaged in the middle and downstream reaches when the FRE facility is operated.
219	APPENDIX E: FISH	3.2.4.1.2	Page 136, 5th paragraph	Not considering best available information | The paragraph disregards large wood mitigation plan element where large wood trapped upstream and at the FRE facility will be placed downstream of the facility, thereby avoiding significant reduction in large wood transport downstream
220	APPENDIX E: FISH	3.2.4.1.2	Page 137, 1st paragraph	Not considering best available information | This paragraph disregards that the major avulsion referenced no longer is associated with off-channel habitat — the original channel has completely filled with sediment. The paragraph is overly generalized.
221	APPENDIX E: FISH	3.2.4.1.2	Page 137, 3rd paragraph	Contradictory text | If there is "a high degree of uncertainty around potential changes to habitat creation," it is unclear how a conclusion of "significant adverse impacts to aquatic habitat" can be made.
222	APPENDIX E: FISH	3.2.4.1.3	Pages 137-138	Non-specificity of impact conclusion | The RDEIS does not specify where such impacts would be expected, nor how and why they would be impacts. There are not many off-channel habitats for fish under the No Action alternative, so the RDEIS should be able to identify which backwater habitats specifically would be impacted, especially upstream of the South Fork. Downstream of the South Fork, including in the vicinity of Bunker Creek, hydraulic modeling predicts that the 2-year flood can have greater inundation extent than the 10-year flood, in large part because of the flood influences of the Newaukum and Skookumchuck Rivers. Thus, effects of FRE operation on backwater and off-channel habitats downstream of the South Fork would be expected to be equivocal.
223	APPENDIX E: FISH	3.2.4.2	Page 139, 3rd paragraph	Insufficient information/reasoning provided, Inconsistent with best available science | The statement, "Lake-type habitat would be unusable for many of the fish…" does not specify which fish species to which it refers nor how many would find the habitat unusable. Further, no literature, citation, or other rationale for the inability of these animal groups to adapt to changing conditions was presented. Salmon and steelhead in the Pacific Northwest frequently leave riverine habitats and encounter lake-type habitat during their outmigration. In some cases, this includes seasonally impounded rivers including at many USACE dams with a primary purpose of flood control. These flood control reservoirs are drawn down annually to provide storage capacity during high-flow events, such that downstream flows are moderated in a similar way to the proposed FRE facility operation. Fish are able to use

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				these lake-type habitats, and even experience increases in growth, but downstream migration can be delayed without the flow cues they rely on for volitional downstream migration (Monzyk et al. 2015). In the Willamette Basin, the USACE has been drawing down select flood storage reservoirs to riverine conditions between flow events to facilitate outmigration of juvenile salmon. This approach to downstream fish passage was first implemented at Fall Creek Reservoir (2011-2021), located on Fall Creek, a tributary to the Middle Fork of the Willamette River. Two weeks of riverine conditions were sufficient to both increase downstream migration of juvenile Chinook Salmon and reduce predation on juvenile fish by native and non-native fish predators (Murphy et al. 2019). The populations of fish and invertebrates in this system have adapted to the modified hydrologic regimes and this system has seen increased adult returns since implementing the operational drawdown. The success of the Fall Creek operational drawdown has been documented and now the USACE, in consultation with state and federal agencies is implementing a similar annual drawdown for other Willamette Project dams in Oregon including Green Peter, Lookout Point, and Cougar Dam (USACE 2025). Accordingly, the RDEIS's broad generalization regarding "fish" not using lake-type habitat is inconsistent with the best available science and, if it is intending to reference salmon and steelhead species, fails to take into account that such species can be expected to remain in the pool or move into riverine habitats upstream. The FEIS must be revised consistent with the best available science and unsupported, conclusory statements like the one identified above must be removed.
224	APPENDIX E: FISH	3.2.4.2	Page 139, 3rd paragraph	Insufficient information/reasoning provided for overly generalized statement | "Localized high turbidity will occur at levels that impair fish behaviors like migration and foraging." The RDEIS's statement that localized turbidity would impair fish behavior is not adequately supported and results in conclusions regarding Project impacts that are not accurate. The highest turbidity would be expected in the inflowing water as it enters the temporary impoundment and potentially in an underflowing turbidity current; turbidity can be expected to be reduced moving away from the immediate inflow channel due to dispersion processes. If high turbidity does occur in localized areas, these areas would be avoidable by fish. Juvenile salmonids are not passive recipients of potential turbidity stress and can employ avoidance behavior as a primary response. They exhibit strong behavioral plasticity and actively redistribute in reaction to changes in conditions to find more suitable microhabitats (Bisson and Bilby 1982; Bjornn and Reiser 1991). Further, there is no evidence that the turbidity that may occur within the temporary pool would be any greater than that occurring during winter storms under the future No Action Alternative. In fact, under the No Action Alternative, there would be no mitigation and both the temporary inundation area and the land upslope from it will remain as industrial forest with an approximately 40-year clear cutting rotation so conditions associated with landslides and turbidity will continue and may even increase with greater intensity and duration of winter storms. In contrast, as part of the FRE facility minimization and mitigation measures, the District has committed to

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				transitioning more than 2,000 acres of timberland to native forest, woodlands, and shrublands, as well as decommissioning several miles of forest road. The vegetation conversion and road decommissioning would occur both within and upslope of the temporary inundation area and would effectively reduce erosion and capture runoff of fine sediments prior to them reaching riverine habitats. Accordingly, the RDEIS's conclusion that the Project will result in high turbidity that impairs fish behavior is wrong, not supported by the science, and fails to reflect the Project as proposed, including its minimization and mitigation measures.
225	APPENDIX E: FISH	3.2.4.2	Page 139, 3rd paragraph	Insufficient information/reasoning provided, Inconsistent with best available science | "Deposition of sediment will smother incubating salmon embryos and sessile organisms like shellfish and lamprey ammocoetes." While some deposition of sediment is likely, the actual extent and duration of this deposition – and thus its impact on salmon embryos and sessile organisms -- will be dependent on a number of environmental variables including flood levels, groundwater inflows, potential for hydraulic gradients associated with turbidity currents, and the amount of source material, the latter of which is dependent on future potential for landslides, vegetation, and soil conditions in the temporary pool. Ammocoetes reside in fine sediments and are highly mobile therein. For example, they have been observed to move quickly up out of fine-grained substrates that became suddenly exposed during downramping and move back into the channel (e.g., in the White River). Thus, lamprey can be expected to move up readily if needed in the deposited sediment. Moreover, the degree of impact for salmon embryos and sessile organisms should be considered in the context of what would potentially occur otherwise under the No Action condition. Under the current No Action condition, redds and sessile organisms within the temporary impoundment reach are either partially or fully scoured out, and/or likely experience substantial fine sediment intrusion during smaller flood flows under which the FRE facility would not be operated. Redds and sessile organisms are likely to be completely scoured out or significantly impacted by fine sediment intrusion or burial during extreme floods when the facility is proposed to be operated. Furthermore, under the future No Action condition, increases in winter storms and flooding as compared to the current condition have been predicted. These wetter and more frequent winter storms would likely increase incidence and severity of bed scour and sediment intrusion in the highly confined Upper Chehalis mainstem even more, which in turn would likely further increase mortality to incubating salmon embryos and sessile organisms as compared to current conditions. Conversely, during near-term and future FRE facility conditions, the potential for extreme scour, fine sediment intrusion, and burial impacts that would occur under current and projected future conditions would be reduced downriver whenever the FRE facility is operated.
226	APPENDIX E: FISH	3.2.4.2	Page 139, 3rd paragraph	Insufficient information provided to support impact | "Salmon spawning habitat would be eliminated by inundation and deposition of fine sediment." While some loss of spawning habitat is likely during years when large floods are retained, the extent of that loss is expected to vary with flood level, inundation depth and duration at the redd, as well as

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				presence of hyporheic and/or turbidity flows in the temporary pool. All salmon spawning habitat will not be “eliminated” as suggested by this statement in the RDEIS. Throughout 2024 and 2025, the District worked diligently evaluating FRE facility operations that would help minimize environmental impacts. Once 2024 operational revisions were selected, the District conducted an inundation analysis to demonstrate how redd inundation impacts could be minimized with operations. The reduction in the number of redds that would be inundated varies by both flood type and species as presented in Attachment 2: Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum.
227	APPENDIX E: FISH	3.2.4.2	Page 139, 3rd paragraph	Insufficient information provided, supporting citation relevance in question | "The benthic macroinvertebrate community that provides food for fish would be eliminated during inundation (Lepori and Hjerdt 2006)." The DEIS provides no support for the assertion that intermittent inundation would eliminate the macroinvertebrate community; this is not supported by literature, particularly when evaluated over short temporal scales. Flooding studies have shown that while the macroinvertebrate abundance may be reduced and assemblage composition may shift immediately after flooding, shifts in the community structure may be less than seasonal variation (Angradi 1997) and shifts may continue across years with seasonal flooding as the community adjusts to more variable habitat conditions (Robinson et al. 2003). Floodwaters would be expected to contribute fine organic material, leaf litter, and terrestrial invertebrates into inundated areas, which can be rapidly colonized by aquatic invertebrates and zooplankton (Junk et al. 1989; Benke et al. 2000). Seasonal inundation can contribute detrital carbon sources from the floodplain to increase food web production (Jeffres et al. 2020a). Once flooding has subsided, source populations upstream in mainstem and tributary habitats would be available to recolonize the reach within the inundation area. In addition, the cited reference appears to address flooding impacts, not conversion to lake environment, and does not report other studies supporting the statement.
228	APPENDIX E: FISH	3.2.4.2	Page 139, 4th paragraph	The RDEIS states "...large logs (larger than can pass through 24-inch-wide trash rack spaces) would not pass downstream of the FRE facility, eliminating a primary source of large wood supply to the Chehalis River." This potential impact is unsubstantiated and disregards information about the proposed project description that was shared with Ecology in the late summer of 2021, prior to their cutoff date for incorporating new information into their SEPA analysis. The two relevant technical memoranda were cited as HDR (2021) and HDR (2021a) on page 2-28 of Attachment E-2 of the DEIS, but do not appear to be considered in determination of impacts presented in Section 3.2.4.2 of Appendix E. These memoranda were written by the District to clarify that large wood would be passed or placed downstream. The HDR (2021a) memorandum explicitly stated that, "During non-operating periods, most smaller debris will be either passed through the conduits or removed from the trash racks and hauled downstream to be released back into the river," and "LWM would be captured, staged, and sorted for use in downstream habitat enhancement projects as determined by the proposed mitigation program (Kleinschmidt 2020)."

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229	APPENDIX E: FISH	3.2.4.2	Page 139, 5th paragraph	Incorrect basis for conclusions of impact | "...reductions in peak flows would impede processes that increase salmon and steelhead habitat complexity and create off-channel rearing habitats and viable spawning areas for these fishes over time." The premise and conclusions that FRE operation would adversely affect channel forming flows are unsubstantiated. There is no evidence presented to support this statement that infers that peak flows during which the FRE facility would be operated are needed to create healthy and productive habitat for fish over time. In fact, the opposite is true, and in the Chehalis River the channel forming flows are below those that are likely to trigger the FRE facility operation. As stated in Section 5.2.1.3 of Appendix F to the SEPA DEIS, "Based on the analysis of migration rates between 1945 and 2013, it appears that channel migration takes place during even small peak floods in unconfined areas in response to flow against banks on the outside of meanders. This is consistent with research in other gravel bedded river systems that suggests flows of approximately 1.5-year to 5-year peak flow recurrence intervals do the most "work" over the long term at controlling and maintaining channel form (Schmidt and Potyondy 2004; Surian et al. 2009)."
230	APPENDIX E: FISH	3.2.4.2	Page 139, 5th paragraph	Incorrect basis for conclusions of impact | "...limiting high-water events that infiltrate the floodplain would also limit the input of terrestrial nutrients to the stream, which would have negative impacts on juvenile salmon and steelhead growth." This assertion is over simplified and not substantiated. There have been floods in which Doty flows are higher than the 10-year flood, and yet the Grand Mound gage did not reach 38,800 cfs (Nov. 2012); in such floods, the FRE facility would not operate, and floodplains between Doty and the Newaukum confluence may be inundated at flows greater than the 10-year level. Such high flow events would bring nutrients to the stream. In addition, the District's proposed vegetative management plan includes plantings and maintenance of flood-tolerant species within the temporary inundation area that would promote transfer of allochthonous and detrital inputs into the pool during operation. The temporary pool would act similar to natural floodwater areas (Junk et al. 1989; Benke et al. 2000) and would transport fine organic material, leaf litter, and terrestrial invertebrates into the temporary pool. Juvenile salmon are opportunistic feeders and readily exploit such prey subsidies when available (Bottom et al. 2005). Seasonal inundation would be expected to change fish prey availability, but there is no evidence that there will not be food for fish, or that fish growth would be impacted.
231	APPENDIX E: FISH	3.2.4.2	Page 140, 1st paragraph	Incorrect basis for conclusions of impact | Per Comment #329 and #330 on Appendix F (Earth), the premise and conclusions that FRE operation would adversely affect channel forming flows are flawed.
232	APPENDIX E: FISH	3.2.4.2.1	Pages 140-141	Incorrect basis for conclusions of impact | Per comments on Attachment E-3, the assumed survival rates are generally not justified nor realistic.

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233	APPENDIX E: FISH	3.2.4.2.2	Pages 142-145	Impacts of No Action are conflated with FRE facility. | The impacts presented in this section are attributed to the FRE facility as compared to a 2035 baseline condition, but those impacts would occur in the future even without an FRE facility as is described in the No Action impact section. The comparison between the future FRE and a 2035 baseline is inappropriate. The future FRE must be compared to a future No Action. Comparing the future FRE to a 20235 baseline could lead the reader to a mistaken conclusion that all future impact would result from the Project – which it is not accurate. In fact, the FRE facility-specific modeled impacts show no impact to spring-run Chinook Salmon, Coho Salmon and steelhead Rainbow Falls to Crim Creek subpopulations beyond the impacts that would already occur under the No Action Alternative. Further, some level of impact to all other subpopulations would occur under the No Action Alternative and, thus, when compared to the No Action alternative, the impact associated with the FRE facility itself would be *reduced* from what is presented in the SEPA DEIS. The RDEIS's presentation of this information must be revised in the FEIS to clearly demonstrate the Project- specific effects independent of future action outside of the Project's influence.
234	APPENDIX E: FISH	3.2.4.2.2	Page 142-147	Incorrect basis for conclusions of impact | 1. Per comments on Attachment E-3, the assumed passage survival rates are not justified, are not based on the best available science, and are unrealistically low. 2. The modeling relied on and overall discussion in this section disregards the deep and extensive scour anticipated within the temporary impoundment reach under the No Action Alternative. Scour would be extensive during major and catastrophic floods and would adversely impact salmon and steelhead spawning. This impact would increase over time as climate change results in increased major and catastrophic flood frequency. Conversely, the Project will reduce scour risk during major and catastrophic floods, thus reducing impacts on salmon and steelhead spawning compared to the No Action alternative. Site specific data on bed scour under 2-year average flow conditions was collected by the District and shared with Ecology. Two years of data demonstrated that bed scour was impacting redds under this average flow, suggesting that the potential impact would be more substantial for redds than has been indicated by the SEPA EDT model. The SEPA EDT model instead relied upon a bed scour calculator designed to estimate bed scour based on other model attributes which in turn may not be based on site-specific data, compounding potential for bed scour inputs that do not match reach specific conditions.
235	APPENDIX E: FISH	3.2.4.2.2.5	Page 145, last paragraph	Incorrect basis for conclusions of impact | The DEIS states that Coho Salmon would experience a 98% decline due to flood retention events and ascribes this purported effect to juveniles unsuccessfully attempting to move downstream during flood retention events. This assumption fails to take into appropriate account the migration periods for fish species as presented in Figure E-4 in the RDEIS. Outmigration for all salmon species starts in March and continues into June. Further, Coho Salmon in the Chehalis basin exhibit complex life history with "as many as six distinct juvenile life history strategies" some of which likely include migrating out of rearing streams at different ages and different times of the year (Jorgensen et al. 2021). Because of this complex life history, any effects from flood retention would be limited to those fish that occur during the specific month that the facility is operated during a flood event; it would not impact an entire year's cohort of juvenile fish

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				of a particular species. Further, based on the migration patterns presented in Figure E-4,outmigrating salmon should not be affected by a modeled catastrophic flood that occurs in February given the outmigration for these species begins in March. One possible reason for such a dramatic decline in Coho Salmon would be the incorrect assumption, evident in SEPA model inputs, that the FRE would provide a complete obstruction for downstream passage from October through March. This would include March when coho salmon smolt outmigrating begins similar to Chinook Salmon but also would affect any Coho Salmon redistributing within the upper Chehalis River during fall. Any such erroneous assumptions must be corrected in the modeling and these conclusions revised in the FEIS.
236	APPENDIX E: FISH	3.2.4.2.2.5	Page 146, 5th paragraph	Incorrect basis for conclusions of impact | The assumption that all juveniles attempting to pass downstream during a flood when the FRE facility is operating would not survive has no ecological basis, is inappropriate and does not reflect the best science, and must be changed in the FEIS. Throughout the Columbia River basin, fish migrate downstream of tributaries and encounter reservoirs and use these lentic habitats. In many river basins in Oregon and Washington, these fish have exhibited behavioral plasticity and the ability to adapt different life history strategies to survive. In some reservoirs, when no dedicated fish passage has been provided, it has been well documented that some salmon will find a way out, even if that means passage through turbines which many fish can survive. Other fish will hold and reside in the reservoir for a period of time. Subyearling and smaller juvenile salmon tend to hug the shoreline of these reservoirs while larger juvenile salmon may occupy deeper waters. In larger reservoirs, such as several of the Willamette Project reservoirs, juveniles may rear for extended periods of time and exhibit growth before even attempting to move downstream through turbines, or if food is plentiful, may opt for an alternative life history strategy and return after a few years to spawn upstream without leaving the reservoir. The abundance of information available from decades of studying fish use of reservoirs in the Columbia River basin provides ample evidence to refute the SEPA RDEIS's assumption that all fish within the proposed FRE facility would perish from being held in a temporary pool for up to approximately one month, which would be the maximum duration of the temporary pool. This assumption – which is demonstrably false – must be corrected in the FEIS.
237	APPENDIX E: FISH	3.2.4.2.2.5	Page 147, 1st paragraph	Inaccurate statement | The RDEIS asserts that the summer temperatures are responsible for declines in juvenile productivity of models. In order to objectively state the impact of the proposed project, the increase in summer temperature due to the FRE facility should be compared to the increase in summer temperature for the No Action Alternative. Also, this statement ignores the temperature modeling completed by the District that showed how mitigation would reduce temperature impacts. Further with recent refinements to reservoir operations, the effect on FRE-related shade loss and water temperature increases has been minimized. The Applicant requests that the FEIS incorporate the latest refinements to reservoir operations and subsequent effects on reservoir vegetation, river shading, and river temperature as provided in Attachment 2: Environmental Impact Reduction Due to

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				Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum to these comments.
238	APPENDIX E: FISH	3.2.4.2.2.5	Page 148, Table E-12	Lack of context for results promotes confusion for the reader | Table E-12 is an example of how the presentation of modeling results can lead to incorrect assumptions. While the table claims to present numbers representing impacts to salmon and steelhead abundance from the Project, in fact, much of the loss ascribed to the Project in this table also occurs under the No Action alternative – it is not an impact of the Project. In addition, this table misrepresents the loss of coho and steelhead subpopulations from Rainbow Falls to Crim Creek. This presentation of percentage impacts appear high but were not put into context of the entire basin which would show them to be much smaller. For example, while the model predicts a complete loss of steelhead in the Rainbow Falls to Crim Creek subpopulation, that subpopulation started with 13-14 adults under the baseline condition. This calls into question whether this truly represents a subpopulation as clearly it would not be considered a self-sustaining population for salmon. While this may represent an aggregation of steelhead within the EDT model, it should not be treated as an independent subpopulation. Similarly, Coho Salmon in this model reach started with only 50 fish, and spring-run Chinook Salmon likely have a similarly small population upstream of Crim Creek, although the initial subpopulation abundances are not representative of recent abundances for both of those subpopulations, complicating things further. In arbitrarily defining subpopulations within the Project Area that likely do not represent phenotypically or genotypically distinct populations, the model predicts not only a loss of fish in this reach, but that loss is also an artificially inflated into a reduction in Diversity to the overall Chinook River population for these two species. With starting populations of 13 to 50 adults under baseline conditions, any loss of Diversity would be an artifact of model configuration and not a real ecological consequence to Coho Salmon or steelhead. Finally, the RDEIS fails to explain that, while 50% to 100% looks dramatic, it equates to less than 1% to 1.2% for spring-run Chinook Salmon. The FEIS must consider the relative importance of these relatively small populations to the persistence of the overall Chehalis River populations as part of the evaluation of any future action in the basin.
239	APPENDIX E: FISH	3.2.4.2.2.5	Page 149 4th paragraph	Unsupported statement | The text states that the "fall-run Chinook salmon abundance ranged as low as two fish in the Above Crim Creek Subbasin." This statement is directly contradicted by Figures E-18 and E-20 which depict the range of all iterations around fall-run Chinook Salmon integrated modeling median was greater than approximately 50 (reading the graphs).This statement overexaggerates the potential impact potentially misleading the reader to a mistaken conclusion of potential impacts associated with the FRE facility.
240	APPENDIX E: FISH	3.2.4.2.2.5	Page 149 4th paragraph	Unsupported statement | This text suggests that the year-to-year variability under the FRE facility scenario would impact access for fishing and implies that the interannual variability of the subpopulation abundances are greater than under the No Action Alternative. Based on the No Action Alternative results presented in E-32 to E-51; however, it appears that this

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				model does not depict any interannual variability nor mid- and late-century scenarios, which is of note given variability of escapement estimates to the upper basin between 2013 and 2020 (Ronne et al.).
241	APPENDIX E: FISH	3.2.4.2.2.5	Page 155, 2nd paragraph	Incorrect basis for conclusions of impact | "In addition, a large fraction of salmon and steelhead spawn in the proposed FRE facility inundation area" — this statement is potentially misleading. The percentages reported are for just those fish that spawn upstream of Crim Creek; however, the actual percentages of the total Chehalis River run, including those that spawn in Crim Creek and in the mainstem and tributaries downstream of Crim Creek, are significantly smaller for each species overall. Those numbers should be reported here for accuracy.
242	APPENDIX E: FISH	3.2.4.2.3	Page 156, 1st paragraph	No basis for statement | This statement implies that Largemouth bass would likely expand their range due to warmer water temperatures, even though, as described on page 162, Rainbow Falls is considered a barrier to these fishes.
243	APPENDIX E: FISH	3.2.4.2.3	Page 157-164	Insufficient information provided, Incorrect basis for inferring impacts | The changes in WUA (weighted usable area, which is a sum of areas weighted by probability of use criteria treated as independent variables) appear to be for months in which the FRE facility would not be operated. These changes appear to be with respect to climate change, not FRE operation during flooding, as the FRE would not operate in summer nor affect summer base flows. It thus appears that changes in flow due to climate change are being conflated with construction and operation of the FRE
244	APPENDIX E: FISH	3.2.4.2.3	Page 160 and 161, Tables E-26, E-27	Incorrect information provided | The footnote pertains to the Caldwell et al. (2001) site upstream of Crim Creek, not the Normandeau (2012) sites below Pe Ell.
245	APPENDIX E: FISH	3.2.4.2.3	Page 163, 2nd and 4th paragraphs	Incorrect basis for conclusions of impact | The statements, "modeled changes in WUA indicate that habitats for rearing adults will be reduced or eliminated in the hottest months" and "The estimated change in WUA over time ...based on average daily temperatures" are based on a circular argument. WUA is calculated based on depth, velocity, substrate, and other physical structural elements, not temperature. In IFIM, temperature is a modifier for whether a reach will support a species and life stage irrespective of the WUA quantity present. Based on an example in the 2017 operations plan (Figure 3.2 in Anchor 2017), it can be inferred that temperature was simply used to scale the WUA-flow relation vertically, without changing the fundamental underlying shape of the curve, which brings up the following problems in its application here: 1. The scaling predetermines any conclusion concerning magnitudes of WUA. That is, it is assumed in the scaling that WUA for the same patch of streambed at a given flow, with the same depths and velocities, is 'worth' more when the water is cooler than when it is warmer (cf Anchor 2017). Hence, predictions of warmer water are automatically associated in the EIS' conclusions with more WUA, which is taken to be a positive, and the converse is taken to be a negative. This is not proof of effect but is a circular argument. 2. Note that WUA is a relative index of habitat availability at a given flow relative to other flows, and its magnitude is not an absolute predictor of population carrying capacity. 3. The effect of temperature should not be represented as a scaled percentage of WUA for

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				a given set of depth and velocity conditions when those conditions are the same for all temperatures considered. The scaling provided in the RDEIS is not biologically sound.
246	APPENDIX E: FISH	3.2.4.2.3	Page 163, 6th paragraph	Incorrect basis for conclusions of impact | The section of the report ascribes the expansion of non-indigenous fishes upstream of Rainbow Falls to the FRE facility, even though the mechanism of that expansion would need to be human intervention, since Rainbow Falls is a natural barrier. Any effect to non-indigenous fish populations is properly considered a cumulative effect, not an effect of the Project. In addition, the analysis does not address the potential for this species expansion under a No Action Alternative thus incorrectly and misleadingly attributing this potential impact entirely to the FRE facility. It also disregards the analysis presented in Appendix N, which shows how the mitigation proposed by the District is expected to mitigate any water temperature impact.
247	APPENDIX E: FISH	3.4 and 3.4.1	Entire Sections	This section discusses the modeling of fish abundance for the No Action alternative using the same integrated model approach used for the proposed Project. Section 3.4 cross-references Section 2.2.3, which details the background information considered and acknowledges the adverse effect increases flood flows have on salmon populations. Section 3.4 also cross-references the explanation of the methodology in Section 2.4.2.1, which includes modeling the impacts of a recurring flood period of three major or greater floods in three consecutive years. Section 3.4.1 reiterates how this recurring flood period is depicted in a series of graphs showing the output of the Life Cycle Model for different fish species in the early-, mid-, and late-century time periods under the median and maximum climate scenarios. The purpose of the modeling is to show how a period of three large floods in three consecutive years affects population abundance depending on whether this recurring flood period never occurs versus occurs in the early, mid, or late century. Strikingly, for all fish species at all time periods in all climate scenarios, the recurring flood period shows no population effects whatsoever. In each figure, there is no difference between the “no recurring flood” graph in the upper left versus any of the other three graphs. The fact that the model shows no abundance impact of any kind from recurring major-or-greater floods in three consecutive years is an indication that the model, as configured by the RDEIS, simply does not capture the effects of major or catastrophic flooding on fish populations. The RDEIS acknowledges and cites background authority that such increase flood flows should have a significant impact on fish populations, but the model shows none. Widely accepted work by Ronne et al. from 2020 in the Chehalis Basin notes that such an impact from flooding has been observed. WDFW has publicly stated recently that the large floods in the Skagit River and other area rivers will likely have significant impacts on three years of salmon returns. WDFW has made similar statements about prior floods, including those in the Chehalis Basin. In sum, then, the RDEIS life cycle model results’ failure to show any impact from three major-or-greater floods in three consecutive years represents a failure of the model configuration to capture the real-world phenomena it was intended to capture: the impacts of the No Action alternative due to increased flood flows. This is a critical modeling error on perhaps the most critical resource examined in the RDEIS. The FEIS must correct this error to properly inform the public and decisionmakers about the impacts of the No Action Alternative.

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248	APPENDIX E: FISH	3.4.3.2.1.5	Page 209	Modeling results inconsistent with basic data | Scour depth data collected by the District under typical seasonal floods indicate that, for the No Action Alternative, (i) scour mortality is higher above Crim Creek than downstream to Rainbow Falls in typical seasonal floods, and (ii) scour mortality above Crim Creek is likely to be extremely high in major floods and effectively near 100% in catastrophic floods. This is not reflected in the model predictions summarized in the tables on this page, just as it is not reflected in the integrated model results on pages 183 through 201. The FEIS must update its modeling to capture the observed phenomenon that major and catastrophic flood flows impact salmon populations, so that it can properly identify the probable significant impacts of the No Action and local actions alternatives (neither of which would reduce high flood flows in the upper Chehalis River).
249	APPENDIX E: FISH	Attachment E-2	Page 2-28	Table 3-25 incorrectly asserts 100% of wood will be removed and lost to the system downstream, citing HDR 2021 and 2024. | From HDR (2021), Revised Project Description, "Debris removal will occur during reservoir drawdown, where the rate of drawdown will be slowed for up to 14 days to allow maintenance personnel to collect and remove debris from the trash rack and temporary reservoir. For further discussion see HDR 2021a." HDR (2021a) is a technical memorandum written specifically to clarify that large wood would be passed or placed downstream; specifically, it states, "During non-operating periods, most smaller debris will be either passed through the conduits or removed from the trash racks and hauled downstream to be released back into the river," and "LWM would be captured, staged, and sorted for use in downstream habitat enhancement projects as determined by the proposed mitigation program (Kleinschmidt 2020)." Inexplicably, none of this information provided in the 2021 memo about passage of smaller wood and reuse of large wood was included in the RDEIS's assessment of wood impacts. In addition, Section 8.4 of the 2024 Revised Mitigation Plan (Kleinschmidt 2024) identified specific actions for mitigating any disruptions of wood transport downstream of the FRE, including creation of a wood bank for future mitigation or restoration projects downstream, the collection and relocation of wood to a location downstream, and the intentional use of large wood for eight habitat enhancement actions downstream. The Earth and Air Quality discipline reports collectively credit the proposed Project's plans to reuse wood in construction, non-flood operations, and flood operations, yet this discipline report fails to do so without explaining its different rationale. The FEIS should remove this incorrect impact.
250	APPENDIX E: FISH	Attachment E-2	Page 2-31, Table E.2-7	Unrepresentative and incorrect assumption | This table describes an invalid assumption used to characterize FRE facility operation and duration during winter conditions. In the SEPA EDT, for the reach of the river from the FRE facility upstream approximately 6 miles, the habitat type was changed from riverine to reservoir for winter months under the FRE facility model scenarios. Instead of modeling impacts specific for the months in which the FRE facility would operate during a major or catastrophic flood, as was presented in Figures E.2-3 and E. 2-4 (page 2-11 of this document), the SEPA EDT model assumed no spawning habitat and 100% mortality for incubating eggs in this reach for 6 "winter" months (October through March):"This condition will be assumed for the entire winter period, because although inundation would occur for a period of days up to a month, it is assumed any spawning/incubating would not be successful for the entirety of that winter period." This

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				assumption inappropriately and artificially increases the perceived impact of the FRE facility. The modeled duration of reservoir habitat is *six times longer* than the *maximum* inundation duration of the District's proposed FRE facility. Thus, the SEPA EDT is not representative of the catastrophic or major flood conditions (1996 and 2009) nor of the simulated FRE operations from 1990-2022 that would have occurred either in January or February. Under the SEPA RDEIS representative major and catastrophic modeled years, the temporary pool would have been inundated either in January (2009, 19 days) or in February (1996, 19 days). The upper extent of the pool would have been inundated for a shorter duration. The inundation period used in evaluating potential spawning impacts is critical to the accuracy of its modeled impacts. Given salmon from each of the runs spawn and eggs incubate across different temporal windows, a temporary pool in December might be expected to have a greater effect on Chinook than Coho Salmon, while the effect might be expected to be reversed with greater impact to coho salmon from a temporary pool in March. By contrast, steelhead redds should not be impacted as they begin to emerge from redds in April and the majority spawn upstream of the inundation area (Light and Herger 1994).The SEPA DEIS's approach to determining incubating egg mortality does not appropriately evaluate all operational months/scenarios. Operations in different months would result in different impacts to different species, specifically the egg to fry survival in this example. A modeling approach which assumes the Project would operate for six straight months --- which it will never do – is misleading and inappropriate and fails to identify the Project's probable impacts. There are at least two approaches that the SEPA DEIS could have taken to evaluate the proposed FRE facility's probable impacts on incubating eggs. First, six EDT scenarios could have been run with the FRE facility operating in a different month during the wet winter period under each scenario. Alternatively, the model could be run for two or three scenarios where the FRE operates in months that, based on the ecology of the salmon species, would represent the greatest impact to each species, thus providing a greater understanding of potential impacts. In either case, the results would more accurately predict run-specific effects on embryo survival that could be used as input to the LCM. Either of these approaches could be used to more realistically and responsibly model the potential effects of the FRE facility as proposed by the District. Using the assumption of reservoir habitat all "winter" invalidates the use of the SEPA Integrated Model as a tool for evaluating the potential effects of the proposed FRE facility. These models do not rely on the actual Project nor the ecology of the salmon species in this upper basin and thus, their results do not demonstrate the probable impact expected to occur to these species as a result of the proposed FRE facility's operation.
251	APPENDIX E: FISH	Attachment E-2	Page 2-4	Erroneous model result? | Review of EDT model results for Coho show Adult (SAR) capacity values of 100,000,000,000,000,000, mainly for the No Action Alternative. Obviously, this is impossible. Values for capacity under FRE facility operational scenarios

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				for the 10-year and 100-year maximum and median climate change scenarios range from 4,667 to 8,614 Coho Salmon. The variation between scenarios is extreme and suggests an issue with the model or that a model artifact (e.g., placeholder number instead of infinity) was mistakenly left in place.
252	APPENDIX E: FISH	Attachment E-3	Page 3-7	Impacts of No Action are conflated with FRE facility. | Although this section is titled "quantitative analyses of anadromous salmonid passage," the values presented are in fact qualitative best guesses by WDFW's Fish Passage Subject Matter Experts panel. This section must acknowledge in the text and through a change in the title that this is not a quantitative analysis. Furthermore, the District's own experts disagree that survival rates through the Project's conduits will be lower than at the Federal Columbia River Hydropower System's high head dams, as the passage assumptions described here suggest. Such a conclusion is inconsistent with the best available science. Moreover, the Project is being designed to meet all NMFS fish passage criteria, and it is therefore unreasonable to assume that survival would not meet those criteria.
253	APPENDIX E: FISH	Attachment E-3	Page 3-10, 10th bullet	Faulty logic and resulting assumptions likely incorrect | The RDEIS describes assumptions made regarding fish passage performance that were incorporated into EDT and the integrated modeling approach. Among those, the RDEIS states that upstream juvenile salmonid foraging movements "will be impeded" during high-flow conditions and during FRE backwatering This should be true throughout the river, and especially at the various falls and in the canyon downstream where upstream passage of juveniles is either prevented or impeded as well. The same performance metrics need to be included in an overall assessment, rather than attributing passage impacts to the population only to the FRE facility.
254	APPENDIX E: FISH	Attachment E-3	Page 3-10, 4th bullet	Analyzing effects based on outdated operations | The bypass channel can easily be designed to provide passage corridors with 1-foot depths at the low passage flow; (e.g., V-shaped low flow channel). Construction bypass channel fish passage will meet National Marine Fisheries Service fish passage criteria. Ecology is aware that the District's coordination with NMFS is already underway.
255	APPENDIX E: FISH	Attachment E-3	Page 3-11, Table E.3-2	Faulty logic and resulting overly conservative estimates likely incorrect; cannot rely on EDT and LCM results accordingly | Table E.3-2 provides estimated construction passage effectiveness percentages that are the foundation for the RDEIS's assessment of Project construction-related impacts on fish passage. The survival numbers included in this table are not consistent with the best available science. To demonstrate this fact, consider that these numbers – if true – would also apply, at a minimum, to Rainbow Falls, Meskill Falls, and the Canyon reach below Crim Creek, locations where passage conditions are more restrictive than would likely occur in the bypass channel. If these survival numbers were accurate (which they are not), spring run Chinook Salmon would experience a net cumulative run survival of 4% (=0.343) by the time they reach Crim Creek. Above Fisk Falls, that number would decrease to 1% -- or less given the much more difficult conditions there. For fall run Chinook, the corresponding numbers are 27% and 18%, respectively. Survival rates of this nature are unreasonably low and do not comport with the best

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				available science regarding spring- and fall-run Chinook Salmon, particularly given the nature-like fishway channel is designed to be more passage friendly than many natural locations in the river. Indeed, if these passage survival numbers were accurate, there would likely be no Chinook Salmon in the Chehalis Basin, which is demonstrably not the case. These survival numbers -- which underpin the RDEIS's entire analysis of construction-related fish passage impacts – must be revised to reflect scientifically supportable passage survival numbers for the proposed bypass channel, which will mimic natural conditions. Indeed, the sensible way of analyzing a reach mimicking or exceeding natural conditions is to say it creates no impact, since survival would be no different than on the natural river.
256	APPENDIX E: FISH	Attachment E-3	Page 3-11, Table E.3-2	Faulty math affecting EDT and LCM modeling results | Table E.3-2 and the surrounding text implies that the EDT model assumes, in a manner inconsistent with the best available science, that all fish that do not attempt passage are killed. In which case the cumulative fish passage numbers are incorrect. Moreover, if those numbers were used as input to the EDT or Integrated model, then those results are also erroneous. For example, in the case of spring-run Chinook Salmon, if 100 fish arrive at the construction bypass, and only 50% of them are likely to pass upstream, then 50 of those 100 fish are expected to turn around and find spawning habitat downstream. Of the 50 that are likely to pass upstream, and with the 80% survival rate presumed in this table , 20% of the fish would die during transit, and of the 40 fish that survived, 15% of them would die due to delayed mortality, meaning 34 of the 50 upstream migrating fish would survive (68%) and 84 of the original 100 fish would survival overall (84%). The RDEIS's conclusion that only 34% would survive is misleading and without basis in sound science. Moreover, the survival rate percentages used in Table E.3-2 are not based on the best available science and are unreasonably low. The survival rate of spring-run Chinook Salmon would therefore be significantly higher than 84%. Furthermore, as noted above, if the inappropriately presumed 34% survival rate has been used as an input in the EDT-LCM modeling, then the modelers are going to predict unrealistically low survival rates overall and those predictions may not be relied upon as the best available information and are so misleading as to prejudice the Project.
257	APPENDIX E: FISH	Attachment E-3	Page 3-12, 4th paragraph	Incomplete analysis of effect and justification of assumptions likely affecting conclusions; cannot rely on EDT and LCM results accordingly | Information is missing regarding what velocities are involved and how they compare to Columbia River dam spillways. Note that USACE studies of PIT-tagged Chinook smolts at the Ballard Locks in Seattle found fish that recycled multiple times after passing through high velocity (15-20 ft/s) flumes discharging to surface water. Velocities through the conduits when the flow is open channel should be identified versus when the conduits are flowing full. Consideration is missing regarding behavior where fry tend to reside in quieter water near the channel margins. Furthermore, following the second paragraph on this page, parr and smolts are more surface-oriented in deep water when the conduits are flowing full.
258	APPENDIX E: FISH	Attachment E-3	Page 3-13, Table E.3-4	Table conflicts with preceding statements | Information presented above on the same page indicates mortality would likely be zero "for larger-sized fish (20 centimeters in length) and smaller-sized fish (10 centimeters in length) when velocity was less than 66 and 58 fps, respectively.". Nevertheless, the RDEIS indicates that these were laboratory studies, and

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				suggests that for that reason, different survival numbers in Table E.3-4 were adopted. However, laboratory studies are a valid manner of determining likely mortality rates and, in the absence of reliable conflicting information, should be relied upon as the best available science to identify probable Project impacts. Moreover, fish passage through a relatively short conduit is not the same as through a dam, where the pressure drop and turbine mechanical injury potential are greater. Accordingly, basing survival estimates on studies of survival through dams can lead to over-estimates of mortality through the FRE facility conduits. These numbers need to be revisited.
259	APPENDIX E: FISH	Attachment E-3	Page 3-13, Table E.3-5	Faulty logic and resulting overly conservative estimates likely incorrect; cannot rely on EDT and LCM results accordingly | Comment #258 regarding Table E.3-2 applies here, too since these numbers are taken directly from that table.
260	APPENDIX E: FISH	Attachment E-3	Page 3-16, Table E.3-7	Incomplete analysis of effect and justification of assumptions likely affecting conclusions; cannot rely on EDT and LCM results accordingly | Table E.3-7 provides estimates for upstream juvenile migrant passage rates during construction and normal Project operations but fails to distinguish passage rates at low, medium, and higher flows. At low flows, juveniles are blocked from moving upstream at numerous drops and falls throughout the upper river before they could reach the bypass channel and conduits. Passage conditions would likely be better in the channel and conduits than at many other locations. At medium flows, juveniles would navigate numerous riffles and cascades with passage conditions similar to the bypass channel and conduits. The cumulative effectiveness of passing those riffles and cascades is being ignored in the RDEIS; it shouldn't be, because doing so artificially over-ascribes impacts to the FRE facility. For example, assuming 64% effectiveness at a single passage restriction would be equivalent to five consecutive restrictions (e.g., riffles and cascades) equating to a cumulative 10% effectiveness (and it should be noted that if the 10% number were to be applied in the EDT model, then the predicted fish numbers would likely not match anything close to observed). At high flows, juveniles are more likely to be finding refuge locally than moving upstream. Because Table E.3-7 fails to accurately reflect passage rates at different flow levels, it does not represent the best science and is inadequate for assessing probable Project impacts. Similarly, the EDT-LCM modeling must also consider varying passage rates at different flow levels in order to reliably and reasonably predict probable Project impacts.
261	APPENDIX E: FISH	Attachment E-3	Page 3-16, Table E.3-8	Insufficient information provided; Faulty logic and overly conservative estimates likely incorrect; cannot rely on EDT and LCM results accordingly | Table E.3-8 provides passage effectiveness estimates for downstream migrating steelhead kelts during construction and normal operations, but does not provide any basis for these numbers, which appear to be extremely low. For example, studies of kelt passage in a Central California reservoir, where water temperatures are generally warmer overall than in the Chehalis River, recorded kelt downstream passage effectiveness of 87% (Ohms and Boughton 2021). Similar arguments should apply to other locations where downstream passage is constricted, such that applying the 43% number cumulatively to natural passage restrictions at Fisk Falls and farther downstream implies zero survival of kelts under the No Action condition. This is clearly incorrect, thus the numbers in Table E-3.8 are in error.

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262	APPENDIX E: FISH	Attachment E-3	Page 3-19, 4th bullet	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | The assumption of sounding is speculative and likely incorrect. As noted on page 3-12, juvenile outmigrants tend to be surface oriented. Sounding by juveniles is a phenomenon that more likely reflects warming of surface water temperatures rather than seeking a route downstream, but the FRE facility would be operated during winter and possibly spring flows before water temperatures become an issue. Assuming they sound to deep water translates to assuming they are passing through the conduits under higher pressures and pressure drops (i.e., higher risk of mortality) than when they pass through after the water level has lowered sufficiently.
263	APPENDIX E: FISH	Attachment E-3	Page 3-20, bullet	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | The RDEIS alleges general uncertainty regarding "basic information from any species on their swimming capabilities and behavior" through "these types of structures" and a lack of "refined velocity estimates." In fact, however, there are various studies of the effectiveness of naturalized channels with non-salmonids after barrier removal; e.g., Bruno, A.J., 2025; Tabor, Waterstrat, and Olden. 2020. The FEIS should include an accounting of such references that indicate high passage success rates.
264	APPENDIX E: FISH	Attachment E-3	Page 3-13, Paragraph 2	Notes that estimated juvenile salmonid downstream migrant passage effectiveness is similar but reduced compared to passage through the bypass channel. A difference of 0% to 10% is noted between tables E.3-3 and E.3-4, species dependent. On page 3-9, water quality during construction is noted as a factor when developing fish passage survival estimates, specifically that turbidity, temperature, and dissolved oxygen will likely be degraded. If these conditions are worsened during construction, would these not affect juvenile outmigrants? These conditions would seemingly be more impactful than navigating the FRE conduits, but contradictory to the conclusions on page 3-13. In fact, since the Water Discipline report concluded that there would be no significant effect on turbidity, temperature, or dissolved oxygen from the proposed Project's construction (Water Discipline Report at 66 and 68), assuming negative impacts from these factors to influence construction fish passage is inappropriate.
265	APPENDIX E: FISH	Attachment E-3	Page 3-2, paragraph 1	Paragraph states FRE conduits to be fully submerged for flows greater than 4,500 cfs. This is not correct. Pressurization begins around 13,700 cfs.
266	APPENDIX E: FISH	Quantitative Analyses of Anadromous Salmonid Passage; Methods; Construction	Page 3-10, bullet 4	The RDEIS states that the bypass channel "does not have ideal depth and flow for fish passage of big-bodied fish during low-flow conditions despite being based on reference reaches." This statement appears to misunderstand the reference reach conditions. In fact, the bypass channel was designed to function identically to the reference reach, or baseline, with regard to fish passage. In this reach, under natural conditions, summer flows have not met minimum instream flows for many years over the last decade. The fact that the bypass reach will mimic these conditions – and therefore also represent low flow conditions in summer months – is not a Project impact, but rather an impact of the No Action alternative. Moreover, if necessary – and unlike under the No Action alternative -- the bypass channel can be adaptively managed in response to agency requests as needed by the addition of

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				low flow deflectors to reduce the wetted width and increase channel conveyance capacity. Accordingly, the RDEIS should conclude that the Project's probable impacts are the same as the No Action alternative and, in fact, provide opportunities for improvement over natural, baseline conditions that the No Action alternative does not provide.
267	APPENDIX E: FISH	Quantitative Analyses of Anadromous Salmonid Passage; Methods; Construction	Page 3-9, bullet 3	The RDEIS erroneously concludes that construction noise "may be a deterrent for adult upstream fish passage and juvenile upstream and downstream foraging events." This is demonstrably false and fails to consider the Project's construction plans. Specifically, all in-water work that would create noise, including pile driving and blasting, will occur *in isolation from the active flow*. By constructing the facility in the dry, noise and vibration is not expected to affect fish behavior or degrade habitat near the construction area. The RDEIS's failure to take into account a fundamental feature of the Project's construction plan results in misleading conclusions regarding construction impacts that, in fact, will not occur. The FEIS must be revised to accurately reflect the District's proposed construction plan.
268	APPENDIX E: FISH	Quantitative Analyses of Anadromous Salmonid Passage; Methods; Construction	Page 3-9, bullet 4	The RDEIS erroneously states that spring-run Chinook Salmon will "hold in reaches downstream of the FRE" and that resulting physiological stress will cause this species to be "less likely to move upstream through a bypass channel." This suggests that any spring-run Chinook Salmon holding is a Project effect, which it is not. Low flow conditions in the summer are a baseline condition; the Project will not increase the physiological stress of spring-run Chinook that may or may not hold downstream of the FRE. Furthermore, the construction bypass will fully isolate the work area and provide conveyance capacity identical to baseline conditions.
269	APPENDIX E: FISH	Quantitative Analyses of Anadromous Salmonid Passage; Results; Construction	Page 3-11, Table E.3-2	No literature, case studies, or passage performance at other facilities are provided to support the adult salmonid construction passage numbers provided in Table E.3-2. To the extent that these numbers were based on the opinion of three Ecology SMEs, the RDEIS should provide citations to specific data or studies relied upon by those SMEs in formation of their opinions, but no such support for these numbers is provided, calling into question the credibility of these numbers. The FEIS must rely on the best available science, not merely SME opinion.
270	APPENDIX E: FISH	Quantitative Analyses of Anadromous Salmonid Passage; Results; Non-flood operation	Page 3-13, Table E.3-5	In addition to the other problems noted herein concerning the RDEIS's unreasonably low and unsupported fish passage number, the RDEIS departs from the 2020 SEPA DEIS fish passage estimates without justification. The 2020 SEPA DEIS Fish Discipline report on page E-79 lists passage for species as follows: Spring-Run Chinook 2020 DEIS, Table E-9 - 94% Fall-Run Chinook 2020 DEIS, Table E-9 - 94% Coho 2020 DEIS, Table E-9 - 94% Steelhead 2020 DEIS, Table E-9 - 96%. Even Ecology, when writing the prior DEIS, disagreed with the current RDEIS fish passage estimates. The FEIS must revise these estimates using the best available science.
APPENDIX F: EARTH				
271	APPENDIX F: EARTH	Summary	Page v, Table F-1 - Construction – Geomorphology	Conflating change with impact without providing basis for conclusion | Permanent alteration of channel within footprint represents a change in channel form locally, but how that translates to a specific impact and what that impact is are not defined.

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272	APPENDIX F: EARTH	Summary	Page v - viii, Table F-1	"A landslide that occurs when water is impounded, resulting in a wave that damages the FRE or overtops and dam" - Mitigation Proposed states "None." LS-4 is the mapped landslide with the largest likelihood of initiating this impact because of its direct line-of-site with the FRE. From the Shannon and Wilson 2017 Technical Memorandum Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species Project Phase 2 Chehalis Dam Site Characterization Landslide Stability Improvement Evaluation, mitigation strategies have been evaluated and shown to meet stability criteria for LS-4. Therefore, the Mitigation Proposed should be changed to "Design for slope stability." - LS-4 is the only landslide in direct line-of -site for the FRE structure. For landslide-induced overtopping of the FRE structure, the landslide typically needs direct line-of-site access to the FRE structure. Otherwise, the induced wave attenuates energy each time is it redirected by reflection off a wall or obstacle. Other landslides that may occur when water is impounded are not in direct line-of-site of the FRE structure the risk of overtopping or damaging the FRE is significantly lower than LS-4. Mitigation strategies, presented in S&W 2017, can be implemented to other landslides. - Significant and Unavoidable Adverse Impact states "Yes." Mitigation strategies for LS-4 has been discussed above. Significant and Unavoidable Adverse Impact should state "No." Mitigation is proposed through stabilization in Table F-5.
273	APPENDIX F: EARTH	Summary	Page v - viii, Table F-1	"'Increased risk of a deep-seated landslide temporarily blocking the river, impacting river flow and resulting impacts when the landslide dam is breached or eroded" - Impact statement does not state that a deep-seated landslide that blocks the river would be due to the project nor whether the blockage is upstream or downstream of the FRE. The impact statement does not state what the impact is, only that there are resulting impacts when the landslide dam is breached or overtopped. If the landslide occurs downstream of the dam the impact finding is likely less than significant and likely not because of the dam. If the landslide occurs upstream, it may assist with sediment transport further downstream. - Mitigation proposed says "None." Mitigation has been proposed in the Shannon and Wilson 2017 Technical Memorandum Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species Project Phase 2 Chehalis Dam Site Characterization Landslide Stability Improvement Evaluation. Mitigation strategies for deep-seated mapped landslides that would be impacted by flood retention operations have been evaluated and shown to meet stability criteria. Therefore, the Mitigation Proposed should be changed to "Design for slope stability." - Significant and Unavoidable Adverse Impact says "Yes." Mitigation strategies have been evaluated and shown to meet stability criteria avoiding any adverse impact. Therefore, the Significant and Unavoidable Adverse Impact should state "No." Mitigation is proposed through stabilization in Table F-5.
274	APPENDIX F: EARTH	Summary	Page v - viii, Table F-1	"An earthquake that occurs when a reservoir is impounded…" - Mitigation Proposed states "None." - The FRE will be designed to accommodate seismic forces when the inundation pool is impounded such that the risk of an uncontrolled release of the inundation pool is minimized and so unlikely as to be considered negligible. RPDR Section 3.3 of Appendix F outlines

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				industry design guidance and the risk-informed approach which will serve as the basis for design. The risk-informed design framework considers a range of hazard levels (return periods) in combination with the anticipated severity of consequences with each. These are compared against the limited risk tolerance described in USACE, USBR, and FEMA public protection guidelines. These federal guidelines require critical individual PFM risks as well as cumulative PFM risks to fall below established public protection guidelines. The statement does not adequately consider the degree of care that will be completed to characterize site conditions, design of the FRE structure, and construction of the facility that will provide a high level of risk reduction for such failure modes. Estimated risks of failure for the FRE structure under earthquake loading is expected to be less than 1:10,000 (0.0001) to 1:100,000 (0.00001) when estimated with a quantitative risk analysis to be completed on the preliminary design. Mitigation is proposed through the design approach. - Significant and Unavoidable Adverse Impact states "Yes." This impact is avoidable through design. Significant and Unavoidable Adverse Impact should state "No."
275	APPENDIX F: EARTH	Summary	Page vi, Table F-1 - Operations – Geomorphology	Incomplete analysis of effect | Alteration of substrate composition and sediment transport within the footprint of the temporary inundation area fluctuation zone – this is a temporary phenomenon, which should be noted in table.
276	APPENDIX F: EARTH	Summary	Page vi, Table F-1 - Operations – Geomorphology	Basis for impact conclusion conflicts with other text | Reduction of large wood downstream of FRE is categorized as a significant and unavoidable impact – Large Wood Management Plan including moving all trapped large wood downstream was designed as mitigation, which is acknowledged in Section 5.4.3 but not in this table.
277	APPENDIX F: EARTH	Summary	Page vi, Table F-1 - Operations – Geomorphology	Basis for impact conclusion insufficiently defined and incorrect | Truncation of peak flows during periods of impoundment affecting channel forming flow processes – non-specific impact – this is based on an incorrect definition of channel forming flow (see Comment #329 and #330)
278	APPENDIX F: EARTH	Summary	Page vii, Table F-2 - Geomorphology	Basis for impact conclusion insufficiently defined and incorrect | Increased tributary incision in the impoundment reach claimed because of incision along mainstem Chehalis River – the mainstem is already entrenched/incised with base level control provided by bedrock, thus mainstem channel is unlikely to incise further over the life of the project
279	APPENDIX F: EARTH	Summary	Page v - viii, Table F-1	"Sediment delivered to the river due to shallow landslides" - This should be omitted from the impact statement as shallow landslides are naturally occurring, largely initiated by excessive rainfall – not through FRE operations. "or landslide movement caused by fluctuations in reservoir water level during reservoir operations" - Mitigation proposed says "None." Mitigation has been proposed in Shannon and Wilson's 2017 Technical Memorandum Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species Project Phase 2 Chehalis Dam Site Characterization Landslide Stability Improvement Evaluation. Mitigation strategies for mapped landslides that would be impacted by flood retention operations have been evaluated and shown to meet stability

Comment #	Revised Draft EIS Component	Main Body or Appendix Section	Location (page, paragraph, sentence, table, bullet)	Comment
				criteria. Therefore, the Mitigation Proposed should be changed to "Design for slope stability." - The EIS also does not consider that with the passage of more restrictive and protective allowable forest practices in the mid-2000s, especially with respect to not building roads across or clear cut harvesting on areas mapped as landslide hazard areas, that the average annual rates of landslide inputs of gravel and large wood will be less than historically associated with timber harvest activities. Thus, the future condition of the upper Chehalis River is likely to involve reduced spawning habitat and instream habitat complexity compared with present because of reduced frequency and severity of anthropogenic landslides. - Significant and Unavoidable Adverse Impact says 'Yes'. There is extensive literature documenting how landslides are beneficial for long term supply of spawning gravels and large wood to the channel in typically gravel-starved rivers of the Coast Range. This literature is ignored in the EIS. Also, mitigation strategies can avoid any adverse impact. Therefore, the Significant and Unavoidable Adverse Impact should state 'No'. Mitigation is proposed through stabilization in Table F-5.
280	APPENDIX F: EARTH	Summary	Table F-1 - Section Proposed Action (FRE Facility and Airport Levee Changes) - Operations: First three Geology Impacts	HDR's 2023 TM provides documentation of landslide mitigation. Specifically, the preliminary design development to date anticipates mitigation of all the landslides in proximity to the FRE structure to prevent landslide failure during flood retention operations for those landslides that could impact the operation of the flood control outlet works. The smaller landslides that would not significantly impact operations, would not be mitigated with the intention that sediment load from such failures would be passed through the structure to provide materials to the stream channel downstream of the FRE structure to mimic, to the degree possible, natural geomorphic processes. While specific designs have not been developed and presented, our documentation considers two specific mitigation actions for the larger landslide features in relatively close proximity to the FRE structure: 1) instrumentation of the landslides to monitor performance including any activity that would indicate the need for further corrective actions to prevent landslide failure during the operation phase of the project, and 2) to complete excavations and contouring of landslides to increase stability factors of safety and to configure stabilizing berms at the critical landslides using excess excavated materials to provide adequate factors of safety so that those landslides would not fail during or following flood operations. The FRE structure has significant freeboard and adequate stability margins of safety to mitigate the potential for adverse performance (failure) of the FRE structure associated with a landslide failure that could generate an impact loading to the upstream face of the FRE structure/outlet, or a seiche wave capable of overtopping the FRE structure. To date, evaluation of deep-seated landslides has identified none that would fail during inundation pool drawdown in such a way that would result in a seiche wave that could overtop the FRE structure. As part of the usual engineering process, this potential will be evaluated further during subsequent investigation and design phases. If a condition is identified that could

Comment #	Revised Draft EIS Component	Main Body or Appendix Section	Location (page, paragraph, sentence, table, bullet)	Comment
				result in development of a seiche wave capable of overtopping the FRE structure, an appropriate mitigation strategy will be developed and incorporated into the project design such as monitoring and stabilization to mitigate this hazard and eliminate the potential for any significant and unavoidable impacts to occur. It is also noted that the concrete gravity section of the FRE structure will be capable of withstanding significant overtopping without failure. Such a potential failure mode would be included in a quantitative risk analysis completed as part of the preliminary design. The project design configuration will, when completed, contain all necessary actions and features to address critical PFMs so that estimated risks are well below the risk tolerance guidelines published by FEMA, USACE, and USBR. Such actions represent proposed mitigation. With the mitigation meeting design criteria, these issues should be rated as No Significant and Unavoidable Adverse Impact.
281	APPENDIX F: EARTH	Summary	Table F-1 - Section Proposed Action (FRE Facility and Airport Levee Changes) - Operations: Fourth and Fifth Geology Impacts	While the table summarizes an opinion of No Significant and Unavoidable Adverse Impact, the column summarizing Mitigation Proposed is not accurate. For example, the 4th item list erosion mitigation measures but does not indicate that the disposal sites for excavation/quarry spoils will be designed to a high engineering standard. It is important that these sections of the document properly characterize the engineering design that are targeted to provide a high level of environmental protection. This includes quarry high wall stability and efforts to provide containment of the completed quarry to minimize the potential for long-term discharge of waste, slope failure, or sediment laden discharge waters within the quarry closure design that will be executed by the construction contractor.
282	APPENDIX F: EARTH	Table F-2	Proposed Action (FRE Facility and Airport Levee Changes) - Construction	The RDEIS impact states, "Quarry wall failure during construction that creates sediment or exposes soil and rock to erosion" with no mitigation proposed. The District's engineers will design and construct the quarry walls in accordance with current stability standards to prevent instability and erosion. Construction will be performed in controlled lifts, and erosion and sediment control measures will be implemented. Revise the RDEIS Mitigation Proposed to 'Best management practices would be implemented to contain eroded soil and limit transport of sediment to the river'
283	APPENDIX F: EARTH		General	Non-defined terms/conclusions of impact | Definition of what is a Geological/geomorphic "impact" is not given, nor of what distinguishes a "significant" vs. "less than significant" impact. For any specific aspect of the Proposed Project where an "impact" is said to be "significant," the following details are missing in the context of geology and geomorphology: What the impact is specifically, and how and why it would be significant (i.e., specific descriptions/explanations of the mechanisms whereby an impact would occur, how and why it would be significant, and what aspect of the environment/resource would be impacted). It appears that any "change" qualifies as an "impact," but that does not mean that the change is ecologically or environmentally meaningful.

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				Concluding that an impact could be significant is not the same as concluding that an impact would be significant.
284	APPENDIX F: EARTH		General	Not considering best available information | Did not consider District's coarse and fine sediment transport analyses, scour data, and spawning habitat data, and the implications thereof with respect to impact and (non)significance of impact.
285	APPENDIX F: EARTH	2.2.3	Page 6, middle of paragraph	RDEIS states "The geologic conditions beneath the footprint of the proposed FRE facility are illustrated by a cross-section profile along the centerline of the FRE facility (Figure F-3)." Should state Figure F-3a.
286	APPENDIX F: EARTH	2.2.3.1	Throughout section	Throughout Section 2.2.3.1 clearly articulates planned landslide mitigation. The proposed mitigations, as presented in Table F-5, does not seem to translate into the summary Table F-1. This table should reflect proposed mitigation that is an integral part of the proposed Project.
287	APPENDIX F: EARTH	2.2.3.1	Page 7, 1st paragraph	Insufficient information provided | "There are many mapped and unmapped deep-seated and shallow, surficial landslides." The number of unmapped landslides cannot be quantified as "many" until they have been mapped or areas with high risk-related features have been analyzed and mapped; until then, the number must be unknown. Moreover, it is unclear if this is referring to the project site or the Willapa hills region in general. There is no basis for postulating the presence of numerous unmapped landslides in the project site.
288	APPENDIX F: EARTH	2.2.3.1	Page 8, end of first paragraph	Text states "Five of the deep-seated landslides show signs of activity." Figure F-4 only shows three. Table F-5 does not identify the deep-seated landslides. Unable to validate which show signs of activity.
289	APPENDIX F: EARTH	2.2.3.1	Page 8, second paragraph	RDEIS states "Two seismic lines extending across portions of Landslide LS-1 were completed in 2024 in conjunction with additional assessment of this landslide." In HDR's Geologic Data Report: Figure 3-1; assuming the RDEIS is referring to seismic lines GSL24-10 and GSL24-09, a small portion of seismic line GSL24-02 also traverses LS-1.
290	APPENDIX F: EARTH	2.2.3.1	Pages 8, 11, 12, Figure F-4 & F-5	The text identifies which landslides could affect the structure and how. The landslides are identified through landslide ID's (i.e., LS-4). Figure F-4 and F-5 do not identify the landslides and therefore, the reader is unable to identify and validate the landslides (and their impact to the structure) as referenced in the text. Figures should be updated to identify the landslides referenced in the text.
291	APPENDIX F: EARTH	2.2.3.1	Page 11, Figure F-4	Landslide ID's are not included in the figure to validate the deep-seated and active landslides. It appears LS-3 and LS-3a are not indicated as active landslides in these figures. The RPDR describes LS-3 and LS-3a as active landslides.
292	APPENDIX F: EARTH	2.2.3.1	Page 14, first paragraph	Text states "Which deep-seated landslides may require mitigation measures, and what the specific mitigation measures may be, has not been determined by the Applicant." In fact, however, the Shannon and Wilson 2017 Technical Memorandum Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species Project Phase 2 Chehalis Dam Site Characterization Landslide Stability Improvement Evaluation evaluated which landslides may require mitigation measures and what those mitigation measures may be.

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				The language also presumes that landslides have an overall negative effect that requires mitigation. This is not correct. Landslides are a primary recruitment source of gravel to the alluvial-bedrock channel, which would be beneficial.
293	APPENDIX F: EARTH	2.2.3.1	Page 14, 4th paragraph	Text indicates that 21 landslides are classified as debris flows but Figure F-6 does not indicate which of the mapped features are debris flows. Morphology of some mapped features in Figure F-6 is inconsistent with typical landslide morphology; erosional and depositional processes associated with ongoing stream channel evolution are not the same as a landslide.
294	APPENDIX F: EARTH	2.2.3.1	Pages 14-15, Figure F-6	Text states Weyerhaeuser geologists identified and mapped shallow, rapid and shallow landslides that could be potentially affected by mid or late-century major or catastrophic floods on Figure F-6. Figure F-6 does not indicate which 7 of the 12 shallow, rapid landslides and which 15 of the 35 shallow landslides could potentially be affected, therefore the veracity of the statement is unknown. Text also does not state that shallow, rapid and shallow landslides are naturally occurring and can be initiated by high intensity rainfall, not solely because of the inundation pool.
295	APPENDIX F: EARTH	2.2.3.1	Page 14, last paragraph	Paragraph is a generalized statement and does not provide how high-intensity rainfall and forest practices relate to the project area or how this informs the Project's probable impacts.
296	APPENDIX F: EARTH	2.2.3.2	Page 16	Overly generalized statement | This section should acknowledge that there is relatively little alluvium upstream of the South Fork, and less upstream of Pe Ell.
297	APPENDIX F: EARTH	2.2.3.4	Page 16, 3rd paragraph	RDEIS states "Gabbro is a high-to very-high-strength, dark gray to black, fine-to medium-grain rock that ranges from massive to blocky. It was only identified in one boring." Geologic Data Report Section 5.2.1 states that gabbro was encountered in borings AL-24-08, NNQ-24-01, and NNQ-24-02. Only one gabbro core sample was lab tested. Also, testing for the gabbro sample showed a compressive strength, Poisson's ratio, and Young's Modulus lower than the average values for basalt samples. The gabbro at the site is not high-to-very-high-strength material.
298	APPENDIX F: EARTH	2.2.3.6	Page 16, paragraph 6	RDEIS states "These sedimentary interbeds are more consolidated and stronger than the overlying McIntosh Formation rocks." This has not been documented in past references and the statement is not referenced to allow the reader to verify the statement. Provide the reference supporting this statement in the RDEIS.
299	APPENDIX F: EARTH	2.2.4.2	Page 17, end of paragraph 2	RDEIS states "Other fault zones and faults present in the vicinity of the Chehalis Basin, such as the Grays Harbor Fault Zone, Willapa Bay Fault Zone, Rainbow Falls Fault, and the Olympia Structure (Figure F-2)." The statement "in the vicinity of the Chehalis Basin" does not define what the vicinity is. The statement should clarify if these faults will impact the structure. Only faults that impact the structure should be listed based on a seismic evaluation looking at magnitude-distance. The closest fault zone to the proposed FRE

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				structure site is the Doty Fault zone, ~8 miles north. Figure F-2 shows faults/fault zones over 50 miles away from the site. Is that "in the vicinity"?
300	APPENDIX F: EARTH	2.4.1.2	Page 20, start of paragraph 2	RDEIS states "Sampling in the explorations included soil sampling with a split-spoon sampler and rock coring." The Geologic Data Report Section 3.2.2 states that Shelby tube, Dames & Moore, and Mod-Cal samples were also taken.
301	APPENDIX F: EARTH	2.4.1.2	Page 20, end of paragraph 2	RDEIS states "Vibrating wire piezometers (VWPs) were installed in selected borings to monitor groundwater levels." Geologic Data Report Section 3.6 states that inclinometers and standpipe piezometers were also installed in select borings. VWP's are used to collect groundwater data in rock and stand-pipe piezometers to collect data in soil.
302	APPENDIX F: EARTH	2.4.1.4	Page 20, last paragraph	RDEIS states "Index testing consisting of water contents, grain-size analysis, and Atterberg limits was performed on the overburden soils. Testing on rock cores included unconfined compressive strength, slake durability testing, direct shear tests, point load tests, specific gravity tests, and petrographic analysis." In the RPDR, Geologic Data Report Section 5.7.1 states that unit weight analyses were also performed on the overburden soils. Section 5.7.2 states that moisture/density and splitting tensile testing was also performed. S&W's 2019 Phase 3 Chehalis Dam Geotechnical Data Report Section 3 states that torsional ring shear tests and hydraulic conductivity tests using a flexible wall permeameter were also performed.
303	APPENDIX F: EARTH	2.4.1.5.1	Page 21, 1st paragraph	The seismic engineering analysis deems the FRFA conditions from the 2017 analyses (CBS 2017) sufficient for preliminary engineering assessment of the FRE structure. While we do not disagree with this statement, we recommend additional context be included in this section for consideration in the impact analysis. Specifically, unlike the straight-axis FRFA, the proposed FRE will be a curved-axis gravity structure which achieves stability through gravity load effects across the base of the section (cantilever) resistance like the FRFA with additional stability provided against sliding and overturning failure mechanisms through development of horizontal arch action (due to the curvature) which transfers a portion of the driving forces against the structure into the abutments.
304	APPENDIX F: EARTH	2.4.1.5.2	Page 23, end of first paragraph	RDEIS states "it may be necessary to improve the properties of the weathered rock beneath the concrete mat by other means, such as consolidation grouting or installation of a system of caissons." RPDR Appendix E (Geotech Design Report) of the RPDR: Section 6.4 Foundation Treatment Plan states "the preliminary foundation treatment plan includes a system of treatments, including a foundation cutoff wall, grout curtain, consolidation grouting, surface treatments such as slaking protection to achieve a good bond between the dam and foundation shaping block and foundation bedrock, and drainage treatments downstream of the seepage cutoff system."
305	APPENDIX F: EARTH	2.4.1.5.2	Page 23, bottom of second paragraph	RDEIS states "Consolidation grouting would be conducted to improve the deformability and seepage properties of bedrock within 10 to 30 feet of the dam foundation." RPDR Appendix E (Foundation Treatment TM) "Consolidation grouting will typically be completed to a depth of 10 to 30 feet depending on rock type, weathering, and observed properties during construction". The statement in the RDEIS suggests that all grouting will be completed

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				between depths of 10 and 30 feet, but the RPDR states it will typically be done there but it is not limited to those depths.
306	APPENDIX F: EARTH	2.4.1.5.2	Page 23, bottom of second paragraph	RDEIS states "Consolidation grouting would be conducted under low to moderate pressures while higher injection pressures would be used for grout curtain construction, which will occur at a greater depth." RPDR Appendix E (Foundation Treatment TM) Section 4.2, "the grout curtain elevations are measured from the top of bedrock. The extents and depths of the grout curtain should be refined as part of future design efforts." Consolidation grouting and the grout curtain will both be done in bedrock in different areas along the FRE foundation. Additionally, no comparison of grouting pressures is described in HDR's supporting documents. The grout curtain pressures would not be automatically higher than the consolidation grouting pressures.
307	APPENDIX F: EARTH	2.5	1st paragraph, 6th bullet point	The RDEIS is supposed to address *probable* significant adverse impacts. See Comment #140, above, for how the combined likelihood of a significant earthquake occurring during a period of temporary inundation pool storage is extremely remote that the associated failure mode on which the impact analysis is based would be considered non-credible for a high-hazard dam based on current industry guidelines.
308	APPENDIX F: EARTH	3.2.1.1	Page 28, second paragraph	The RDEIS states that certain construction activities “would modify the existing geological conditions and create sediment that could enter the Chehalis River.” The mechanisms whereby sediment “could” enter the river are not described, let alone how probable and why. Sediment impact could be significant, or it could not. Information is insufficient to be able to say one way or the other.
309	APPENDIX F: EARTH	3.2.2.1	Page 30, second to last paragraph	The RDEIS states that there is a “very low potential” for a deep-seated landslide occurring when the Project is in flood operations and, further, a “very low potential” that landslide movement would cause a landslide-induced wave to impact the FRE structure. This is incorrect. In fact, there is no potential for this action. The only deep-seated landslide with the potential for overtopping is LS-4, which is in direct line of site of the structure. LS-4 will be stabilized to prevent landslide potential. Other deep-seated landslides are not in direct line of site of the FRE structure. Mitigation is proposed through stabilization in Table F-5.
310	APPENDIX F: EARTH	3.2.2.1	Page 31, second paragraph	RDEIS states mitigation is proposed to develop of Surface Water Quality Mitigation Plan to mitigate impacts. Statement does not provide what the impacts are and why they would be significant. There is extensive literature documenting how landslides are beneficial for long-term supply of spawning gravels and large wood to the channel in typically gravel-starved rivers of the Coast Range. Mitigation is proposed through stabilization in Table F-5.
311	APPENDIX F: EARTH	3.2.2.1	Page 31, paragraph 4	Decommissioning roads is associated with reduced risk of sediment delivery through both surface erosion and landslide generation. The latter may offset or avoid potential for landslides – this is not identified or discussed or considered in the preceding paragraphs.
312	APPENDIX F: EARTH	3.2.2.1	Page 31, second to last paragraph	RDEIS states ‘ Impacts from instability, failure, or erosion of the stockpiled material and the slopes and ground on which the stockpiled material is place could be significant.’ Statement does not provide what the impacts are. Disposal locations have not been decided, nor has

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				it been defined that disposal will 'likely' be within the temporary inundation pool area. Best management practices will be used for disposal.
313	APPENDIX F: EARTH	3.2.2.1	Page 31, last paragraph	RDEIS states '…impacts due to quarry wall collapse and erosion of material used to restore the quarry would be significant.' Mitigation is proposed, as stated in the paragraph "The impacts would be mitigated by the proposed quarry site restoration following completion of quarry operations and FRE facility construction by addressing soil stability and water conditions and vegetating the site(s) (FCZD 2024),". Because mitigation is proposed the impact is not significant. Since the revised project description, the District has completed additional studies; however, the original proposed mitigation identified in the 2020 EIS for the quarries remains credible and should be considered.
314	APPENDIX F: EARTH	3.2.2.1	Page 30, third paragraph	RDEIS states 'Should landslides occur in response to FRE facility operations, these events could have a significant impact'. RPDR Appendix E (Geologic Data Report) provides summary of proposed landslide stability mitigation to stabilize landslides that were evaluated as risk of instability that could affect the FRE. The Appendix also provides reference to S&W's landslide evaluation that provided stability analysis of landslides that were evaluated to potentially impact the structure. RDEIS provides the mitigation proposed through stabilization in Table F-5. Additionally, the impact is not defined. Mitigation has been proposed and therefore this impact (undefined) is not significant.
315	APPENDIX F: EARTH	3.2.2.1	Page 30, last paragraph	Text states 'There is potential for a deep-seated landslide to occur at any time after FRE facility construction and for the landslide to temporarily block the river.' RPDR Appendix E (Geologic Data Report) provides summary of proposed landslide stability mitigation to stabilize landslides that were evaluated as risk of instability that could affect the FRE. The Appendix also provides reference to S&W's landslide evaluation that provided stability analysis of landslides that were evaluated to potentially impact the structure. RDEIS provides the mitigation proposed through stabilization in Table F-5. Text then states 'Impacts associated with subsequent breaching of the blockage and river erosion of landslide material would be significant.' Impacts are not defined (i.e., environmental? Damage to the structure?). If impact is relating to damage to the FRE, this is unlikely because mitigation strategies for deep-seated landslides and provided. Furthermore, for a breach to damage the FRE, it would require a direct line of site for the inundation wave to impact the FRE. If not in direct line of site, the inundation wave will propagate against meanders. Therefore, impacts need to be further defined, and the impact is likely not significant.
316	APPENDIX F: EARTH	3.2.2.1.1	In response to whole section	Substantial mitigation measures will be implemented for the FRE structure and flow through outlet to address the seismic and landslide failure modes described in the RDEIS. Constructed projects must meet permit requirements and standard of care for design. In the EIS, the design should be considered as meeting industry guidelines/standard of care that results in these failure modes having estimated annual exceedance probabilities significantly less than 1:10,000 years and perhaps one or two orders of magnitude lower. These risk reduction/mitigation measures do not seem to have been considered in the

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				RDEIS document and assessments of "Significance." The standards for design and construction of flood control structures like the FRE are well established in the U.S. and around the world. Modern risk-informed regulatory guidelines have established well accepted public protection guidelines. Modern structures designed to meet the federal public protection guidelines of FEMA, USACE, USBR, and various state agencies should therefore not have credible dam safety potential failure modes that fall below (risk of failure less than) public protection guidelines assigned significant adverse impacts. Non-credible potential failure modes should not be assessed under environmental reviews.
317	APPENDIX F: EARTH	3.2.5	First bullet	RDEIS states 'A breach of the FRE structure may occur at the same time water is impounded in the temporary reservoir….However, if a breach of the FRE structure did occur when the temporary reservoir was holding water, the results would be significant and unavoidable' The result of significant and unavoidable because of a breach does not take into consideration the likelihood of the event. The comment acknowledges the structure will be built to current dam design standards making this event avoidable.
318	APPENDIX F: EARTH	3.2.5	Second bullet	RDEIS states 'There is uncertainty about the ability to identify and accurately characterize the potential for identified deep-seated landslides to mobilize due to reservoir inundation and reservoir level fluctuations or due to other causes (extended precipitation).' The statement does not provide information on why uncertainty exists. Comprehensive landslide evaluations have been completed, as provided in the RDEIS Table F-5. The landslides have been comprehensively mapped and characterized. Landslide evaluations will continue to develop through the design phase. RDEIS states 'There is uncertainty about the potential monitoring programs to effectively identify landslides….' Statement does not provide information about why they are uncertain about monitoring programs. Monitoring programs will follow best practices for deep-seated landslides deemed of concern. This statement implies all deep-seated landslides are of concern and will impact the structure. This is not correct, RDEIS Table F-5 identified the deep-seated landslides and mitigation strategies. RDEIS states 'The potential for a landslide to move sufficiently to block the river may increase due to reservoir impoundment. Such an event would be significant and unavoidable.' Based on the above notes, mitigation and monitoring programs have been approved and will be further developed. Proposed mitigations makes this avoidable.
319	APPENDIX F: EARTH	3.2.5	Third bullet	Statement does not take into consideration the positive benefits of the re-introduction of gravels for spawning. Shallow landslides can be activated through natural high-intensity rainfall events, and it is not accurate to presume a shallow landslide would not have been activated in the rainfall event itself, with or without the inundation pool. RDEIS Table F-5 provides mitigation strategies provided under the current landslide study. Statement does not provide clarity of where the uncertainty comes from. Table F-5 provides

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				mitigation strategies. Currently there are no instances where mitigation is not technically feasible and mitigation strategies will continue to develop through design.
320	APPENDIX F: EARTH	5.2.1.1	Page 42, 3rd paragraph	Insufficient information provided | Soft sedimentary origin particles are easily broken apart, so need to know what fraction of the coarse riverbed substrates they comprise. Regarding "the instream gravel samples," it is unclear where and which ones, collected by who and when.
321	APPENDIX F: EARTH	5.2.1.2	Page 43, 2nd paragraph	Insufficient information provided | regarding which "geographic information system (GIS) database (using the LiDAR data)" and data specifically.
322	APPENDIX F: EARTH		Page 46, Table F-8: Reach 2B comments	Basis for statement insufficiently defined and likely incorrect | There is exposed bedrock and armored large cobble throughout this reach, which is generally not characteristic of aggraded state.
323	APPENDIX F: EARTH		Page 49, Figure F-9	Inaccurate presentation of data | This figure does not accurately depict upstream-downstream trends and differences in gravel and cobble distributions because: 1. the horizontal axis is not linear, where the bars represent discrete observation locations and do not represent equal distances between bars; 2. the caption title is incomplete: the data were reportedly collected on bar surfaces, not the riverbed; and 3. the presence of bedrock is neglected.
324	APPENDIX F: EARTH		Page 50, Figure F-10	Data missing | The figure legend does not reflect the caption title – both lines appear to be for the surface layer, not the sub-surface.
325	APPENDIX F: EARTH	5.2.1.2.2	Page 51, 3rd paragraph	Basis for statements insufficiently defined and likely incorrect | The statements in this paragraph are unsupported and lead to exaggerating the potential sediment supply to the system and associated impacts of FRE operation. At minimum the following need to be addressed: 1. The RDEIS states that an estimated 5.7 to 8.7 million tons of sediment from landslides were supplied to the Chehalis headwaters (upstream of the proposed FRE facility) during the 2007 flood, citing Watershed GeoDynamics [WGS] and Anchor QEA 2017. However, those numbers are not found in the cited document, and it is unclear where those numbers originated. 2. The RDEIS refers to 3.3-5 million tons of cobble and gravel material being delivered to the channel as a result of landslides. These numbers are inconsistent with WGS' formally published values for all sediments, see Table II in: Nelson and Dubé. (2016). 3. The numbers were not differentiated in the source study between upstream and downstream of the FRE location; the RDEIS appears to attribute all of it to upstream; 4. The RDEIS asserts without scientific support that there is still a "huge volume" of sediment stored in the stream valley and bed upstream of RM 104. In actuality, there is a significant quantity of bare bedrock in some of the reaches upstream of RM 104. The RDEIS's conclusions are suspect when it misapprehends the facts about the area it analyzes. Moreover, the RDEIS has a pattern of overestimating habitat potential in the upper Chehalis reaches leading to incorrect fish impact analysis, as well as

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				underestimating the transport capacity of the Chehalis River in 2-year flood events leading to incorrect observations about the proposed Project's downstream geomorphic, habitat, wetland, wildlife, and fish impacts. Incorrect descriptions like the one in this paragraph show that the picture that the RDEIS's is painting and its analysis are mistaken.
326	APPENDIX F: EARTH	5.2.1.2.2	Page 51, 4th paragraph	Incomplete analysis potentially leading to incorrect conclusion(s) | There is some error in extracting channel widths from older aerial photographs that are not georeferenced in space and are of variable resolution and picture quality. A rough estimate of digitizing error is that it was at least +/- 15 feet and possibly more (see Section 2.2.1.2 in Appendix J of the District's 2024 Revised Mitigation Plan). Many of the differences depicted in Figure F-11 therefore may reflect the digitizing error rather than a real physical change. This error is acknowledged briefly on page 55 (top paragraph), but the analysis then does not attempt to evaluate the effect of error on the results and corresponding conclusions drawn. This has bearing on inferring impacts to channel forming processes and off-channel habitats in Appendix E Fish. The FEIS should improve this analysis to avoid overstating fish impacts.
327	APPENDIX F: EARTH	5.2.1.2.2	Page 53, 1st paragraph	Basis for statement insufficiently defined | Quantitative evidence is not presented supporting the statement that "Following the 2007 flood, the channel has slowly been narrowing as vegetation grows on the gravel bars." This has been inferred in Appendix E Fish to be associated with attenuation of extreme flood flows leading to reduced habitat complexity. However, as discussed in Comment #329, #330, #335 and elsewhere in these comments, and as recognized in the RDEIS at pages 55 and 57, channel-forming flows are largely driven by lower-flow flood events (in the Chehalis, typically 2-year flows as in other gravel bed systems), and such flows are not regulated by the proposed Project.
328	APPENDIX F: EARTH	5.2.1.2.2	Page 53, 1st paragraph	Basis for statement insufficiently defined | Need details regarding how stored sediment volume and average bedload transport rates were calculated, how that resulted in concluding it would "likely take several decades," and whether that indicates the channel is presently (i.e., two decades later) near or at its pre-2007 condition, or that it will still take several more decades. This is important for context regarding impacts to available spawning habitat, and how much is actually available over the long term. It is part of a larger pattern in which the RDEIS seems to regard upper Chehalis habitat not as it is in current conditions, but as a more idealized version of habitat in which, for example, more spawning habitat and redds occur upstream of the proposed Project than below it (a fact demonstrated to be false by WDFW's redd mapping over several years, but nevertheless used in the RDEIS modeling).
329	APPENDIX F: EARTH	5.2.1.3	Page 57, last paragraph	Contradictory text | Elsewhere in the RDEIS, it asserts that the Project operations will adversely affect channel forming discharge. Those statements are refuted here, where the RDEIS correctly states: "Based on the analysis of migration rates between 1945 and 2013, it appears that channel migration takes place during even small peak floods in unconfined areas in response to flow against banks on the outside of meanders. This is consistent with research in other gravel bedded river systems that suggests flows of approximately 1.5-year to 5-year peak flow recurrence interval do the most "work" over the long term at controlling and maintaining channel form..."

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330	APPENDIX F: EARTH	5.2.1.3	Page 55, 3rd paragraph	Statement conflicts with other text and conclusions | "However, average channel migration rates during the other time periods did not correlate directly with the peak flow between photographic periods (Figure F-14), suggesting channel migration occurs even during small peak flows with a recurrence interval of 1 to 2 years." – These are characteristic channel forming flows in unconfined channels; thus the statement effectively contradicts subsequent claims of adverse impacts of FRE operations to channel forming discharge and off-channel habitat availability and accessibility.
331	APPENDIX F: EARTH	5.2.1.4	Page 58, 4th paragraph	Insufficient information provided | It is unclear if wood was cleared from the channel or primarily from the floodplain after the 2007 event, and where along the river clearing was performed. This is important for context regarding what constitutes a change from baseline conditions that can be attributed to the Project. Several impacts are attributed to the Project related to reducing large wood (often because the RDEIS discounts the proposed plan to use large woody material collected in flood events for habitat purposes). These impacts findings do note that the upper Chehalis is already wood-poor, and that the proposed mitigation offers a mechanism to retain large wood from catastrophic flooding in the river system rather than letting it be removed, as was done in 2007.
332	APPENDIX F: EARTH	5.2.1.4	Page 59, 1st paragraph	Statement conflicts with conclusions | "Additionally, large storms (such as the December 2007 storm) provide a key supply of LWM to the Chehalis. In the upper watershed, large wood is delivered by landslides and debris torrents. Landslides and debris torrents are critical mechanisms for nourishing the mainstem Chehalis and floodplain with the scale and volume of large wood necessary for meaningful aquatic habitat complexity." Along with resupplying the channel with gravel for spawning and channel forming processes, landslides are described here as a benefit in the context of the Chehalis River salmon population. Yet landslides associated with the FRE operation are concluded in the RDEIS to be a significant (implied adverse) effect. The FEIS needs to resolve this contradiction: if landslides are an important source of spawning gravel and LWM to the upper system, and occur naturally, they should not be considered significant adverse effects of the proposed Project.
333	APPENDIX F: EARTH	5.2.1.5	Page 60, 1st paragraph	Insufficient information/reasoning provided and not considering best available information to support conclusion of effect | It is unclear if the statement: "there is minimal published research on the effects of losing high peak flows in dammed systems" refers to flood retention (or, 'dry') dams specifically. There is a substantially greater amount of research literature on downstream effects of blocking dams vs. dry dams, which likely reflects a lower (and plausibly negligible) impact generally of dry dams historically. Note that dry dams are found in the United States and elsewhere; it is only the scale of the proposed Project that makes it unusual. In any case, there is an extensive history of publications in the geophysical and hydraulic engineering literature on the effects of dams and anthropogenic peak flow reductions on hydrology and channel form downstream in general and specifically for dry dams, and on flows needed to emulate the effects of channel forming flows. For example, see Sumi 2008: Graf 2006; Magilligan and Nislow 2005; Inbar 1990. The fact that the RDEIS is not aware of this body of literature might explain its erroneous conclusion, contrary to its own observations and Ecology's guidance on ordinary

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				high water marks, which reducing major and catastrophic peak flows will interrupt channel-forming processes. The FEIS should abandon this unsupported conclusion and make the necessary changes to its impacts analysis in this and all other discipline reports.
334	APPENDIX F: EARTH	5.2.1.5	Page 61, 2nd paragraph	Basis for statement insufficiently defined and conflicts with other text | The statement that "Major avulsions that occur with large-magnitude floods have a key role in maintaining the long-term dynamic between creation and loss of off-channel habitats" ignores that major avulsions that maintain off-channel habitats also happen during smaller floods and contradicts statements elsewhere that smaller floods can be associated with channel migration. It is unclear what that role is, how it works, and what "maintaining the long-term dynamic between" means.
335	APPENDIX F: EARTH	5.2.1.5	Page 61, 3rd paragraph	Incorrect basis for conclusions of impact | The premise in the EIS behind what comprises a channel forming flood is flawed and thus all conclusions based on postulated changes in channel forming floods and corresponding impacts are unsupported; key counter arguments include: 1. Ecology defines channel-forming flood/bankfull discharge as that flow occurring "…at the maximum product of flow frequency and sediment transport." See Ecology, Determining the Ordinary High Water Mark for Shoreline Management Act Compliance in Washington State, No. 16-06-029, at 33 (Oct. 2016), available athttps://apps.ecology.wa.gov/publications/documents/1606029.pdf. The definition in the RDEIS is inconsistent with Ecology's definition. 2. Ward et al. (2002) is used incorrectly as a supporting primary citation and is not an appropriate reference nor basis for defining what is a "channel forming discharge" because no analyses, neither empirical or theoretical, were performed evaluating the nature of channel forming discharge, and they did not identify 10- to 25-year floods as an important channel forming framework. The paper is a broad conceptual framework discussion piece only. Neither are the other citations in this section as they are also essentially conceptual framework discussions. 3. While the greater stream power of individual events within the 10- to 25-year and longer recurrence interval flood range might affect bedrock channel morphology more effectively than individual, more frequent peak flow event magnitudes, because of the controlling influence of rock strength on erosion rate, the corresponding time scale for resulting changes in channel form is much longer than for an alluvial or bedrock-alluvial river channel and the FRE facility lifespan; see the following examples: Wohl. and Merritt (2001), Wohl and David (2008). Instead, research indicates that frequent flows are more impactful on channel form in bedrock-alluvial channels over timeframes relevant to assessing impacts of FRE facility operations. For more thorough accounts, see examples: Blom et al. (2017); Wohl and Wilcox (2005); Wohl and David (2008). Therein they show through data that the infrequent events are less important for channel forming purposes than the frequent event, consistent with Wolman and Miller (1960) and Ecology's definition. 4. Kleinschmidt (2024) determined via sediment transport modeling that the 2-year flood cumulatively transported orders of magnitude more sediment than the 10-year or 100-year floods, but this was not acknowledged in the RDEIS.

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				5. Wohl et al. (2015) is also used incorrectly as a supporting citation – the premise of that conceptual framework paper is that it is important to maintain sediment continuity downstream. The bedload transport modeling performed by Kleinschmidt (2024) indicates that such continuity will be maintained with the Proposed Project.
336	APPENDIX F: EARTH	5.4.1.1	Page 62, 1st paragraph of section	Not considering best available information | The statement that "This calculation does not include any root strength factor from shrubs or trees on the hillslope, which would contribute to increased slope stability as vegetation grows but would not contribute when vegetation dies off after inundation events" ignores the time lapse between inundation/drawdown and loss of root strength. As an analog, root strength is maintained for several years after clearcutting before a landslide occurs. Also, vegetation has not appeared to die off at Mud Mountain Dam as evidenced by historic aerial photographs on Google Earth.
337	APPENDIX F: EARTH	5.4.1.2.1	Page 63	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | The section pertains to the fate of suspended washload (fine silt and clay particles) entering the temporary inundation area, depositing, and being resuspended. The basis/supporting arguments behind each assumption in this section are missing, however, and some assumptions may be wrong that affect the results. For example, in the cited reference for the model (Anchor 2019), the suspended sediment settling velocity was assumed to be 0.1 m/day based on a 2014 geomorphology report. Representative settling rates for quartz clay and fine silt in still water are on the order of 0.1 m/day and 10-20 m/day, respectively. The starting fraction/concentration of silt and clay in the water column, and corresponding volume of sediment deposited, are not specified, and it is possible very different quantities of each fraction are resuspended by wave action and returned to the river. Any conclusions based on the analysis of effects are thus equivocal. Moreover, because this model is from 2019, it by definition could not consider any differences occasioned by the 2024 Revised Project Description and proposed mitigation plan. For example, the project moved upstream somewhat and its design was refined, affecting the size and shape of the temporary inundation area and perhaps its drainage of the temporary pool. Plus, it included a Vegetation Management Plan that would manage vegetation within the temporary inundation area. These things may affect the modeling of settling and resuspension of particles, but they were not considered because the model was not updated. Regrettably, the old model (including the assumptions and uncertainties described at the outset of this comment) was replicated without correcting those issues.
338	APPENDIX F: EARTH	5.4.1.2.1	Page 63	Basis for statement insufficiently defined and conflicts with other text | Explanation is missing regarding how wave action in regular reservoirs, where there is no vegetation below the full pool level to begin with, would be relevant to the FRE where there is still vegetation cover after the water level drops. The third paragraph recognizes this, yet it is discounted in the preceding paragraphs. Any conclusions based on the analysis of effects are thus equivocal.

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339	APPENDIX F: EARTH	5.4.1.2.2	Page 64, 1st and 2nd paragraphs	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | The WEPP modeling assumed sand-sized particles are deposited within 200 feet of the river, but support for this assumption is not provided, and closer examination indicates that it is not a reasonable assumption. The settling velocity of sand in quiet water ranges around 100-2,000 m/day depending on size. In addition, the channel is confined and entrenched, where the width of channel conveying suspended sand is much narrower than 200 feet on either side of the channel. As a consequence, most if not all suspended sand arriving at the head of the temporary inundation area can be expected to deposit in the vicinity of the channel bottom, not the side slopes, and remain mostly within the channel. The effects are thus likely incorrect and overstated.
340	APPENDIX F: EARTH	5.4.1.2.2	Page 64, 3rd paragraph	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | 1. Irrespective of whether the 200 feet deposition zone assumption is reasonable, there are issues with the WEPP hillslope model component used that preclude using it to quantitatively estimate erosion associated with a temporary impoundment with any confidence or expectation of realism. It is a 'black box' web-based interface with predefined overly broad parameters that estimates rill and inter-rill erosion for an assumed disturbed soil condition. Whether (and extent to which) the parameters embedded in the interface are applicable to the temporary inundation zone was not evaluated in the SEPA EIS. To the extent that can be inferred from NRCS and USFS websites, the soil erodibility data used to calibrate WEPP parameters were primarily from agricultural crop lands rather than forested hillslopes, and the data used to calibrate forested runs had prediction errors in suspended sediment concentrations in the receiving stream that were larger or smaller than measured by up to about a factor of 10 (e.g., https://www.fs.usda.gov/rm/pubs_other/rmrs_2006_conroy_w001.pdf). 2. There is no information on how the vegetation management plan was interpreted and parametrized in using the USFS web-based WEPP interface, particularly with respect to what the distinction was between flood-tolerant vs. non-flood tolerant in terms of erosion mechanisms, and how the difference affects calculated erosion rate. Any conclusions based on the analysis of effects are thus equivocal.
341	APPENDIX F: EARTH	5.4.2.1.2	Page 68, 2nd paragraph	Updated operations | Appendix N (Water) used flood operations developed by Anchor QEA in 2017 in its operations analysis. The Applicant has refined the operations since that time. Please see the Debris Management and Reservoir Operations Technical Memoranda, each attached along with these comments. The revised operations proposes a shorter-duration debris management period at a lower elevation; the inundation pool also tends to fill to a lesser extent and draws down faster. These changes would affect modeling predictions representing primarily fine sediment impacts, which may lead to different conclusions in the Earth and Fisheries discipline reports. The FEIS should consider the new information.
342	APPENDIX F: EARTH	5.4.5	Page 71	Insufficient information/reasoning provided to support conclusion of effect | 1. The statement, "…streamflows necessary for most channel-forming processes are reduced…" is unclear regarding what the specific "channel-forming processes" are, what the mechanisms are whereby they are influenced by flow, how they are influenced, and at

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				what flows. It is furthermore unclear what level/amount of change is considered adverse, and why, and what is meant by “necessary." 2. Similar information is missing for the statement, “This reduction in peak flows, and corresponding reduction in large wood and sediment transport, would directly impact creation of habitats that depend on those channel-forming processes.” In actuality, the proposed Project does not regulate the channel forming flows, which are more frequent than major and catastrophic flood flows. Moreover, the RDEIS’s analysis ignores that flood conditions vary. In the period of record, some occasions when the Grand Mound gage flows have not exceeded 38,800 cfs have nevertheless had very high flows at the Doty gage. (November 2012 saw 22,300 cfs at Doty and only 27,000 cfs at Grand Mound, per USGS data) So, sometimes very high flows will occur above the Newaukum River confluence, even with the proposed Project. There is no basis to conclude that channel forming processes will be halted.
343	APPENDIX F: EARTH	5.4.5	Page 71, 4th paragraph	The RDEIS wrongly concludes that “During FRE flood operations, streamflows necessary for most channel-forming processes are reduced. This reduction in peak flows, and corresponding reduction in large wood and sediment transport, would directly impact creation of habitats that depend on those channel-forming processes.” First, as discussed elsewhere in these comments, and as concluded by RDEIS Appendix F itself at pages 55 and 57, channel-forming processes occur at smaller flows—typically the 2-year flows in the Chehalis as in other similar systems—than the Project would regulate. Second, the RDEIS consistently underestimates the system’s sediment transport capacity, ignoring again that lower, more-frequent flows than major flood flows can mobilize sediment and do most of the “work” (using the RDEIS’s words!) to create such habitat, such as by causing avulsions. There are ecological parallels to the 2-year flood’s geomorphic significance, as well. Wetland habitat, for example, under National Research Council guidelines is typically defined with reference to 2-year hydrology, so a wetland dependent on riparian flooding would have to be inundated by 2-year flood flows. Thus, lower, more frequent flood flows both form the channel and contribute to important habitat formation processes. Third, the upper Chehalis is a wood-poor system, and the wood entering the system during major and catastrophic floods has historically been cleaned up or removed, as it was following the 2007 flood. The proposed Project includes mitigation plans to use large wood collected in such storms for habitat mitigation or restoration, thereby preserving its presence in the river. During normal, non-flood operations, the Project proposes to pick up large wood that collects upstream of the facility and place it downstream. As a result, the conclusion above fundamentally misunderstands the Chehalis River system it analyzes and ignores aspects of the project Proposal. The FEIS should abandon the flawed reasoning above and remove the repeated references in this and other discipline reports, the main RDEIS document, and the Summary to disruptions to channel-forming

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				flows or the wetlands, wildlife, and fish impacts such disruption will create. These are not probable impacts of the Project.
344	APPENDIX F: EARTH	6.2.1.1	Page 72, second paragraph	The RDEIS states "Soil would be disturbed to construct the FRE facility, and up to 13.8 miles of unpaved access road would be widened for quarry and construction access." The District has refined quarry demand and anticipates using the same number of quarries with fewer roads. The Main document section 2.3.3.1, pg. 16 and Appendix 1 section 3.2.6 pg. 37 of this RDEIS correctly state that no more than 2 quarries with no more than 80 acres of total disturbance for the quarries are included in the Proposed Action. The above-quoted language should therefore be revised to state: “pending quarry selection, up to 6.2 miles of unpaved access road would be widened for quarry and construction access.”
345	APPENDIX F: EARTH	6.2.1.1	Page 73, 6th paragraph	Insufficient consideration of mitigation actions | Impacts would be localized at the site and mitigated offsite.
346	APPENDIX F: EARTH	6.2.1.1	Page 73, 5th paragraph	Insufficient consideration of mitigation actions | Mitigation of channel impacts within FRE construction footprint will occur offsite. It is physically impossible to mitigate channel changes by actions directly within the construction footprint.
347	APPENDIX F: EARTH	6.2.2.1.1	Page 74, 1st paragraph	Incorrect terminology | Use of the term “period of record flows” is not correct. In the 2020 draft EIS, a 30-year flow time series was synthesized for scenarios, which corresponds to a portion of the period of record.
348	APPENDIX F: EARTH	6.2.2.1.1	Page 74, 1st paragraph	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | regarding last sentence: The inflow doesn’t continuously exceed outlet capacity once the conduit become pressurized – the condition is temporary until sufficient head occurs to maintain a pressurized outflow equal to the inflow as the hydrograph is rising; on the falling limb of the hydrograph, the outflow temporarily exceeds the inflow until the open channel flow capacity is reached through the conduits. Modeling indicates the duration of the effect is on the order of hours, not days.
349	APPENDIX F: EARTH	6.2.2.1.1	Page 76, paragraph 2	It states the reservoir drainage rate will be 2 ft/day for 2 weeks, but this has been further developed since the RPDR. The draft Debris Management During Flood Retention Report (Attachment 1 to Attachment 2: Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum) reports it will take up to 5 days for the 100-year flow to remove LWM based on Mud Mountain Dam operation rates. The drainage rate is not specified and can be increased from 2 ft/day depending on what elevations are available for navigation by log broncs and work boats and how much LWM is left to store.
350	APPENDIX F: EARTH	6.2.2.1.1	Page 76, 4th paragraph	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | 1. The premise that “Cobble, gravel, and coarse sand would be deposited in deltas…” is likely incorrect – the Chehalis River in the temporary impoundment reach is generally entrenched such that a delta, which represents an expanding depositional surface, cannot typically form; instead, coarse sediments would be expected to remain deposited in the channel as a depositional layer.

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				2. Fine sand has a fall velocity around 1.5 cm/s, which equates to settling out in 3-4 minutes in 10 feet of still water. Most fine sand should be expected to settle out within and near the channel. Most sediments depositing away from the channel would be expected to be clay and silt. 3. The likelihood of a turbidity current forming is not identified, where the denser, sediment laden water flowing into the temporary inundation area continues along the channel bottom (e.g., Cesare et al. 2001). This would tend to reduce the volume of sediment depositing away from the channel. It could also induce a hydraulic gradient across redds that maintains transport of oxygen to and metabolic waste products from developing salmonid embryos during the temporary impoundment and could be associated with reduced turbidity levels later during drawdown compared with the fully mixed water body assumption.
351	APPENDIX F: EARTH	6.2.2.1.1	Page 76, 6th paragraph	Analyzing effects based on outdated operations | The estimate of 32+ days for the temporary inundation pool to completely empty reflects the 2017 operation plan that assumed 2 weeks for debris removal. The basis for the 2 weeks for debris removal was operations at Mud Mountain Dam and an assumed shore collection point location for off-loading and storing wood collected by boat. This does not reflect planned operations for the FRE, in which a lower elevation collection point closer to the FRE is likely, and a shorter expected duration of wood debris collection ranging up to 5 days (Wood Management TM). Under the plan being developed by the District, the maximum time to drain has been observed via modeling of the 9 historic floods that would trigger operation would be less than 21 days. The Applicant requests that the description of the debris management during flood retention operation be updated and the impact analysis be revised in the FEIS per the recent refinements documented in Attachment 2: Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum to these comments.
352	APPENDIX F: EARTH	6.2.2.1.1	Page 76, 6th paragraph	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | See Comment #337, 1st and 2nd paragraphs regarding assumption that “Coarser sand-sized particles would likely remain on the hillslopes” – those sizes are unlikely to deposit on the hillslopes in the first place. The purported effect is overstated and based on an incorrect assumption.
353	APPENDIX F: EARTH	6.2.2.1.1	Page 76-77, 7th paragraph, and exposition on Page 78	Unsupported analysis of effect and assumptions likely incorrect | The basis given behind assuming landslide potential is associated with drawdown after temporary inundation is lacking and may not be supported by equating to Mud Mountain Dam (MMD) or by literature. The terrain inundated by MMD (alluvial deposit and Osceola Mudflow geologic units) is very different from and more erodible than the hillsides that would be temporarily inundated during FRE operation (Tertiary extrusive volcanic rocks with sedimentary rock interbeds). Conversely within the literature, while the potential for unvegetated bank sloughing during deep drawdowns has been identified as a potential effect in the USACE's draft 2025 SEIS for Willamette Project reservoirs, shallow-rapid landslides above the waterline were not identified as a concern. More specifically, during rapid (e.g., 6 days) winter drawdowns in Fall Creek reservoir, erosion of unvegetated, deposited sediments appears to be the primary source of fine sediments downstream; initiation of landslides was

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				not identified as a concern (cf. Keith et al. 2024). The RDEIS provides no other evidence of shallow-rapid landslides occurring along the margins in reservoirs in the Washington and Oregon Coast Range that are drained rapidly (e.g., for juvenile salmon outmigration or sediment maintenance). Instead, it appears that the presumed physical processes of landslide initiation with water level drawdown are being conflated with riverbank collapse with falling river stage and with delayed slope instability after clearcut harvests, both of which are different in nature. The RDEIS's assumption that there is an increased landslide potential associated with temporary inundation drawdown is unsupported and leads to inaccurate and potentially misleading conclusions regarding potential Project impacts that are not consistent with the science.
354	APPENDIX F: EARTH	6.2.2.1.1	Page 77, 10th paragraph	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | The RDEIS does not provide a basis for assuming there would be temporary loss of root strength after temporary inundation. Root structure would likely still be present for an extended period before it decomposed sufficiently for loss of integrity. Historic aerial photography of the Mud Mountain Dam temporary impoundment area indicates vegetation on hillside, terrace, and riparian surfaces has persisted despite periodic temporary inundation. This analysis should be revised to reflect that root structure is expected to persist for extended periods.
355	APPENDIX F: EARTH	6.2.2.1.1	Page 79 wave erosion, 2nd paragraph	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | It is unclear if the 8,470- and 143,000-ton figures for the total amount of clay and fine silt are an estimate of what might have been deposited, and if so, how they were estimated. Relevant information includes the estimated inflow of suspended sediment over the period of inundation in tons per day, the estimated duration of inundation, what fraction of the inflow is composed of clay and fine silt by weight, what fraction is suspended over hillside and terrace areas, and of that, what fraction remains in suspension. Furthermore, it is unclear how the resuspended material is assumed to be transported downstream over time, whether it would occur all at once, progressively, or other pattern. Inferences of effect are therefore equivocal.
356	APPENDIX F: EARTH	6.2.2.1.1	Page 79-80 Surface erosion	Unsupported analysis of effect and assumptions likely incorrect | See Comment #339 and #340 on Section 5.4.1.2.2. The assumptions in the analysis are not supported and likely incorrect.
357	APPENDIX F: EARTH	6.2.2.1.1	Page 80-86 sediment transport	Insufficient information provided supporting validity and utility of model | It is unclear the extent to which the 2020 SEPA DEIS HEC-RAS model was modified for the 2025 DEIS analyses, and why/how they differed from each of the modifications that were implemented in the District's analyses (cf. Kleinschmidt 2024, which showed how the RDEIS modeling could end up with very different results depending on how the model is configured).
358	APPENDIX F: EARTH		Page 83 Figure F-18	Not considering best available information, inconsistency with other text, unfounded conclusions | This figure and conclusions based on it contradict/ignore fine and coarse sediment transport modeling and spawning gravel mapping performed by District indicating that the upper Chehalis River is generally transporting sediments that accumulated during the catastrophic 2007 input event downstream, where transport capacity exceeds supply.

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				Accordingly, the long-term cumulative storage increases predicted in the RDEIS within the ~6-mile reach upstream of the proposed FRE location over time is highly unlikely for existing conditions and therefore wrong. Similarly, the predicted long-term decrease in cumulative sediment storage downstream is also highly unlikely and therefore wrong. These predictions are furthermore inconsistent with (i) the comment in Table F-8 that the river is "currently still reworking 2007 sediment input;", (ii) the first paragraph on page 53 that concludes with "…it will likely take several decades for the channel to return to pre-2007 coarser substrate and channel conditions;" and (iii) the note in Section 5.4.2.1.4 regarding the model predicting unrealistic deposition. Given the model predictions are unrealistic, conclusions regarding significance of an impact and whether it is adverse that are based on the predictions are unfounded.
359	APPENDIX F: EARTH		Page 84 Figure F-19	Incomplete analysis of effect and potential for misinterpretation leading to incorrect conclusion(s) | This figure indicates that the modeling is predicting storage primarily of fines and sand outside of the channel, but this point seems to have been missed in the RDEIS. In particular, the modeling is predicting that the river is capable of transporting gravel and cobble downstream with negligible storage predicted, but the reverse is predicted for fines and sand. That is illogical. Because of this inconsistency, the modeling predictions should not be relied on for inferring direct impacts of fines to fish in the channel. Furthermore, the process of floodplain storage of fines is generally considered beneficial for floodplain maintenance/evolution and to provide a future vegetation growth medium.
360	APPENDIX F: EARTH		Page 85 Figure F-20	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | 1. The text on p. 82 accompanying this figure is inconclusive. 2. Analysis is missing regarding how predictions of grain size compare to field data along the length of the river, which is important for interpreting the results and demonstrating model accuracy. Given the issue identified regarding inaccurate predictions of deposition, the predictions of grain size are also likely to be inaccurate and not representative.
361	APPENDIX F: EARTH	6.2.2.1.3	Page 86, 2nd paragraph	Conclusion inconsistent with analysis | With regard to fine sediment deposition, the RDEIS concludes that "These impacts could be detrimental to fish and aquatic habitat by increasing fine sediment deposition in the riverbed (substrate)." However, the model predicts that fine sediment deposition will be primarily outside of the channel. This is consistent with a finding that there will be negligible impacts to aquatic habitat in the riverbed, not that the impacts "could be detrimental." This finding should be revised to be consistent with the modeling results.
362	APPENDIX F: EARTH	6.2.2.1.4	Page 86-87, Figure F-21	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | Given that reach grade in the mainstem above the FRE is controlled by exposed bedrock, it is unlikely that the Project could result in an incision in the first place. The modeling results, which appear to be incorrect, are likely the outcome of assumptions regarding scour depth limiting parameter value in HEC-RAS model, not a physically representative simulation.
363	APPENDIX F: EARTH	6.2.2.1.5	Page 88, 2nd paragraph	Insufficient information provided | It is not described in the RDEIS whether the wood that entered the channel during the 2007 flood was removed mechanically or by high flows, and whether the wood was removed from the channel or the floodplain. This is critical for

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				characterizing typical baseline conditions against which effects and mitigation should be compared, and whether there is a lot of wood typically in the channel or not. Generally, there is not, but this paragraph implies the 2007 event is the reference condition.
364	APPENDIX F: EARTH	6.2.2.1.5	Page 88, 3rd paragraph	Insufficient information/reasoning provided to support conclusion of effect | The statement "…few trees can be expected to survive inundation…," is non-specific about how long different species could survive and ignores the mitigation plan where flood tolerant species would be planted.
365	APPENDIX F: EARTH	6.2.2.1.6	Page 89, 2nd paragraph	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | 1. A 2-year flood can be associated with greater channel migration than a 10-year or larger flood event. During FRE operation, what would be a shorter duration extreme event could be transformed to a longer duration intermediate event with greater net channel migration. This beneficial environmental effect of the Project should be evaluated in the RDEIS. 2. Bank stabilization by riparian vegetation is generally considered to be a beneficial effect.
366	APPENDIX F: EARTH	6.2.2.1.6	Page 89, 3rd paragraph	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | Channel avulsions can and do occur at the 2-year flood, at which flow the wood collected in the temporary impoundment and placed downstream during Project flood operations would still be available to form jams, similar to existing conditions.
367	APPENDIX F: EARTH	6.2.2.1.6	Page 89, 5th paragraph	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | The RDEIS states that sediment deposition "in the form of deltas" would occur within the temporary inundation area (between RM 115 and RM 108) during flood operations. However, deltas typically do not form inside an entrenched channel. See Comment #350 on Section 6.2.2.1.1.
368	APPENDIX F: EARTH	6.2.2.1.7	Page 90-91, 5th paragraph	Incorrect basis for conclusions of impact | Following the Comment #329, #330, and #335 on Section 5.2.1.5, the premise and conclusions that FRE operation would adversely affect channel forming flows are flawed.
369	APPENDIX F: EARTH	6.2.4	Page 92, 2nd paragraph	Not considering best available information | The basis of design described in Appendix J in the District's Revised Mitigation Plan addressed and confirmed the technical feasibility of the proposed mitigation actions, in terms of both function and persistence. Cost estimates indicate that the cost of mitigation is less than that spent in the ASRP, so the measures should be economically feasible. The projects were sited at locations where the willingness of landowners is likely high based on initial interactions and circumstances.
370	APPENDIX F: EARTH	6.2.5	Page 93	Not relying on best available information, relying on flawed analyses, insufficient information/reasoning provided | The bullets are vague, overly generalized, and not substantiated both technically and with respect to how the conclusions were arrived at following the incorrect assertion that the proposed mitigation may not be technically feasible and economically practical. The RDEIS needs to explain its reasoning for why not, what the specific corresponding effects are, and how that leads to making these conclusions.

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APPENDIX G: LAND USE				
371	APPENDIX G: LAND USE	2.4.2.1	Page 27, First Section	Appendix G cites the updated structure inventory described in Anchor QEA 2025 'Memorandum to: Nate Kale, Office of Chehalis Basin; Ken Chalambor and Jenn Tice, Ross Strategic. Regarding: Structure Database and Finished Flood Elevations – Updated October 2025.' It states that the database includes 14,784 structures within the land use study area. The Anchor QEA 2025 Memorandum identifies 18,882 structures. This raises concern about consistency and appropriate identification and tracking of structures that are impacted by flooding and subsequently removed from the floodplain through FRE operations under current and future climate conditions. This potentially incomplete structure database is then carried into the analyses described in Section 3.2.2.1.3.
372	APPENDIX G: LAND USE	3.2.1.1.1	Page 30, first full paragraph	The RDEIS is mistaken in concluding that the proposed Project is inconsistent with the Lewis County land use policies. It appears to be relying on outdated code that was updated when Lewis County finished its Growth Management Act periodic update in 2025. The project site is designated as Forest land in the Lewis County Comprehensive Plan and is zoned as forest resource land. *See* Lewis County Comprehensive Plan at 28, *available at* https://lewiscountywa.gov/media/documents/Volume1_CompPlan_ysRfkKW.pdf; LCC 17.30.430. Such land allows "rural government services" with an administrative approval, LCC 17.42.020, which means "those governmental services historically and typically delivered at an intensity usually found in rural areas" of Lewis County, LCC 17.10.180. Lewis County's rural area already has two large traditional dams operated by a government entity for many decades (the Mayfield and Mossyrock Dams, operated by Tacoma Power). Therefore, this Project is a use permissible within the zoning. The FEIS should withdraw this significant adverse impact finding.
373	APPENDIX G: LAND USE	3.2.1.1.1	Page 30, second to last paragraph	The RDEIS is mistaken in asserting that the proposed Project would conflict with Lewis County Shoreline Master Program (SMP) policies. The SMP includes flood hazard prevention as one of its goals. Lewis County SMP 2.09. An entire section of the SMP is dedicated to flood hazard management policies and regulations. SMP 4.05. New structural flood hazard management measures are permittable as shoreline modifications. SMP 4.05.02.G. In-water shoreline modification structures are permittable as conditional uses in Rural Conservancy shoreline areas, which is the Project site's designation, SMP 6.01.01 Table 6-1, and there is a specific set of regulations for structural hazard flood reduction measures. SMP 6.08. In short, the Lewis County SMP has many provisions that allow and regulate facilities like the proposed Project, which the project will simply follow in the permitting process. The RDEIS's reliance on other reports to conclude that such a permit would be impossible to is misplaced: those other reports decline to credit the project's mitigation plans, leaving such details to permitting. Here, the RDEIS has identified the permits necessary and the constraints they would place upon the project to mitigate its impacts. The permit requirements are not uncertain; the FEIS should analyze them as it does for BMP and other permit requirements, conclude that they would mitigate the project or else it cannot be built, and withdraw this significant impact finding.

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374	APPENDIX G: LAND USE	3.2.2.1.3.1	Table G-10a and Table G-10b	It is not possible to verify the values with the data the state supplied. The District attempted to recreate the RDEIS's analysis and could not do so; it found a significantly higher structure count using the methods described in the document.
375	APPENDIX G: LAND USE	3.2.2.2.3	Page 53	The discussion on the possibility that the "full extent of the buildable area downstream of the FRE facility could be utilized…" if removed from the threat of a catastrophic flood and a finding of significant impact is extremely misleading. Changes to FEMA's SFHA area are developed in coordination and partnership with the local community. Local communities get a say in how development occurs in their floodplains. Development would not likely occur in a vacuum based on a FEMA map and no other awareness of risks and threats in a watershed. Development is allowed in both the 100-year and 500-year floodplains, so long as the regulatory floodway is maintained. Local communities that participate in the National Flood Insurance Program are required to adopt and maintain floodplain ordinances in alignment with federal standards for that development as a minimum (many communities across Washington and the United States adopt much more stringent ordinances for floodplain development, as is their right). The SFHA is also defined by the 100-year flood event, which is not being used in this study (favoring instead the "major" and "catastrophic" floods). It is noted that the return interval of both of those flows goes down (less than the 100-year event) in future climate, meaning those flows do not and cannot represent what the SFHA will look like in the future. In short, it is a logical stretch to assume that a reduction in floodplain footprint would lead to additional development that would then be at risk.
APPENDIX I: PUBLIC SERVICES & UTILITIES				
376	APPENDIX I: PUBLIC SERVICES & UTILITIES	2.2.2.2	Page 9, 4th paragraph	(The Chronicle 2018) is referenced in body of appendix but not listed in references section of appendix.
377	APPENDIX I: PUBLIC SERVICES & UTILITIES	2.2.2.2	Page 10, 2nd paragraph	(Greater Grays Harbor Inc. 2019) is referenced in body of appendix but not listed in references section of appendix.
378	APPENDIX I: PUBLIC SERVICES & UTILITIES	3.2.1.1.1	Page 15, 3rd paragraph	As accurately stated in Appendix 1 Section 3.2.3, maintaining "uninterrupted water supply to the town of Pe Ell during construction of the FRE facility" is part of the project. No evidence has been presented in this EIS or in the information provided by the Applicant that indicates maintaining an uninterrupted water supply to the town of Pe Ell is infeasible. Further, no description or technical discussion is provided in the EIS explaining what "reinforcing the water line in-place" is or entails. Additionally, there are multiple ways in which uninterrupted water supply can be provided to the town of Pe Ell besides "reinforcing the water line in-place." Also, it is inaccurate to describe means of maintaining uninterrupted water supply to Pe Ell, such as "reinforcing the water line," as mitigation as the information provided by the applicant and this EIS (App. 1 Sec. 3.2.3) identify providing

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				uninterrupted water supply to Pe Ell as part of the project. For these reasons, the EIS inaccurately identifies the construction of the FRE as having a significant adverse impact on the town of Pe Ell's water supply. The adverse impact to the town of Pe Ell's water supply should be identified as less than significant.
379	APPENDIX I: PUBLIC SERVICES & UTILITIES	3.2.1.1.2	Page 15, 3rd paragraph	Seems inconsistent. Above it says the Pe Ell waterline may require an "extensive" relocation which would have a significant adverse impact, but here utility relocations are considered less than significant. In both cases, it seems too early to tell what relocations would look like. "Extensive" is not well defined.
380	APPENDIX I: PUBLIC SERVICES & UTILITIES	3.2.2.1.1	Page 17, last paragraph	Please see the comments to the Environmental Justice Discipline Report noting that listing a catastrophic earthquake failure of the facility is so improbable that it is not a credible risk under industry standards. Moreover, it is anomalous to list this extremely improbable risk without also noting that reducing major and catastrophic flooding improves public services and utility availability during large flood events. It prevents power outages, allows service provides better transportation access to those who need services, reduces emergency response call volumes, and prevents contamination of public water supplies (and contamination from public sewer treatment facilities). The environmental benefits of the facility acting as it is designed to do are so much more likely than the impacts described here that the benefits should be discussed.
381	APPENDIX I: PUBLIC SERVICES & UTILITIES	3.2.4	General comment for section	Dam safety standards used in design should be listed as a form of permit-required mitigation.
APPENDIX J: RECREATION				
382	APPENDIX J: RECREATION	2.2.2	Page 8, last paragraph/ Page 9 first paragraph	(Lewis County Sirens 2018) is referenced in body of appendix but not listed in references section of appendix.
APPENDIX K: TRANSPORTATION				
383	APPENDIX K: TRANSPORTATIO N	3.2.2.1.1	Page 28, paragraph 4	States there is one debris management storage area previously operated by Weyerhaeuser and it will be accessed by the FR 1000 route. This has been further developed since the RPDR. It also states the woody material would be removed by truck. In the draft Debris Management During Flood Retention Report (Attachment 1 to Attachment 2: Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum) there are two debris storage areas. It is unspecified how the LWM will be transported off-site.
384	APPENDIX K: TRANSPORTATIO N	3.2.2.1.3	Page 42, first paragraph	The RDEIS's modeling notes that I-5 would be flooded for considerable duration in the late-century (40-60 hours, depending on climate scenario) even with the proposed Project. The District is performing hydraulic and hydrologic analysis to recreate the conditions the RDEIS notes and will continue to refine the design to serve the project purpose and need.

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				Under current consideration is the possible addition of a floodwall on the east edge of I-5, which would help alleviate such flooding. Such a floodwall would be similar to, though less impactful than, a Local Actions Alternatives floodwall proposed in the area just west of I-5, which is analyzed in the RDEIS. The proposed location on the east side of I-5 would be shorter, less expensive, and less environmentally and culturally impactful to construct that the proposed local Actions Alternative floodwall because the eastside floodwall could be a shorter I-wall instead of a taller T-wall and would be in an already-disturbed highway area.
385	APPENDIX K: TRANSPORTATIO N	3.2.5	Page 87, last paragraph on page	The Transportation Discipline Report finds no significant and unavoidable adverse impact from the proposed Project, and in fact analyzes the potential transportation benefits of the proposed project at length. This is a model of how the FEIS should consider the project benefits when they are relevant to determining its environmental impacts.
APPENDIX L: TRIBAL				
386	APPENDIX L: TRIBAL	Summary	Page v, Table L-1, 1st row and 5th row (and subsequent duplicate mentions)	This table makes reference to the ongoing NHPA Section 106 process that should be explained above it in clear terms, including its identification of tribal resources, assessment of project effects, and consulting on ways to avoid, minimize, and/or mitigate adverse effects with the consulting parties. The FEIS should defer to the Section 106 process, as well as the Corp's government-to-government consultation with Tribes.
387	APPENDIX L: TRIBAL	1.1	Page 1, first paragraph	It is unclear why only two Tribes are included in this Tribal Resource Discipline report when the Cultural Resources report includes more tribes in the scope of that report. Explanation should be added or a correction made, especially because the Cowlitz Tribe is actively participating in Section 106 consultations.
388	APPENDIX L: TRIBAL	1.1	Page 1, first paragraph	The study area is not well defined. The study area for other impacts does not automatically translate into the tribal or cultural contexts. The FEIS will need to explain how the study area relates potential project impacts (i.e., physical, visual, auditory, and atmospheric impacts). The scope of "tribal resources" is defined to include "collective rights and access to traditional territories" yet this study does not include analysis access and does not include data relating to property ownership.
389	APPENDIX L: TRIBAL	1.2	Page 3, last paragraph	Please list which Tribes the USACE is consulting with under NHPA Section 106. It is prudent to include the full list of consulting Tribes, who are included in the Section 106 emails for this Project. It may also be useful to note that the Cowlitz Indian Tribe, Quinault Indian Nation, and Confederated Tribes of the Chehalis Reservation have all be active participants in such consultation. Additionally, the Corps' government-to-government consultation with Tribes should also be included.
390	APPENDIX L: TRIBAL	1.2	Page 4, first paragraph	Because it is not yet clear from the USACE's assessment whether or how the project would impact Tribal treaty rights, please re-phrase the sentence as follows: "The Corps is expected to assess potential impacts of the Proposed Action on Tribal resources, including potential impacts related to Tribal treaty rights, if any." Tribal sovereignty is outside the scope of the proposed Project's effects. The FEIS should omit references to sovereignty, which is not challenged by the proposed Project.

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391	APPENDIX L: TRIBAL	1.2	Page 4, fourth and fifth paragraphs	Although the District does not object to the discussion of the North of Falcon process or the culvert decision, this background discussion does not outline a nexus to this proposed project. Discussing such a nexus is a difficult issue that unnecessarily wades into the prerogatives of the U.S. Government and Tribes. For the FEIS, it might be better to defer to the Corps on this issue instead.
392	APPENDIX L: TRIBAL	2.2.2	Page 13, Table L-5	The District has no objection to quantifications of the Quinault's annual catch, but the RDEIS does not explain how the table data fit into the study area or the RDEIS's analysis of impacts. Discussing such a nexus is a difficult issue that unnecessarily wades into the prerogatives of the U.S. Government and Tribes. For the FEIS, it might be better to defer to the Corps on this issue instead.
393	APPENDIX L: TRIBAL	2.2.2	Page 14, Table L-6	Please see Comment #392, which applies equally to this table.
394	APPENDIX L: TRIBAL	2.2.4	Page 15, Table L-7	The FEIS should specify which of the listed species are in the study area to illustrate which could be potentially affected by the proposed Project.
395	APPENDIX L: TRIBAL	2.3	Page 18, bullet list	This list includes a work by Shannon et al. from 2019, which is cited elsewhere in the RDEIS as well. Although the Shannon et al. 2019 study may provide some background, it was reportedly not considered sufficient by consulting Tribes. An additional study, undertaken in consultation and collaboration with the Tribes, is ongoing and will be finalized through the Section 106 process. The FEIS should incorporate the information learned in that process.
396	APPENDIX L: TRIBAL	2.4	Page 18, first paragraph of section	This paragraph lacks any nexus to the proposed project. The FEIS should reframe the statement from "impacts" generally to those impacts from effects of the proposed project. In addition, there should be a differentiation of Treaty resources (i.e., those related to adjudicated Treaty rights) versus other types of resources.
397	APPENDIX L: TRIBAL	2.4	Page 19, first full paragraph and bulleted list	Not all of these Tribes are mentioned in preceding Section 2.2. The FDEIS should clarify whether these Tribes have interests and/or impacted resources in the study area. Did Tribes note such interests or impacted resources in the letters being referred to?
398	APPENDIX L: TRIBAL	3.1	Page 21, first paragraph	The phrasing would be clearer if the FEIS amended this sentence to note that construction is anticipated to last five years.
399	APPENDIX L: TRIBAL	3.2.1	Page 22, first paragraph, bullet list	The RDEIS discusses loss of access but does not analyze tribal access under current conditions for reference, nor does it specify where such access restriction would occur. For example, the discussion of access in this paragraph immediately follows discussion of the airport levee construction; loss of access there is an unusual impact to propose considering there is an existing levee and publicly maintained road. To the extent that this list is discussing potential loss of access to the area near the FRE, there is no information provided about current tribal access there for comparison. It would make more sense for the FEIS to defer to the ongoing Section 106 process, in which consultation with Tribes is underway to identify resources, determine effects, and determine what mitigation if any is appropriate, as well as the Corps' government-to-government consultation with Tribes. This

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				is especially true in light of the third and fourth bullet, which reference fish habitat loss, diminishment of fish for Tribal harvest, and loss of culturally significant wildlife and plants. As noted frequently throughout these comments, the RDEIS's analysis of all three of these issues is deeply flawed. At a minimum, the RDEIS (a) fails to properly model the negative impacts to fish habitat and abundance of the No Action alternative; (b) incorrectly overstates the Project's impacts to fish through incorrect model assumptions and calibration; and (c) incorrectly asserts that the project will damage habitat for wildlife and plants based on a misunderstanding of geomorphic and habitat formation processes. Because these incorrect conclusions in turn affect issues of Tribal cultural importance, the FEIS should correct them, but also it should await the information and outcomes from the Section 106 process in which Tribal impacts can be properly considered, as well as the Corps' government-to-government consultation with Tribes.
400	APPENDIX L: TRIBAL	3.2.1.1.1	Page 23, first paragraph and bullet list	As noted in Comment #399 above, the RDEIS here considers construction impacts to aquatic habitats and species and notes that significant adverse impacts on those resources have Tribal implications. However, as the comments to the Fish and Earth discipline reports note, those impacts are frequently mistaken or overstated. For example, the fish passage estimates result from SME opinion contrary to the weight of scientific literature on such passage and assume impacts from blasting and vibration that will occur in the dry, outside the river, despite literature suggesting these impacts are manageable through BMPs. This section also quotes the Fish Discipline report's turbidity conclusions despite the fact that the Earth Discipline report concluded that standard BMPs imposed in permitting would render such effects nonsignificant. In general, the aquatic habits and species impacts described in this section are generally mitigable through typical permitting practices and mitigation measures, and many such measures are proposed in the Project's mitigation plan, but the RDEIS discounts them as too uncertain. The FEIS must realistically consider the mitigation proposed in determining the project's probable impacts, rather than describe the highly improbable impact of the project being constructed without any mitigation. In so doing, it will necessarily have to reevaluate Tribal impacts, as a more realistic assessment of environmental impacts will result in reduced Tribal impacts.
401	APPENDIX L: TRIBAL	3.2.1.1.1	Page 24, first through third paragraphs	See Comment #400 above. As another example of the flawed assumptions on which the fish habitat is based (which gives rise to the Tribal impacts discussed here), the RDEIS says that Chinook spawning is "concentrated in" the temporary reservoir area. This is part of a pattern in which the RDEIS misapprehends the quality of the habitat in the Project's vicinity, idealizing it compared to current conditions. In fact, in the most recent comprehensive redd survey both above and below the proposed Project location (Ronne et al.'s 2018 survey), only a limited percentage of Chinook redds were found in the temporary inundation area. Most redds for coho, fall Chinook, and spring Chinook salmon and for steelhead were located either downstream of proposed Project site or upstream of where it would temporarily inundate. See the Inundation Analysis with 2024 Project Design and 2025 (O4P2) Operational Scenario, attached to these comments. It is difficult to correctly ascertain probable Tribal impacts when the information this section of the RDEIS relies on is mistaken. The FEIS should instead defer to the Section 106 process, in which resources

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				may be identified, effects determined, and mitigation agreed-upon where appropriate, as well as the Corps' government-to-government consultation with Tribes.
402	APPENDIX L: TRIBAL	3.2.1.1.1	Page 25, first bullet	The RDEIS repeats the Wildlife Discipline report's finding that marbled murrelet habitat in the Project vicinity will be impacted, in the context of traditional hunting treaty reserved rights that probably do not implicate murrelets; moreover, murrelet habitat is rare and may not be suitable near the project site due to stand age. Surveys during permitting are likely to help identify and mitigate for such impacts. Similarly, the proposed Forest Conversion plan can preserve habitat that would otherwise be logged, which would mitigate for wildlife impacts and potentially for Tribal impacts. These impacts are therefore not likely to be "unavoidable." They can be addressed in the Section 106 consultation and the Corps' government-to-government consultation with the Quinault on their treaty rights, and mitigation may be proposed to preserve tribal cultural or treaty-related access to hunting resources.
403	APPENDIX L: TRIBAL	3.2.1.1.1	Page 25, second and third bullets	The FEIS should clarify if these construction activities-related impacts are temporary and what type of impact. Moreover, the species listed again do not seem directly related to traditional hunting practices. The FEIS should try to more clearly distinguish between environmental impacts and Tribal impacts, even if there is overlap.
404	APPENDIX L: TRIBAL	3.2.1.1.1	Page 26, last paragraph	There is unclear terminology; perhaps this should be "less than significant impact," not "less than significant adverse impact." Recommend global correction on this terminology. Moreover, the RDEIS here cites the Water Discipline report's conclusion that construction water quality impacts are less than significant, which belies the Fish Discipline report's conclusions that construction water quality impacts will have significant adverse fish impacts that, in turn, are tribal impacts because of fish's cultural and treaty-rights significance. As noted in comments on the Fish Discipline Report (RDEIS Appendix E), the unreliability of the impacts analysis significantly impairs the RDEIS's Tribal impacts conclusions. The FEIS should correct these errors; it would do best to defer to the Section 106 process as well as the Corps' government-to-government consultation with Tribes.
405	APPENDIX L: TRIBAL	3.2.1.1.1	Page 27, first paragraph	Same as Comment #404: the Fish report incorrectly rejects the Water report's water quality conclusions; the Tribal report should not do the same.
406	APPENDIX L: TRIBAL	3.2.1.1.1	Page 27, last paragraph	The FEIS should use the term "less than significant impact" instead of "less than significant adverse impact" for clarity. Recommend global correction on this terminology.
407	APPENDIX L: TRIBAL	3.2.1.1.2	Page 28, fourth paragraph	This is unclear. If a resource has been documented as a TCP, and assuming that this documentation was done in collaboration with Tribes, the TCP already has connection to a Tribe or Tribes per the National Register Bulletin (NRB) 38.
408	APPENDIX L: TRIBAL	3.2.1.1.2	Page 28, second paragraph.	This section should clearly define who the Section 106 consulting parties are for this proposed project. Recommend identifying all of the consulting parties on the Section 106 email list, with a note as to which entities have been actively participating in consultation, if warranted.

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409	APPENDIX L: TRIBAL	3.2.1.1.2	Page 28, third paragraph	Formal consultation is discussed earlier in the appendix. It is unclear who is 'coordinating' here with who in this context in Section 3.2.1.1.2. Technically, EO 21-02 does not apply to this project; it applies when a project is not undergoing Section 106 consultation, but this project is subject to Section 106 consultation because it is federal undertaking. See Executive Order 21-02 ("Agencies shall consult with DAHP and affected tribes on the potential effects of projects on cultural resources proposed in state-funded construction or acquisition projects that will not undergo Section 106 review under the National Historic Preservation Act of 1966 (Section 106)…"). Since the Section 106 process seeks to identify resources, assess potential effects, and generate agreed-upon mitigation if appropriate, the FEIS should defer to that process. The US Army Corps of Engineers is the lead federal agency responsible for assessing effects from its undertaking in consultation with consulting parties. USACE will seek DAHP concurrence on determinations of resource eligibility and project effects.
410	APPENDIX L: TRIBAL	3.2.1.1.2	Page 28, fourth paragraph	The TCP report by Shannon et al. 2019 was reportedly not acceptable to the tribes; hence, a new TCP report is underway as part of ongoing Section 106 consultation. The new report will identify the resources more clearly; the Tribal Discipline report is premature in assessing potential effects before the resources are identified and fully evaluated. The FEIS should await information from the Section 106 consultation and incorporate its outcomes.
411	APPENDIX L: TRIBAL	3.2.1.1.2	Page 29, first paragraph	The FEIS should reframe direct/indirect effects assessment for resources based on Section 2.1 of the Cultural Resources Discipline Report in accordance with the D.C. circuit court March 2019 ruling: https://www.achp.gov/sites/default/files/2019-06/NPCA%20v%20Semonite.pdf. Also see ACHP June 2019 memo: https://shpo.nv.gov/uploads/documents/OGC_memo_to_ACHP_staff_re_meaning_of_direct_6-7-19.pdf.
412	APPENDIX L: TRIBAL	3.2.1.1.2	Page 29, first paragraph	Unclear and inconsistent use of terms throughout regarding "impacts" or "effects." The FEIS should be consistent in terminology and evaluation herein. If this appendix is defaulting to evaluation under Section 106, then it should clearly outline that evaluation process or cross reference to the Cultural Resources Discipline Report.
413	APPENDIX L: TRIBAL	3.2.1.1.2	Page 29, first paragraph	Under Section 106, if sites are determined not eligible for listing in the NRHP, then they do not get assessed for project effects. To state here that they are directly affected prior to discussing eligibility is inaccurate, confusing, and premature. The FEIS should clarify the assessment of impacts or effects and outline the assessment process in a clear manner.
414	APPENDIX L: TRIBAL	3.2.1.1.2	Page 29, second paragraph	Statement needs to be corrected for accuracy. The USACE makes determinations of NRHP eligibility in consultation with the Section 106 parties and seeks DAHP concurrence on such determinations. Evaluation of the sites is ongoing, so it is premature to discuss effects to them.
415	APPENDIX L: TRIBAL	3.2.1.1.2	Page 29, second paragraph	The FEIS should state what the other archaeological sites were determined; if this information is not yet known, that is an indication that it is too early to discuss effects to these sites.

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416	APPENDIX L: TRIBAL	3.2.1.1.2	Page 29, third paragraph	Under Section 106, if sites are determined not eligible for listing in the NRHP, then they do not get assessed for project effects. To state here that they are directly affected prior to discussing eligibility is inaccurate, confusing, and premature. The FEIS needs to clarify assessment of impacts or effects and outline the assessment process in a clear manner.
417	APPENDIX L: TRIBAL	3.2.1.1.2	Page 29, third paragraph	This appendix does not explain how the Section 106 process informs SEPA analysis. The FEIS needs to clearly explain the connection, and how and when updates will occur in the SEPA process as the Section 106 process progresses.
418	APPENDIX L: TRIBAL	3.2.1.1.2	Page 29, fourth paragraph	This analysis lacks any information about the NRHP eligibility of these sites and the status of consultation regarding eligibility determinations. Although the District does not object to the RDEIS's conclusion, the FEIS should appropriately protect such sites from unnecessary public identification, but it still needs to provide enough information to understand its analysis.
419	APPENDIX L: TRIBAL	3.2.1.1.2	Page 29, fifth paragraph	This sentence in unclear because it is hard to distinguish how the Section 106 process relates to the FEIS in this context. The District believes that the FEIS should defer to the Section 106 process and await and incorporate its outcomes.
420	APPENDIX L: TRIBAL	3.2.1.1.2	Page 30, first paragraph	This is the first mention regarding land ownership. This information is relevant to this analysis and should be identified earlier when discussing resources and access to resources. The starting point for an effects analysis on a place-based tribal resource should be whether the Tribes currently have access to the private property in question.
421	APPENDIX L: TRIBAL	3.2.1.1.2	Page 30, fourth paragraph	Unclear terminology. "[L]ess than significant adverse impact" seems like it is the same as "not adverse." It is more common to frame a conclusion as "not adverse."
422	APPENDIX L: TRIBAL	3.2.1.1.2	Page 30, fifth paragraph	This section should reflect how the Tribes currently access the locations being discussed because access is related to the baseline conditions analysis in Section 106 process and is imperative in understanding potential impacts to such access.
423	APPENDIX L: TRIBAL	3.2.1.1.2	Page 31, first paragraph	Property access information is relevant to this analysis and should be identified. The starting point for an effects analysis on a place-based Tribal resource, such as hunting, should be whether the Tribes currently have access to the property in question. Further it is premature to make a conclusion of a "significant adverse impact" when the identification phase of the Section 106 process is not complete and there are no eligible cultural resources yet identified.
424	APPENDIX L: TRIBAL	3.2.1.2.1	Page 31, third paragraph	It is premature to make a conclusion of a "significant adverse impact" when the identification phase of the Section 106 process is not complete and there are no eligible cultural resources yet identified. Furthermore, the Corps' government-to-government consultation with Tribes is ongoing. Moreover, the proposed impact is predicated on construction water quality impacts, but the Water Discipline report notes that such impacts will be less than significant. Since the wildlife impacts would derive from the water quality impacts, the absence of the latter suggests the absence of the former.

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425	APPENDIX L: TRIBAL	3.2.1.2.1	Page 32, first paragraph	Table L-7 does not specify which species are within the different project locations therefore it is premature to make conclusions about impacts. Knowing the location of the species in the table is important to assessing impacts. Moreover, the proposed Project's mitigation plans include measures, such as the Forest Conversion plan, which would offset the potentially lost or fragmented habitat through retaining forest that would otherwise be logged; these areas could help support Tribal resources or access.
426	APPENDIX L: TRIBAL	3.2.2.1.1	Page 34-36, multiple pages	The RDEIS repeats the conclusions from the Fish and Wetlands Discipline Reports concerning impacts from flood operations. But many of these purported impacts are overstate, based on flawed assumptions, or contrary to the best available science. For example, the aquatic habitat impacts are based on a host of incorrect assumptions that do not match the proposed project design, such as the incorrect notion that the all wood will be removed from the system, that sediment transport will be disrupted, that channel-forming flows will be eliminated, that fish passage will be abysmally low, and that much of the vegetation would die in each inundation. The imported analysis from other reports ignores the proposed project design and mitigation, the scientific evidence in the mitigation plan documents and other relevant literature, and often the analysis of different parts of the RDEIS itself. Moreover, the impact analyses often compare the project's operation in 2080 with a non-flood condition in 2025, for example by noting the habitat above the proposed facility as important for fish abundance in a warming climate. This analysis ignores that the Project's proposed mitigation would result in lowering river temperatures downstream of the facility, which could reduce this climate change impact. The analysis also fails to note that in the No Action Alternative, major or catastrophic flooding is predicted in the upper basin every 3 years. Such flood flows would have significant adverse effects on this upstream habitat through increased scour and disruption of spawning behaviors, a fact noted in the Fish Discipline Report, but not captured in its modeling of the No Action Alternative even when three major-or-greater floods in three consecutive years are modeled. By failing to capture these non-project effects, the RDEIS fails to capture the impact of the No Action alternative to which the project is compared, exaggerating the negative impacts of the project. The RDEIS also fails to capture the potential downstream benefit the proposed project could create by protecting redds from major or catastrophic flood flow scour. This is part of a pattern in which the RDEIS treats the proposed project as disrupting a pristine and valuable habitat, when the current conditions and projected future conditions suggest habitat that is struggling to provide full function now, and will be severely disrupted by forces other than the Project in the future. The FEIS must correct these misconceptions and idealizations to measure the *Project*'s probable significant adverse effects, not the adverse effects of climate change and other forces. Only then can it properly assess the Project's Tribal impacts, when so many of the environmental changes producing Tribal impacts are happening irrespective of the Project.
427	APPENDIX L: TRIBAL	3.2.2.1.1	Page 38, first and third paragraphs	Neither marbled murrelet nor Townsend's big-eared bat are listed in table L-7. There is no explanation why they being considered in Tribal resources.
428	APPENDIX L: TRIBAL	3.2.2.1.1	Page 38, second paragraph	The proposed impacts here derive from the Wetlands Discipline report's unfounded assertion that the project will create long-term changes in downstream habitat through

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				altering or eliminating channel-forming flows. This analysis is simply wrong. A number of scientific sources, the RDEIS's own observations of the Chehalis system and other gravel-bed systems, Ecology's own guidance concerning ordinary high-water marks, and the sediment transport work in the proposed Mitigation Plan all note that channel-forming processes occur at lower flows, typically 2-year flows. Furthermore, 2-year flow is considered the benchmark for wetland hydrology. So, lower flows than major-flood flows, which the Project will not regulate, will carry out the geomorphic and ecological processes that the RDEIS says the Project will disrupt. Even if that were not so, floods are not uniform: in some floods that do not reach the Project's operations trigger of 38,800 cubic feet per second at Grand Mound (e.g., 2012), the Doty flows may be higher than in some major floods. There is no reason to believe that the area downstream of the Project will lose habitat function as the RDEIS proposes. Nor would temperature increase downstream, but for the RDEIS's dismissal of the proposed vegetation management and riparian planting mitigation, which were modeled to *decrease* downstream temperatures compared to baseline conditions. The FEIS should abandon this analysis and revise its assessment of Tribal impacts accordingly.
429	APPENDIX L: TRIBAL	3.2.2.1.1	Page 38, third paragraph	This section should be edited to reflect whether the species listed are included in Table L-7. If not, the FEIS should explain why the species are relevant to Tribal impacts. Moreover, this is another instance in which the RDEIS compares the proposed Project with a hypothetical world in which a major or catastrophic flood is not occurring. The fact that less mobile species might not be able to escape the temporary inundation should be considered in context: such species would equally have trouble avoiding the high flood flows of a major or catastrophic flood and the landslides that have historically accompanied them, and downstream of the facility they might survive due to the Project's flood protection when they otherwise would have died. Catastrophic floods are *catastrophic*. The FEIS should consider the Project's impacts beyond a baseline, unregulated major or catastrophic flood.
430	APPENDIX L: TRIBAL	3.2.2.1.1	Page 39, first and second paragraphs.	It is unclear if this analysis focuses on the species listed in Table L-7 or all species. It's not clear what is being considered a Tribal resource, particularly as related to Treaty rights. This discussion is vague and hard to ascertain how a significant conclusion is supported. Moreover, the first paragraph relies on the incorrect assertion addressed in Comment #398.
431	APPENDIX L: TRIBAL	3.2.2.1.2	Page 39, last paragraph.	The downstream temperature impact finding from the Water Discipline report is recited here as a Tribal impact. However, that report notes that the proposed mitigation, if designed and implemented as described in the Project's mitigation plan, would suffice to offset these temperature impacts. The FEIS should credit the proposed mitigation and find these impacts to be avoidable.
432	APPENDIX L: TRIBAL	3.2.2.1.2	Page 40, third paragraph and last paragraph	The third paragraph should more clearly describe the Section 106 process. In the last paragraph, there is no context provided for why undefined non-salmon species are included in the cultural resources subsection. But even if there was a nexus to Tribal or cultural resources, the impacts are ascribed to alterations of *summer* flow from the Project's operations. The Project operates only in major or catastrophic floods, which do not occur in summer; they are wet-season phenomena and are anticipated to remain winter as

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				summers get drier. Perhaps this impact derives from the channel-forming flow being lessened, but if so, that conclusion is incorrect as noted in other comments regarding channel forming flows.
433	APPENDIX L: TRIBAL	3.2.2.1.2	Page 41, second paragraph	This section needs to identify and explain the baseline for this analysis and conclusion. Flooding would occur without the FRE; thus, it is unclear how ongoing flood risk is a project impact. Indeed, the Project reduces flooding at all relevant transportation locations and so provides a benefit over the No-Action Alternative. One of the areas that sees some flood benefit is the Chehalis Tribal Reservation itself, which would likely provide transportation benefit to Tribal members, although the benefit is modest because of flooding from another river system in that area.
434	APPENDIX L: TRIBAL	3.2.2.2.1.3	Page 41, last paragraph	The RDEIS repeats the Environmental Health Discipline Report's bizarre conclusion that the project would create a significant adverse impact if a catastrophic earthquake occurred at the time the project was holding a temporary inundation pool, leading to facility failure. As that report acknowledged, the facility will have to meet rigorous Dam Safety Office standards protecting against a 10,000-year earthquake. Given the infrequency in which the facility holds back water, the odds of such an earthquake coinciding with the flood is so small as to not merely be "very unlikely," as noted in this paragraph, but not a credible risk according to industry standards. Moreover, it is perverse to discuss this remote possibility as a significant adverse impact without noting the much more likely chance that the facility will work as intended, reducing floods, which provides a distinct Environmental Health benefit. The FEIS should analyze the *probable* impacts of the Project, rather than going out of its way to emphasize adverse effects and minimize beneficial ones.
435	APPENDIX L: TRIBAL	3.2.3	Page 43, second paragraph	The Corps will consult on Treaty rights, but Tribal sovereignty is outside the scope of the proposed Project's effects. The FEIS should omit references to sovereignty, which is not challenged by the proposed Project.
436	APPENDIX L: TRIBAL	3.2.3	Page 43, fourth paragraph	This paragraph should include all Section 106 consulting parties. Moreover, its description is inaccurate and omits most of the Section 106 process. This should be reframed to reflect that the Section 106 process requires the assessment of project-related adverse effects on NRHP eligible properties, then the Section 106 consulting parties will consult to resolve adverse effects on those properties. The next step in the process is for the Section 106 consulting parties to agree upon appropriate mitigation measures. Typically, a Programmatic Agreement or Memorandum of Agreement that includes the agreed-upon mitigation measures is executed.
437	APPENDIX L: TRIBAL	3.2.3	Page 43, fifth paragraph	It is not clear how additional cultural resources work would result in application of EO 21-02. The proposed Project is already undergoing the Section 106 process and is therefore outside the scope of EO 21-02.
438	APPENDIX L: TRIBAL	3.2.4	Page 44, first paragraph	All Section 106 consulting parties should be included here.
439	APPENDIX L: TRIBAL	3.2.4	Page 44, last paragraph	The RDEIS described a statement by the Quinault Indian Nation that "specific and enforceable mitigation measures must be disclosed within the EIS and not left to later

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				processes." While the District does not necessarily agree that such measures are legally required to be fully determined in an EIS, the District agrees in principle that it has proposed many specific mitigation measures, and that the RDEIS failed to credit those measures as the minimum mitigation expected to be imposed in permitting, as well as to analyze those measures. This failure did a disservice to the public and decisionmakers who wish to consider the EIS's analysis of the probable impacts of the project, not merely its improbable, unmitigated, "worst-case scenario" impacts. The FEIS should consider the proposed mitigation in its impacts analysis.
440	APPENDIX L: TRIBAL	3.2.5	Page 45, second paragraph	It is premature to make a conclusion of a "adverse impacts to TCP" when the identification phase of the Section 106 process is not complete and determinations of eligibility are ongoing. A later sentence in this same paragraph states "No determination of eligibility or adverse effects to cultural resources has been made yet as part of the Section 106 process."
441	APPENDIX L: TRIBAL	3.4	Page 49, second paragraph	The FEIS should explain what these best management practices would be to avoid or minimize adverse effects. In general, typical permitting requirements should be considered when analyzing the impacts of both the Project and the No Action Alternative. Just as the No Action Alternative is anticipated to avoid, minimize, or mitigate adverse effects through permitting (even for as-yet undefined, unproposed, unpermitted, and uncertain projects), the Project's impacts should be measured with the constraints of permitting in mind. This is especially true here, where the Section 106 consultation and the Corps' obligation to consult with Tribal treaty rights holders is underway—these processes will address tribal impacts, and the FEIS should incorporate their outcomes. The FEIS should also consider typical permitting constraints in its other discipline reports, for example fish passage requirements; globally, the FEIS should not dismiss as "uncertain" the measures and standards the Project would necessarily have to use to be permitted and constructed.
APPENDIX M: VISUAL				
442	APPENDIX M: VISUAL	3.2.2.1.1	Page 26, paragraph 4	States there is one debris management sorting area, and it is included in 107 acres. This acreage varies from previously stated 110 acres. This has been further developed since the RPDR. In the draft Debris Management During Flood Retention Report (Attachment 1 to Attachment 2: Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum), there are two debris storage areas, and the acreage difference may impact the total clearing acreage.
APPENDIX N: WATER				
443	APPENDIX N: WATER	Summary	Page v Surface Water Quality	Insufficient information provided and incomplete analysis of effect | "…decreases of dissolved oxygen of more than 10% or 0.2 milligram per liter (mg/L), due to loss of riparian cover and stream shading that exceed water quality criteria" – although 303d listing is based on concentrations falling below 9.5 mg/L (e.g., listing IDs 77950, 77949, 10693, 77948, moving in downstream direction). The RDEIS needs to present what the actual

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				concentration that was predicted is and provide specific evidence that the predicted concentration is stressful, and for how long and when. It is doubtful that a 0.2 mg/L reduction is (i) detectable, and (ii) biologically meaningful. The RDEIS needs to distinguish between truly significant adverse vs. temporary minor impacts and provide specific biological justification/basis.
444	APPENDIX N: WATER	Summary	Page v Surface Water Quality	Basis for impact conclusion insufficiently defined and incorrect | "Exceedances of turbidity water quality criteria after major floods during inundation pool drawdown or during subsequent storms or high flows when the temporary inundation pool is not storing water due to resuspension of deposited sediments" The operation of FRE would reduce the peak turbidity experienced downstream by reducing the flows (suspended sediment concentration and thus turbidity increases exponentially with flow), such that the maximum turbidity level experienced under the No Action alternative would not be experienced with the Proposed Project. In addition, analyses and assumptions associated with the resuspension hypothesis are flawed – for example, see relevant comments for Appendix F Earth regarding what size classes deposit where in the channel vs the floodplain/hillslope, and the inadequacy of modeling used to simulate sediment availability for resuspension. Conclusion of impact is clearly unsupported without further appropriate analysis.
445	APPENDIX N: WATER	Summary	Table N-1, Proposed Action-Operations, Surface water quality	Concerns about turbidity exceedances have not been shown to be greater than that currently experienced during high flows in existing conditions.
446	APPENDIX N: WATER	Summary	Table N-2, Proposed Action-Operations, Surface water quality	In section 3.2.2.1.1.2 Surface Water Quality, potential pollutants including mercury and methylmercury were described as having <u>no adverse impacts</u>. Table N-2 lists the impact finding pollutant mobilization as having <u>less than significant</u> impacts instead.
447	APPENDIX N: WATER	2.2.2.2	Page 23, Table N-8	Table N-8 states the 10-year flow is the Major Flood. Multiple documents state the Major Flood as 38,800 cfs. Table N-6 states the Major Flood is a 7-year event.
448	APPENDIX N: WATER	2.2.2.4	Page 29, 3rd paragraph	Error | This paragraph is incorrect. Table N-14 does not list turbidity for the upper Chehalis River. The link for the DOE (2025a) citation shows only a 4.2-km-long reach of the Chehalis River listed (ID 15915) between Stearns Creek and the Newaukum River, based on 4 excursions beyond the criterion out of 12 samples collected between 1992 and 2001.
449	APPENDIX N: WATER	2.2.2.4.2 Temperature	Page 39	PSU 2025 Report is not provided | The temperature analysis cites to work described in "Chehalis River and Tributary Water Quality and Hydrodynamic Modeling: SEPA Revised Draft EIS Scenarios." This document has not been provided. Ecology had an obligation to provide this supporting material to inform review of the RDEIS and development of comments.
450	APPENDIX N: WATER	2.2.2.4.3	Page 40, 4th paragraph	Insufficient justification for conclusion | Just because concentrations fall below 10 mg/L does not mean they are sufficiently adverse to be biologically meaningful. Values of 9.2 to 9.3 mg/L during the summer are above levels associated with significant stress.

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451	APPENDIX N: WATER	2.2.2.4.5	Page 42, 2nd paragraph	Error | See Comment #448. Table N-14 does not list turbidity.
452	APPENDIX N: WATER	2.2.2.4.5	Page 42, 3rd paragraph	Insufficient justification for conclusion(s) | 1. The mean daily flow at the Doty gage on 2/9/2017 (when the 610 NTU measurement near the FRE location reportedly occurred) was 9,340 cfs, which is less than the 2-year flood. According to Figure 2.4 in WGS & Anchor (2017), the estimated suspended sediment load at the gage is approximately 25,000 tons/day at 9,340 cfs, and at the 10-year flood (around 25,000 cfs), the estimated suspended load is approximately 200,000 tons/day. It is unclear what the NTU would be during FRE releases, but literature suggests an approximate linear increase in turbidity NTU exists with increase in suspended sediment concentration. For the reported 3/29/2017 measurement of 12.2 NTU at 1,920 cfs, the corresponding suspended sediment load based on Figure 2.4 would be approximately 300 tons/day. Converting these to concentrations of tons/ft^3 and extrapolating the NTU-tons/ft^3 numbers linearly to the equivalent concentration for a flow of 25,000 cfs and a load of 200,000 tons/day is equivalent to an estimated 1,880 NTU at the 10-year flood. There would likely be some dilution as the sediment flows through and disperses within the temporary impoundment, but the point is that there could be a similar amount of turbidity without the FRE in place. Based on the limited details provided in the EIS, this could constitute a significant adverse impact under the No Action alternative. FRE operation could thus reduce extreme turbidity levels compared with what would occur under the No Action scenario. 2. There is inherent ambiguity with respect to interpreting the water quality criterion when a water body is at flood stage and highly turbid. This should be recognized in the RDEIS.
453	APPENDIX N: WATER	2.3, 3.2.2.1	Pages 55, 77, 78	The FRE facility operations used in analysis are from the Anchor QEA 2017 report *Operations Plan for Flood Retention Facilities* which has been superseded by updated operations, which provide similar levels of downstream protection while reducing pool durations upstream of FRE structure.
454	APPENDIX N: WATER	2.4 Technical Approach	Page 56	The Reservoir Water Quality Report (Anchor QEA 2019a) is not provided | The DEIS states, "A combination of CE-QUAL-W2, HEC-RAS, and Water Erosion Prediction Project (WEPP) models were used to evaluate the different deposition and resuspension mechanisms for major and catastrophic floods; model details are documented in the Reservoir Water Quality Report (Anchor QEA 2019a)." The Anchor QEA (2019a) document was not provided and appears to include important modeling details that have yet to be evaluated. This report was requested from Ecology but was received too late to review and comment within the designated comment period. Additional comments may be forthcoming.
455	APPENDIX N: WATER	2.4 Technical Approach	Page 56	CE-QUAL-W2 Modeling Files not provided | CE-QUAL-W2 modeling files were provided from Ecology but did not include the impounded reservoir model. In addition, the footprint model that was provided did not have the turbidity module turned on. CE-QUAL-W2 modeling files for the impounded reservoir and for the footprint model with turbidity are required to evaluate modeling results and conclusions. These additional model files were

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				specifically requested from Ecology and will be reviewed along with additional model components, when delivered. Additional comments may be forthcoming at that time.
456	APPENDIX N: WATER	2.4 Technical Approach	Page 56	It is unclear if topographic shade is applied correctly in the CE-QUAL-W2 River Model | Review of the CE-QUAL-W2 modeling files showed that the footprint model uses topographic shade in the headwaters, but the river model (construction model files) does not use topographic shade in the incised section of the river model. This inaccuracy in the 2020 SEPA model was identified by the District's October 10, 2024 Mitigation Technical Memorandum. To understand the temperature effects downstream of the FRE facility, the same approach for topographic shade should be used in both the footprint model and river model. Although the Chehalis River valley is generally wide, very high riverbanks provide shade even where riparian vegetation is sparse.
457	APPENDIX N: WATER	2.4 Technical Approach	Page 56	Segment orientation angle is set to zero in the CE-QUAL-W2 footprint (construction) model | Segment orientation angle should be based on topographic maps and not set to 0. The results of an example simulation run by the District showed that temperature differences up to 0.45°C could occur in model runs with and without topographic segment orientation angle. The SEPA model's accuracy should be improved by incorporating this model parameter.
458	APPENDIX N: WATER	3.2.1.1.1.1	Table N-18	RDEIS Paragraph 3 on page 67 of Appendix N states acreage of disturbance for quarry sites and access roads listed in Table N-18 is based on the assumption that "Construction of the Proposed Action includes mining of rock from up to three potential quarry sites." The Main document section 2.3.3.1, pg. 16 and Appendix 1 section 3.2.6 pg. 37 of this RDEIS correctly state that no more than 2 quarries with no more than 80 acres of total disturbance for the quarries are included in the Proposed Action. The Project should be accurately described, and acreages of disturbance in Table N-18 and other findings of impact should be revised to accurately reflect the Proposed Action and its probable impacts.
459	APPENDIX N: WATER	3.2.1.1.1.2	Page 67, paragraph 2	RDEIS states there is access to one debris sorting yard, but this has been further developed since the RPDR. In the draft Debris Management During Flood Retention Report (Attachment 1 to Attachment 2: Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum), there are two debris storage areas, and they will be accessed from the same proposed access roads.
460	APPENDIX N: WATER	3.2.1.1.1.2	Page 67, paragraph 2	RDEIS states there is one debris sorting yard, but this has been further developed since the RPDR. In the draft Debris Management During Flood Retention Report (Attachment 1 to Attachment 2: Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum), there are two debris storage areas.
461	APPENDIX N: WATER	3.2.1.1.3	Page 73, 1st paragraph	The construction water demand is stated as 3.7 cfs. The actual demand has been updated based on an HDR analysis since the Revised Project Description. Please see the Construction Water Demand Technical Memorandum, which estimates that the highest average monthly construction water demand would be 0.88 cfs (in July, at the height of

Comment #	Revised Draft EIS Component	Main Body or Appendix Section	Location (page, paragraph, sentence, table, bullet)	Comment
				construction season), with a lower average demand in other months. This figure weights in peak demand more heavily than it would likely occur, and so it is conservative. Even adding an additional conservative buffer of 20% above this 0.88 cfs, the projected maximum average monthly demand would be 1.08 cfs. That means that the highest-demand month would, on average, use less than a third of the water previously proposed. The average annual demand is predicted to be even lower, at 0.63 cfs. The FEIS should incorporate this updated water estimate into its analysis.
462	APPENDIX N: WATER	3.2.2.1	Page 77, 3rd paragraph	This paragraph is unclear on how frequently the inundation pool would operate during the 1989-2018 historical period. Our modeling showed only 7 initiations, while the paragraph initially states 13, then 7 occurrences for the historical period.
463	APPENDIX N: WATER	3.2.2.1	Page 77, 3rd paragraph	It appears that this paragraph may be conflating active operations, when water is being stored based on downstream conditions, with short-term backwater effects when conduit capacity may be temporarily overwhelmed by high inflows for a matter of minutes to hours. The phrasing of the paragraph makes it unclear what is occurring at the FRE site for these "24 high-flow events."
464	APPENDIX N: WATER	3.2.2.1	Page 78, 4th paragraph	Analyzing effects based on outdated operations | The revised mitigation plan proposes a shorter duration for woody debris retrieval by moving the location of on-land transfer of collected wood to closer to the FRE facility than indicated in the 2017 operation report on which the 14-day figure is based.
465	APPENDIX N: WATER	3.2.2.1; 3.2.2.1.1.1	Page 78, 2nd and 3rd paragraphs; Page 80, 3rd paragraph	These drawdown procedures are outdated and have been updated in consultation with geotechnical engineers to safely expedite the emptying of the pool.
466	APPENDIX N: WATER	3.2.2.1	Page 78, 3rd paragraph	The debris removal period has been shortened to 5 days based on further study of expected debris accumulation and removal rates.
467	APPENDIX N: WATER	3.2.2.1	Page 78, paragraph 3	States the removal process will take up to 14 days. This was further developed since the RPDR. In the draft Debris Management During Flood Retention Report (Attachment 1 to Attachment 2: Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum), it is reported to take up to 5 days for the 100-year flow to remove LWM.
468	APPENDIX N: WATER	3.2.2.1	Page 78, last paragraph	The discussion on operation of the FRE changing sediment transport and channel-forming processes by eliminating large peak flows is misleading and incorrect. The example used is the 2007 flood, with a peak flow at the FRE location estimated as 34,700 cfs being attenuated to 6,450 cfs with FRE operations. The 34,700 cfs peak above Doty was an abnormally large (almost a 500-year flood at Doty). Catastrophic floods are not usually used to define "channel forming" events.
469	APPENDIX N: WATER	3.2.2.1	Page 78, Footnote 20	The 60-day duration isn't supported by any given data.

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470	APPENDIX N: WATER	3.2.2.1	Page 79, second paragraph from the end	Is the Project, or FRE, being held responsible for the temperature impacts, summarized in section 3.2.5, due to climate change? Are temperature impacts due to climate change accounted for in the No Action or Local Actions Alternatives?
471	APPENDIX N: WATER	3.2.2.1; 3.2.2.1.1.1	Page 79, Table N-20; Page 80, 3rd paragraph	Minimum flow downstream of the FRE structure is not expected to drop below 300 cfs at any time during drawdown periods. The 260 cfs flowrate isn't explained in the report.
472	APPENDIX N: WATER	3.2.2.1; 3.2.2.1.1.1	Page 79, Table N-20; Page 80, 3rd paragraph	Modeled inundation pool releases have shown a maximum flow during drawdown periods around 10,000 cfs in some storm events.
473	APPENDIX N: WATER	3.2.2.1.1.1	Page 80, 3rd paragraph	Analyzing effects based on outdated operations | Operations have been revised since the 2017 operations plan that the 34 days figure is based on, and are associated with shorter times to drain the temporary impoundment (less than 21 days, maximum).See Attachment 2: Reservoir Operations Analysis (Draft) Technical Memorandum to Attachment 2: Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum to these comments.
474	APPENDIX N: WATER	3.2.2.1.1.2 Surface Water Quality	Page 90	Relative modeling results are unclear. | The mid- and late-century conditions are compared to the No Action Alternative, but it should be compared to the No Action Alternative with climate change. It appears that the correct comparison has not been made.
475	APPENDIX N: WATER	3.2.2.1.1.2	Page 92, Dissolved Oxygen, 3rd paragraph	Insufficient justification for conclusion(s) | The predicted differences are reported to be negligible, and the ambient levels are below water quality criteria, so it is unclear how a negligible decrease can be considered a significant adverse impact. The decreases do not appear to be enough to push levels below some biologically meaningful threshold.
476	APPENDIX N: WATER	3.2.2.1.1.2	Page 92, 5th paragraph	No data is shown to surmise increased turbidity during pool drawdown above existing conditions during a flood.
477	APPENDIX N: WATER	3.2.2.1.1.2	Page 93, 3rd paragraph	No quantity of expected sediment increase within the temporary inundation pool area or expected sediment decrease in the 0.5-mile downstream of the FRE structure is shown. What quantities are expected given the existing geologic conditions at these sites?
478	APPENDIX N: WATER	3.2.2.1.1.2	Page 92-93, Turbidity, 3rd–7th paragraphs	Unsupported analysis of effect and assumptions likely incorrect | These inferences and conclusions are unsupported. See comments for Appendix F (Earth) regarding incomplete justification and adequacy of modeling and assumptions of increased sediment deposition in the channel vs. outside the channel, and resuspension.
479	APPENDIX N: WATER	3.2.2.1.1.2	Page 93, Turbidity, 8th paragraph	Analyzing effects based on outdated operations | These results are based on old operations with the 2-week wood debris removal scenario. This has been reduced substantially to generally 5 days or less (Attachment 1: Debris Management During Flood Retention Report (Draft) to Attachment 2: Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum to these comments), and other aspects of operations have been updated in design to reduce the total time to drain.

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480	APPENDIX N: WATER	3.2.2.1.1.2	Page 93-94, Turbidity, 8th and 10th paragraphs	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | What is not considered sufficiently, and needs to be, is the relative difference in severity of turbidity during major and catastrophic floods under the No Action condition compared against the with-FRE facility operation condition, and what that means to aquatic organisms. Although the duration of elevated outflow turbidity compared to inflow turbidity after the floods recede may be extended when the FRE facility is operated, organisms downstream of the facility would not experience the extremely high turbidity levels compared with upstream. It is plausible that the downstream dose-response outcome under the with-FRE facility operation condition is less impactful than under the higher No Action turbidity levels, which would be a benefit, not an impact. Without such an analysis, the conclusion of impact is speculative.
481	APPENDIX N: WATER	3.2.2.1.1.2	Page 94, Turbidity, 9th paragraph	Insufficient information provided, unsupported analysis of effect, and assumptions likely incorrect | 1. It is unclear what modeling was performed and how. See comments for Appendix F (Earth) regarding invalidity of WEPP modeling for predicting storm runoff of deposited sediments, and CE-QUAL-W2 does not model storm runoff erosion/delivery/in-channel turbidity mechanisms. 2. Background turbidity would not be expected to be low during an intense rainstorm; details on when it would be low are not provided and should be.
482	APPENDIX N: WATER	3.2.2.1.1.2	Page 94, Turbidity, last paragraph	Incomplete analysis of effect and justification of assumptions likely affecting conclusions | Standardized water quality criteria are insufficient for determining whether a significant adverse effect is likely – need to perform a dose-response analysis (e.g., Pilkerton et al. (2025).
483	APPENDIX N: WATER	3.2.2.2.1	Pages 101-104, Figures N-16a thru N-17b,	Figure labels say "Change in depth" but the legend shows what is assumed to be total depth. As stated, it would show a greater than 25-foot reduction in depth in the channel which is not correct.
484	APPENDIX N: WATER	3.2.2.2.1	Page 107, 2nd paragraph	The potential for significant adverse impacts from the airport levee construction occurring before or without the FRE is misleading. The FRE and Airport levee are both part of the proposed action, will likely be permitted together, and will be coordinated in such a way to achieve the project goals of flood level reduction. In addition, any construction or alteration of facilities in the floodplain and floodway would be required to follow relevant local floodplain development ordinances. If adverse impacts are likely if completed first, the raising of the levee would not happen without the FRE being operational.
485	APPENDIX N: WATER	3.2.4.3	Page 115, second bold bullet point and its sub-bullets	The Agency Proposed Mitigation is of the right type (a Water Use and Rights Mitigation Plan), but its phrasing is unnecessarily restrictive. Existing stringent regulatory and permitting requirements under the Water Code, chapter 90.03 RCW and chapter 173-522 WAC (Chehalis River Basin Instream Flow Rule) already regulate any proposed withdrawals, diversions, and use of water. (This is part of the reason the FEIS should conclude that the proposed Project's impacts will be mitigated or avoided in the permitting process.) The RDEIS's description of purported required components of the Mitigation Plan prejudges some of that permitting process by including a limitation that the water be withdrawn from the Chehalis River, as opposed to from nearby tributaries, groundwater,

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				other sources, or some combination thereof. The law allows, and the permitting process could include and mitigate for the effects of, use of such water. The FEIS should describe the necessary components of the mitigation plan with reference to the Water Code and the Chehalis River Basin Instream Flow Rule, without otherwise restricting the range of options. Similarly, instead of suggesting that "mitigation measures should occur as close to the FRE facility as possible," the FEIS should allow the permitting process to employ mitigation measures that apply to surface water body reaches determined to be impacted, without reference to the location of the FRE facility.
486	APPENDIX N: WATER	3.2.5	Page 117, 2nd and 3rd bullets	The low-DO impacts identified in the RDEIS here are not probable, as they would only be engendered by flood operations occurring in the mid- to late-summer, which would not occur. Section 6.2 of Appendix J of the Revised Project Description states that "the normal operating period [of the FRE structure] will be September through April based on the historical record of floods large enough to trigger operation." The concern over decreased DO, both upstream and downstream of the structure, during flood operations in the mid- to late summer is unlikely due to the unlikely occurrence of flooding during the summer. The RDEIS's climate change predictions note that summer low-flows, not flood-flows, are likely. The FEIS should remove this impact because it is not probable.
487	APPENDIX N: WATER	3.2.5	Page 117, 5th bullet and preceding paragraph	The RDEIS incorrectly concludes that the construction water demand of the project will have significant and unavoidable impacts. As the RDEIS recognizes immediately below this text, a water use permit would be required for use of water for construction, and such a permit would address these impacts. As such, the impacts are not "unavoidable"; Ecology has identified the very process that will avoid them, or else the project cannot be constructed. Identification of the mitigation mechanism is enough; it need not be fully developed for the impact to be deemed avoidable. See Quinault Indian Nation v. Imperium Terminal Servs., LLC, 190 Wn. App.696, 708, 360 P.3d 949 (2015), *rev'd on other grounds*, 187 Wn.2d 460 (2017). The FEIS should identify this impact as avoidable.
488	APPENDIX N: WATER	3.3.2	Page 120, 5th paragraph	Stating that the scale of peak flow reduction from floodplain storage improvement projects under the Local Action Alternative during major/catastrophic floods may inaccurately suggest that the peak flow reduction is comparable to that achieved by the FRE structure alternative.
489	APPENDIX N: WATER	3.4.1	Pages 122-123	Incomplete analysis of effect | This section ignores effect of increased flooding with climate change on water quality downstream under the No Action scenario in terms of increased severity and frequency of turbidity.
490	APPENDIX N: WATER	3.4.2	Page 123	The RDEIS does not discuss potential effects of increased size and frequency of future winter storms on turbidity, increased flooding and channel erosion downstream, resultant channel widening, followed by reduced summer flows, shallower depths in wider channel reaches, and warmer summer temperatures. These are future conditions that should be expected and to which the FRE future condition should be compared.

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APPENDIX O: WETLANDS				
491	APPENDIX O: WETLANDS	3.2.1	Pages 40-41	Overstates significance; lacks functional loss and net-effect analysis | While the DEIS correctly identifies wetland impacts within the project footprint, its determination of significant adverse impact is not supported by SEPA criteria. The affected wetlands are Category II and III wetlands that are common within the Chehalis Basin, with no Category I or IV wetlands impacted. A substantial portion of the identified wetland and buffer impacts are temporary and would be restored following construction. The DEIS does not distinguish temporary disturbance from permanent loss, does not evaluate wetland functional loss, and does not assess net effects after compensatory mitigation. As such, the conclusion of significant adverse impact is not substantiated by the information presented.
492	APPENDIX O: WETLANDS	3.2.1.1.1	Figure O-11 and Figure O-12	RDEIS states "Quarry access and haul road work would impact 0.39 acre of wetlands (12 total wetlands) and 17.28 acres of wetland buffers…" Since the revised project description, the District has further evaluated the quarries and expects wetland impacts can be reduced during the permitting phase.
493	APPENDIX O: WETLANDS	3.2.1.1.2	Page 43	Neglects to account for created aquatic/riparian features and post-construction recovery; mischaracterizes relocation as permanent loss | The DEIS identifies temporary construction-phase disturbances associated with Crim Creek realignment and bypass channel construction, it does not acknowledge that the proposed action results in the creation of a new, permanent waterbody and associated riparian buffers. The relocated channel would establish a new ordinary high-water mark, convey aquatic flows, and support riparian vegetation following construction. As such, impacts represent a relocation and temporary disturbance of aquatic and buffer functions, not a permanent loss. The DEIS does not evaluate post-construction recovery, buffer revegetation, or net functional outcomes, which are necessary to support a determination of significant adverse permanent impact.
494	APPENDIX O: WETLANDS	3.2.1.2.2	Page 47	Contradicts downstream impact claims; confirms no adverse surface water quantity effects | The DEIS Appendix N 88, 2, states that, "There is no predicted increase in downstream flood extents, flood elevations, or flood frequency as a result of the FRE facility operation, and therefore FRE facility operation would result in no adverse impacts on surface water quantity downstream."
495	APPENDIX O: WETLANDS	3.2.2.1	Pages 48-50	Unsupported equivalency: temporary inundation misclassified as significant under SEPA | The DEIS asserts that recurring flood operations would have effects similar to major and catastrophic floods on downstream floodplain wetlands, while also characterizing wetland creation and loss dynamics as poorly understood. This conclusion is not supported as the RDEIS does not demonstrate comparable magnitude, duration, or probability of effects across flood scenarios, nor does it identify permanent wetland conversion. Temporary inundation shown in Tables O-16, O-20, and O-21 and Figures O-11 and O-12 does not constitute a significant adverse impact under SEPA. General scientific uncertainty regarding long-term floodplain evolution does not constitute a major information gap where impacts are temporary, reversible, and not shown to result in wetland loss.

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496	APPENDIX O: WETLANDS	3.2.2.1.1	Pages 48-51	Unexplained significance change; climate and hydrology conflated | Section 3.2.2.1.1 concludes that probable adverse impacts to downstream floodplain wetlands and open-water/NHD habitats from inundation associated with FRE operations would be significant; however, this conclusion is not supported by new data or analysis and represents an unexplained departure from the findings of the 2020 SEPA DEIS, which determined that similar impacts would be less than significant. The Revised DEIS states that a "similar analysis" to the 2019 Downstream Floodplain Wetland Analysis was used, incorporating "updated data sources," but it does not clearly identify what those updated data sources are, how they differ from prior analyses, or how they justify a change in impact significance. The assessment of indirect hydrologic impacts to downstream floodplain wetlands relies primarily on model-derived wetland extents and changes in the frequency of overbank inundation, without adequately accounting for the multiple hydrologic inputs that maintain floodplain wetland function in the Chehalis Basin. These include groundwater inflow from valley side slopes, hyporheic exchange, precipitation-driven runoff, springs, and smaller tributaries, all of which reduce wetland dependence on mainstem overbank flooding. As a result, the analysis overstates the sensitivity of downstream wetlands to changes in river stage alone. In addition, the discussion blends the projected effects of climate change with the effects of FRE operations without clearly distinguishing between the No Action and Proposed Action Alternatives. While the analysis considers climate-driven changes in hydrology under the Proposed Action, it does not provide a comparable evaluation of climate change effects under the No Action Alternative, which is necessary to isolate project-related impacts. Moreover, FRE operations are expected to occur during the rainy season (November through March), when floodplain wetland soils are already maintained by precipitation and groundwater recharge, and when wetland vegetation is largely dormant. Climate projections indicating increased winter precipitation further suggest that precipitation-driven hydrology, rather than overbank flooding frequency, will remain the dominant control on downstream wetland moisture conditions. These same factors were identified in the 2020 SEPA DEIS Wetlands Discipline Report (pp. 0-50 to 0-53) as reasons why potential downstream floodplain wetland impacts would be minor. Notably, the Revised DEIS now identifies fewer acres of downstream wetlands as potentially affected than were identified in the 2020 analysis, yet reaches the opposite conclusion that impacts are significant, probable, and adverse. This change is not supported by the new evidence, functional assessment, or impact magnitude analysis and appears inconsistent with both the prior SEPA record and the information presented in the Revised DEIS.
497	APPENDIX O: WETLANDS	3.2.2.1.1	Pages 48-51	Infrequent flooding mischaracterized as controlling wetland hydrology | The wetland analysis is superficial and largely hypothetical, relying on remote sensing datasets and modeled future hydrology rather than an understanding of how these floodplain wetlands currently function. Under existing conditions, these wetlands are inundated, on average,

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				only during major flood events occurring approximately once every seven years. As such, they do not meet the National Research Council's (NRC) criterion for river overflow as a controlling source of wetland hydrology, which requires inundation or saturation to occur in at least one out of every two years to be considered hydrologically influential (NRC 1995). Consequently, these wetlands are not dependent on overflow from the Chehalis River under current conditions, and a reduction in the magnitude or duration of inundation during infrequent major floods would not affect their ecological function.
498	APPENDIX O: WETLANDS	3.2.2.1.1	Pages 51-54	Single-scenario flood modeling misapplied to dynamic wetland conditions | The wetland analysis incorrectly applies results from a hydraulic model that was developed to address a different question—flood risk reduction—and then extrapolates a single modeled 10-year flood scenario to represent all future 10-year floods. This approach does not reflect the dynamic nature of flood hydrology or the spatial variability of rainfall across the Chehalis Basin. It is incorrect to assume that the inundation pattern produced by a single modeled 10-year event would recur every 2 to 3 years. For example, when heavy rainfall occurs primarily in the Newaukum or Skookumchuck basins, the FRE facility would not operate, yet downstream floodplains may still be inundated. Conversely, there have been flood events in which flows at Doty exceeded the 10-year flood while flows at the Grand Mound gage did not reach the 38,800 cfs threshold (e.g., November 2012); in such cases, the FRE facility would not operate for flood retention, and floodplains between Doty and the Newaukum confluence could experience inundation exceeding 10-year levels. These and other plausible flood scenarios are not evaluated in the analysis. As a result, the modeling does not characterize the range of inundation patterns to floodplain wetlands patterns that may actually occur, and the outputs are applied outside their intended purpose. The model was designed to evaluate flood risk reduction, not wetland hydrologic dependency or ecological response, rendering its use for wetland impact determination inappropriate.
499	APPENDIX O: WETLANDS	3.2.2.1.1	Page 52	Inconsistent application of wetland hydrology criteria; infrequent flooding mischaracterized as impact | 2020 Appendix O EIS states, "these probable adverse impacts are considered minor for wetlands because the affected wetlands would not be eliminated or lose their primary hydrologic source but would no longer be inundated by overbank flooding that occurs infrequently." The USACE and EPA (Environmental Laboratory 1987) jointly define wetlands as, "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." Guidance from the National Research Council for determining wetland hydrology indicates that the water source must be present typically in 5 years out of 10 years, or more commonly referred to as occurring in 1 year out of 2 years (NRC 1995).
500	APPENDIX O: WETLANDS	3.2.2.1.1	Page 52, last paragraph	The RDEIS does not identify what wetland functions would be altered under baseline conditions for 2-4 days of flood inundation every 2-3 years. The District's BA provides an

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				analysis of potential effects on growth opportunities in overbank floodplain rearing habitat for juvenile salmon. Using studies from other systems, floodplain rearing growth potential is unlikely to be measurable unless floodplains are inundated for at least 15 days, with measurable growth after 30 days. An analysis of previous flood events indicates overbank flooding of floodplain habitats downstream of the FRE are limited to the area just upstream of the South Fork confluence, and flooding persisted for 2-4 days. This is not sufficient, under baseline conditions, to function as productive rearing habitat for juvenile salmon.
501	APPENDIX O: WETLANDS	3.2.2.1.1	Page 53	Deprecated data used; open water misclassified as wetlands | The DEIS includes open water and aquatic habitat classes derived from the deprecated 2016 modeled wetlands inventory as "potential wetlands," inflating wetland acreage and overstating impacts. Open water habitats do not meet regulatory wetland criteria and are not classified as wetlands under federal or state guidance. The inventory itself is medium resolution, identifies only potential wetlands, and is no longer supported by Ecology for regulatory analysis. Wetland impact conclusions should be based on field-verified delineations and functional assessments, as provided in the RMP, with open water habitats evaluated separately as aquatic resources.
502	APPENDIX O: WETLANDS	3.2.2.1.1	Pages 54	Contradicts floodplain science; misstates hydroperiod–vegetation relationship | The DEIS statement asserting that less frequent flood inundation may maintain floodplain wetlands in a wetter state and promote emergent or scrub-shrub vegetation is internally inconsistent and not supported by floodplain hydrology or vegetation science applicable to the Chehalis River. In the Chehalis Basin, reduced flood frequency is associated with decreased floodplain wetness, while shifts from forested to emergent or scrub-shrub vegetation occur under conditions of increased or prolonged inundation. Hydroperiod length, not reduced flooding, drives vegetation shifts (Mitsch & Gosselink 2015). Additionally, the Revised DEIS incorrectly concludes that the FRE will eliminate channel-forming flows and therefore interfere with wetlands formation and vegetative functions. As discussed in a comment to Appendix D (Earth), channel-forming flows in the Chehalis mainstem (as in most rivers) occur at flows of far less than the major-flood flow. Like most rivers, the channel forming flow in the Chehalis occurs at around the current 2-year flood flow; this is also the flow that typically drives wetlands formation and vegetative processes. Because the FRE would operate until what is now the current 7-year flood flow, it would not interfere with these channel- and wetlands-formation flows.
503	APPENDIX O: WETLANDS	3.2.2.1.2	Page 54, last paragraph under **Temporary Reservoir**	The stream miles provided in this paragraph are not correct. The correct numbers are: • 16.66 miles/109.89 acres of stream: • 6.6 miles mainstem Chehalis River • 10.0 miles of tributaries • Of this, 11.8 miles are fish-bearing. • Includes 0.48 mile affected by temporary construction disturbance: • 0.38 mile of the Chehalis River • 0.06 mile of Crim Creek • 0.04 mile of non-fish-bearing tributaries.

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504	APPENDIX O: WETLANDS	3.2.2.1.2	Page 55–58	Contradicts downstream impact claims; confirms no adverse surface water quantity effects | The DEIS Appendix N 88, 2, states that, "There is no predicted increase in downstream flood extents, flood elevations, or flood frequency as a result of the FRE facility operation, and therefore FRE facility operation would result in no adverse impacts on surface water quantity downstream."
505	APPENDIX O: WETLANDS	3.2.2.1.2	Page 57	Contradicts downstream impact claims; confirms no adverse surface water quantity effects | The DEIS Appendix N 88, 2, states that, "There is no predicted increase in downstream flood extents, flood elevations, or flood frequency as a result of the FRE facility operation, and therefore FRE facility operation would result in no adverse impacts on surface water quantity downstream."
506	APPENDIX O: WETLANDS	3.2.2.1.2	Page 58	Unquantified sediment/wood impacts; ignores RMP re-entrainment and LWM mitigation | Instead, these wetlands are sustained primarily by shallow groundwater inputs, local precipitation, and their landscape position. The DEIS does not demonstrate that FRE operations would alter these dominant hydrologic mechanisms in a manner that would result in wetland degradation. By relying on modeled future hydrology rather than field-verified wetland conditions, the analysis does not meet SEPA's requirement for a reasoned evaluation of environmental impacts. While screening-level datasets are appropriate for identifying areas of potential concern, they are insufficient for determining impact magnitude or significance without site-specific verification.
507	APPENDIX O: WETLANDS	3.2.5	Page 67	Pre-judges the adequacy of mitigation | Section 3.2.5 states, "Impacts to wetlands and waterbodies from construction activities are more localized and therefore more easily replaced, but mitigation cannot fully replace the lost wetland and waterbody functions from frequent inundation of the temporary reservoir and the resulting downstream floodplain adverse effects." The assertion that mitigation cannot fully replace lost functions is premature. That determination will be made during a future permitting phase based on more specific characterization of existing wetlands and proposed mitigation and the associated functional analysis of both.
508	APPENDIX O: WETLANDS	3.4	Pages 72-74	The DEIS does not adequately analyze climate change effects on floodplain wetland hydrology under the No Action Alternative | The discussion of climate change effects on floodplain wetland hydrology is minimal in the No Action Alternative. The effects of climate change on floodplain wetland hydrology should be expanded to create a basis for more clearly distinguishing the effects of the proposed action from the effects of climate change. This is especially important because those effects potentially offset one another. Climate change effects on hydrology are part of the baseline condition and not attributable to the FRE operation. This point needs to be clearly stated and discussed as part of the No Action Alternative discussion.
APPENDIX P: WILDLIFE				
509	APPENDIX P: WILDLIFE	Summary	Page v, Table P-1, row 2	Minimizing construction impacts. | Nest abandonment can be avoided by conducting vegetation clearing and construction outside the bird nesting season. Mortality, disturbance,

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				and injury to larger mobile bird and mammal species can be reduced by conducting construction activities when species are not tied to nesting or denning sites.
510	APPENDIX P: WILDLIFE	Summary	Page v, Table P-1, row 3	Construction impacts level determination. | The DEIS indicates that effects on migratory pathways are significant during construction but does not describe the magnitude or severity of those potential impacts that support that determination.
511	APPENDIX P: WILDLIFE	Summary	Page via, Table P-1, row 1	Mortality is not an inevitable result of reduced flooding hydrology.
512	APPENDIX P: WILDLIFE	Summary	Page vici, Table P-1, row 3	Operations impacts level determination. | The DEIS indicates that effects on migratory pathways are significant during construction but does not describe the magnitude or severity of those potential impacts that support that determination.
513	APPENDIX P: WILDLIFE	2 Methodology	Overarching Concern 1	Components of impacts to wildlife are not specifically addressed. | The four primary components of impacts to wildlife resources (magnitude, geographic extent, duration, and particularly the probability of occurrence) in general are not mentioned, with the lone exception of considering geographic extent (for habitat loss from the FRE facility and associated infrastructure). Instead, the text implicitly assumes that each of these components is substantial enough that, on balance across the four components, a summary conclusion of significant impacts is warranted. The analysis is incomplete and does not support the finding of significant impacts.
514	APPENDIX P: WILDLIFE	2 Methodology	Overarching Concern 2	Significant impacts determined without confirmed presence of the species. | Repeatedly, a conclusion of significant impacts to marbled murrelets and Townsend's big-eared bat rests on the assumption that suitable nesting trees (murrelets) and roosting trees (bats) occur in the study area and could be used by these species. Given the lack of confirmed observations of these two species in the proposed Project area, it is presumptuous to conclude that significant impacts will occur.
515	APPENDIX P: WILDLIFE	2 Methodology	Overarching Concern 3	Likely to be a lack of suitable mature forests for nesting marbled murrelets in Proposed Project area. | The District is not aware of old-growth stands occurring in the extensively developed, lower Chehalis River floodplain areas or in the commercially managed forests in the FRE facility and temporary inundation area in the upper river. Additionally, the probability of large stands of mature forest (which would provide suitable habitat for murrelets because of the reduction in edge effects and corvid predation in particular) occurring in the upper river portion of the proposed project area is likely low given the heavily fragmented and managed habitat in the area from years of commercial forest harvesting.
516	APPENDIX P: WILDLIFE	2.2.1.1	Page 7, paragraph 1	The Mitigation Plan considers the constraints of using the NLCD mapping in the FRE construction and temporary inundation area.
517	APPENDIX P: WILDLIFE	2.2.2	Pages 35-36	As the RDEIS states, Oregon spotted frog (OSF) do not occur in the study area as documented by field surveys (p. 35). The RDEIS's statement that OSF are part of the still-water breeding amphibian species assemblage in the study area is not accurate based on

Comment #	Revised Draft EIS Component	Main Body or Appendix Section	Location (page, paragraph, sentence, table, bullet)	Comment
				the RDEIS's own conclusions. Revise the FEIS to reflect that OSF do not occur in the project area.
518	APPENDIX P: WILDLIFE	2.2.2	Pages 35-36	Oregon spotted frog occurrence confusion. | Oregon spotted frog is mentioned as part of the still-water breeding amphibian species assemblage in the study area (p. 34) and then is noted as not occurring in the study area, as documented by field surveys (p. 35). This contradiction occurs elsewhere in Appendix P also. Neither Oregon spotted frog nor their habitat have been documented in the upper Chehalis Basin.
519	APPENDIX P: WILDLIFE	2.2.2	Page 37	Winter wren taxonomy. | Winter wrens on the Pacific Coast are now treated as a separate species, Pacific wren.
520	APPENDIX P: WILDLIFE	2.2.2	Page 37	Solitary vireo taxonomy. | Solitary vireos west of the Great Plains are now treated as a separate species, Cassin's vireo.
521	APPENDIX P: WILDLIFE	2.2.2	Page 37	Yellow warbler taxonomy | Yellow warbler is now formally the northern yellow warbler as the mangrove yellow warbler was elevated to full species status.
522	APPENDIX P: WILDLIFE	2.2.2	Page 37	Genus Dendroica taxonomy change. | The wood warbler genus Dendroica has now been revised to Setophaga.
523	APPENDIX P: WILDLIFE	2.2.2	Page 38	American wigeon spelling | American wigeon is the correct spelling; there is no "d" in wigeon.
524	APPENDIX P: WILDLIFE	2.2.2.1.2	Page 41	Old-growth forest stand occurrence. | Marbled murrelet is noted as possibly occurring "...if mature or old-growth forest stands with suitable nesting structure are present." Later on p. 50 when discussing Johnson's hairstreak, the text indicates "…there are no old-growth forests within the study area." The District's understanding is there are no old-growth forests remaining in the study area.
525	APPENDIX P: WILDLIFE	2.2.3.2.1, Marbled Murrelet	Page 49, paragraph 2	As described in the Mitigation Plan, the District has committed to conducting pre-construction nesting habitat suitability surveys to identify suitable marbled murrelet nesting trees in all forested areas in which tree removal is proposed, and in the disturbance-based threshold distance of 328 feet (for noise disturbance) from tree removal activities. The surveys will identify suitable nesting trees and inform tree removal timing to avoid tree removal during the nesting season. The District expects the quantity of trees to be preserved and taken out of timber production outside of the temporary inundation area (and thus to continue growth to attain larger size) as part of its Forest Conversion Plan will more than offset the amount of suitable nest trees that may be removed or disturbed within the facility footprint and temporary inundation area. Since the time of the Revised Project Description, the District has had many opportunities to observe the quarry sites and riparian corridor while conducting other site investigations. Suitable nesting trees were quite limited in these observations. Of the mature conifers observed with suitable diameters, most lacked the robust branch structure to support nesting platforms. Based on tree canopy height GIS analysis and opportunistic surveys

Comment #	Revised Draft EIS Component	Main Body or Appendix Section	Location (page, paragraph, sentence, table, bullet)	Comment
				completed to date, the District conservatively estimates between 2 and 5 percent of coniferous trees within deciduous riparian corridors and mixed coniferous/deciduous transitional forests may be suitable for nesting. The District believes that future marbled murrelet habitat surveys during permitting will demonstrate that any such habitat impacts from the Project will be avoidable through mitigation.
526	APPENDIX P: WILDLIFE	3.2.1.1.2	Page 67, 3rd paragraph	Cited guidelines for noise harassment for murrelets are outdated. This noise threshold has been replaced with guidance from USFWS (2015). The noise threshold was replaced with a distance threshold from the edge of suitable nesting areas to the source of noise from specific activities.
527	APPENDIX P: WILDLIFE	3.2.1.1.2	Page 72, 1st paragraph	Geographic extent of impact recognized. | The geographic extent of impacts within the greater Chehalis Basin is recognized for habitat loss from construction of the FRE facility and associated infrastructure. This is helpful. Framing potential impacts within a regional context like this is one of the four primary components that should be addressed when assessing impacts to wildlife (see Overarching Concern 1 above).
528	APPENDIX P: WILDLIFE	3.2.1.1.2	Page 73, 2nd paragraph	Text misplacement? | Paragraph on bats and birds does not discuss migratory pathways impacts; the text seems misplaced.
529	APPENDIX P: WILDLIFE	3.2.1.2.1	Page 74, 1st two paragraphs	No BMPs mentioned. | The probability of turbidity and water drawdown impacts during construction of the FRE facility and associated areas occurring within the amphibian breeding season is not mentioned. No BMPs mentioned, which could reduce turbidity impacts.
530	APPENDIX P: WILDLIFE	3.2.1.2.1	Page 74, 5th paragraphs	No BMPs mentioned. | BMPs mentioned for construction of quarry sites and access roads to avoid and minimize impacts of turbidity and contaminants during construction; this results in a less than significant impact. This information was not mentioned in the discussion of construction impacts for the FRE facility and associated areas.
531	APPENDIX P: WILDLIFE	3.2.2.1.1	Page 86, last paragraph	The RDEIS assumes the facility would reduce flood inundation events to an extent that floodplains would no longer receive overbank flooding and provide habitat for aquatic species. With respect to juvenile salmonid rearing opportunities, the habitat made available from overbank flooding recedes within 2 to 4 days, a time period not sufficient to elicit a measurable response in growth potential based on studies along the Yolo bypass in northern California.
532	APPENDIX P: WILDLIFE	3.2.2.1.1	Page 87, paragraph 2	The RDEIS contends that flood retention operations will eliminate channel forming flows. Channel forming flows are equivalent to approximately the 2-year and 10-year events. The proposed facility is not expected to operate for flood retention during 2-year events, and operations to retain 10-year flows will be intermittent and likely limited based on refinements to the operational rule curves.
533	APPENDIX P: WILDLIFE	3.2.2.1.1	Page 87, 4th paragraph	Upland habitat also impacted by reduced flooding downstream? | Not clear how upland wildlife habitat, in addition to aquatic habitat, is also significantly impacted by reduced flows in the floodplain areas downstream. Generally, there should be an expansion of upland habitat in areas experiencing less overbank flooding.

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Attachment 2:

Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations Memorandum

Chehalis River Basin Flood Control Zone District

February 4, 2026

Memorandum

Date:	February 4, 2026
Project:	Chehalis River Basin Flood Damage Reduction Project
To:	Chehalis Basin Flood Control Zone District
From:	HDR & Kleinschmidt Associates
Subject:	**Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations & Debris Management During Flood Retention Operations**

1.0 Background

The Proposed Chehalis River Basin Flood Damage Reduction project (Proposed Project) objective is to implement a series of measures aimed at reducing damage to the communities of the Chehalis River Basin from Pe Ell to Cosmopolis during major flood events. Among these measures is a proposed Flood Retention Expandable (FRE) structure on the Chehalis River, south of Pe Ell, Washington.

Following submittal of the Revised Project Description Report (HDR Engineering, Inc. [HDR] 2024), a Chehalis River Basin Flood Damage Reduction draft Preliminary Design Report (PDR) was initiated to document ongoing draft design refinements, as the design process iterates toward a future 30 percent design that will be documented in a completed PDR. The draft PDR records ongoing draft design decisions, assumptions, and methods related to the development of the design of the FRE structure and related elements and collects technical details of the main features of the Proposed Project elements as they continue to develop.

A SEPA Revised Draft Environmental Impact Statement (RDEIS) for the Proposed Project was issued on November 20, 2025 with comments due February 4, 2026. To support the submission of comments on the SEPA RDEIS, some draft design elements are being formalized in reports and memoranda to describe the current state of the project design. While still not at a full 30 percent preliminary design level, these elements are at a point at which they can reasonably inform tribal governments, state and federal agencies, partners, stakeholders, and the public about the nature of the project.

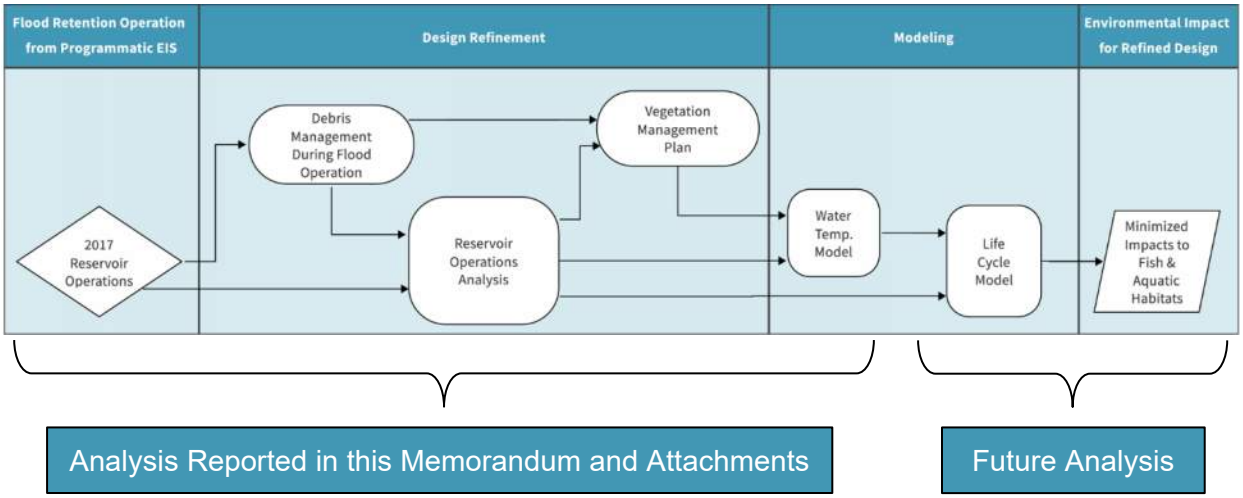
2.0 Purpose

This memorandum is provided to inform the reader of one of the efforts undertaken by the Chehalis River Basin Flood Control Zone District (District) since the 2020 SEPA draft EIS and 2024 Revised Project Description, to avoid and minimize potential adverse impacts to salmonid populations in the Chehalis Basin related to the proposed FRE facility.

3.0 Introduction

The proposed 2017 operating rules (2017 Operations) for triggering, filling, and draining a temporary inundation pool were developed by Washington state in support of a Programmatic EIS, out of which came the proposed FRE facility. Early evaluation of the environmental impact of the 2017 Operations indicated adverse impacts to salmonid populations in the Upper Chehalis River basin (Washington State Environmental Policy Act [SEPA] draft EIS; Ecology 2020). The FRE facility design was refined over the next several years to avoid and minimize impacts to salmonid populations. A flow chart summarizing the refinement and modeling process is provided in Figure 1.

Figure 1. Flow Chart of Project Refinement to Reduce Environmental Impact



Refinement began with flood retention operations, of which an important component is debris management during flood retention operations. Reductions to the time spent collecting debris, smaller areas for debris collection, and locating debris collection areas lower in the temporary inundation area allow greater flexibility in reservoir operation to preserve upstream riparian areas. This information was used in the reservoir operations analysis to refine how the temporary inundation pool is filled and drained, reducing the impact to salmonid populations while continuing to meet flood damage reduction goals. Refined debris management and reservoir operations data allowed examination of how the change in inundation levels would reduce impacts to salmonid redds upstream of the facility, as well as refinement of the Vegetation Management Plan (VMP) analysis regarding vegetation survival (Figure 1). The resulting increased shade and reduced frequency and duration of temporary inundation pools were entered into the water temperature model, showing estimated decreased future river water temperatures. In the future, the updated debris management, reservoir operations, redd inundation, vegetation management, and temperature data will all feed into updated Ecosystem Diagnosis and Treatment model (EDT) and life cycle analyses to demonstrate potential reductions in environmental impacts compared to the 2020 SEPA draft EIS and 2025 SEPA revised draft EIS.

4.0 Debris Management During Flood Retention Operation

The 2017 Operations reflected a 14-day debris management period where drawdown of the temporary inundation pool slows to a rate of 2 feet/day from 10 feet/day between the pool elevations of 500 and 528 feet to gather and store woody material that has accumulated in the pool during flood retention operations. From review of debris management operations at a similar flood control reservoir in western Washington, Mud Mountain Dam, further refinement was possible to reduce the debris collection period from 14 days to 5 days for a 100-year storm event. Smaller storms that warrant activation of the FRE facility might not generate significant debris, and thus the period may be truncated or even eliminated. The total storage area required for these operations was also refined, and debris storage areas further downstream, lower in the pool, were selected for debris management. The updated 5-day debris management period exists between the pool elevations of 477 and 487 feet. This allows the pool to more quickly draw down to a lower elevation and return more of the upstream watershed to free-flowing conditions sooner than the 2017 Operations.

The explanation above summarizes an extended analysis of debris management operations for the Proposed Project. For a more rigorous explanation of the analysis, please see the attached Debris Management During Flood Retention Report (Draft; Debris Management Report [Attachment 1]).

5.0 Reservoir Operations Analysis

“Reservoir Operations” is a technical engineering term for how the facility fills and then draws down its temporary inundation pool during and after flood events. There is no permanent reservoir for the Proposed Project; it is merely called a “reservoir” in the modeling programs used to simulate the temporary inundation pool.

Starting with the 2017 Operations as a baseline operations set, various operational refinements were proposed and evaluated through modeling with HEC-ResSim and HEC-RAS software. One of the most notable improvements in operations is the O4 operations trigger (refer to Attachment 2 for terminology of operations scenarios), which provides a much more dynamic system than the more rigid 2017 Operations trigger. The 2017 Operations uses a trigger flow of 38,800 cfs at the Grand Mound streamgage; releases are to be reduced to 300 cfs 48 hours before this flow is reached at Grand Mound and pool drawdown is not initiated until flows at Grand Mound drop back below 38,800 cfs. Instead of following this unchangeable schedule for all storms, the O4 operations trigger better replicates the actions of a live reservoir operator who would be actively monitoring streamflow conditions, both upstream and downstream of the FRE facility. The O4 trigger aims for a flow no greater than 38,800 cfs at Grand Mound but allows more freedom in the timing of gate closures and openings. This allows the FRE facility to store less water than the 2017 Operations for the same storm while still providing equivalent levels of protection downstream. The debris management parameter (D5) was also refined based on research discussed above in Section 4 and in more detail within the attached Debris Management Report (Attachment 1). Drawdown rates were also examined, and with

consultation with geotechnical engineers, an increased drawdown rate of 20 feet/day below 480 feet was implemented in the updated operations sets.

The most recent operations sets (O4Q1D5P1 and O4Q1D5P2) now provide similar levels of downstream flood protection while significantly reducing the duration and, in some cases, extent of the temporary inundation pool. Figure 2 and Figure 3 show proposed reservoir operations modeling of the January 2009 flood event between the 2017 Operations and the O4Q1D5P2 operations set. As shown in Figure 2, the O4Q1D5P2 operations set (red line) begins storing water a day earlier than the 2017 Operations (green line) but starts increasing releases and drawing the temporary pool down a day earlier than the 2017 Operations. The refined debris management operations are also apparent with a shorter debris management period at a lower elevation for the O4Q1D5P2 operations set compared to the 2017 Operations. With the increased drawdown rate of 20 feet/day after the debris management period has ended, the O4Q1D5P2 operations set only retains a temporary pool for 20 days, compared to the 2017 Operations which hold a pool for 30 days. Figure 3 shows the flow at Grand Mound based on the proposed reservoir operations, with the 2017 Operations and O4Q1D5P2 peak flows overlapping and both reducing the peak flow from 59,009 to 50,343 cfs – a 17.2 percent decrease.

Figure 2. Reservoir Elevations, Inflows, and Releases - 2017 Operations and O4Q1D5P2 Operations

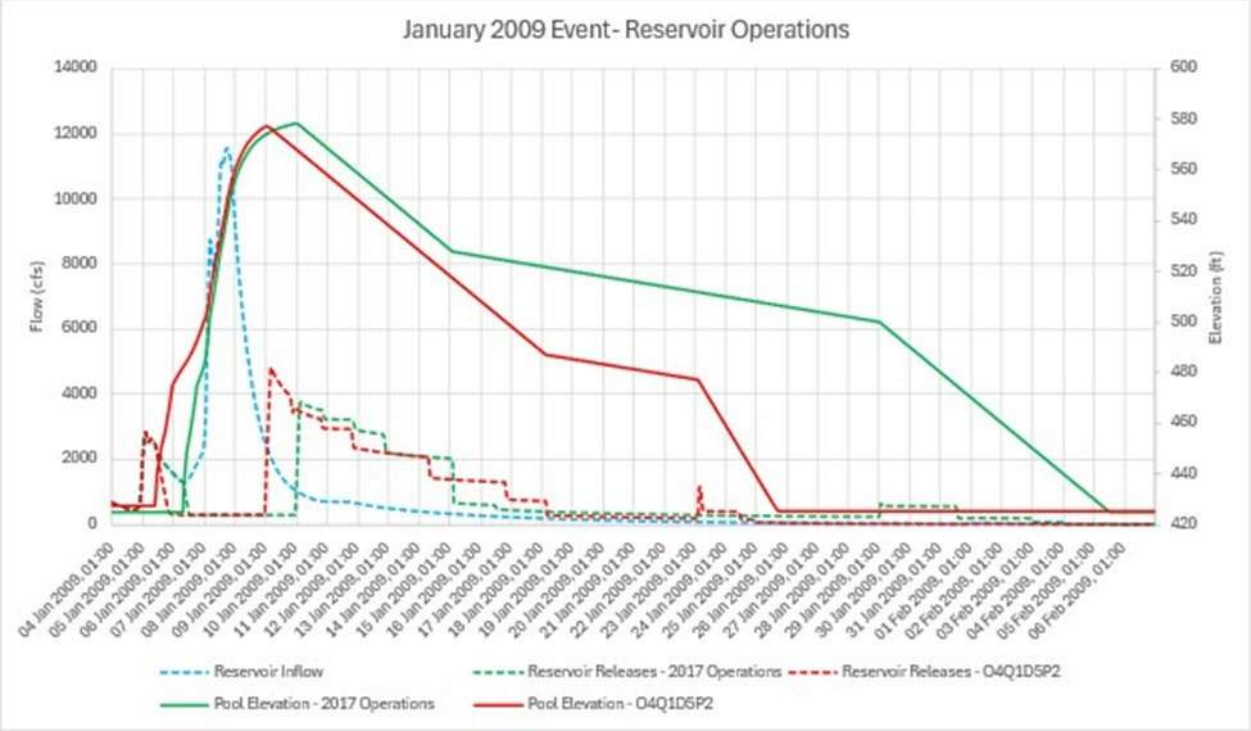
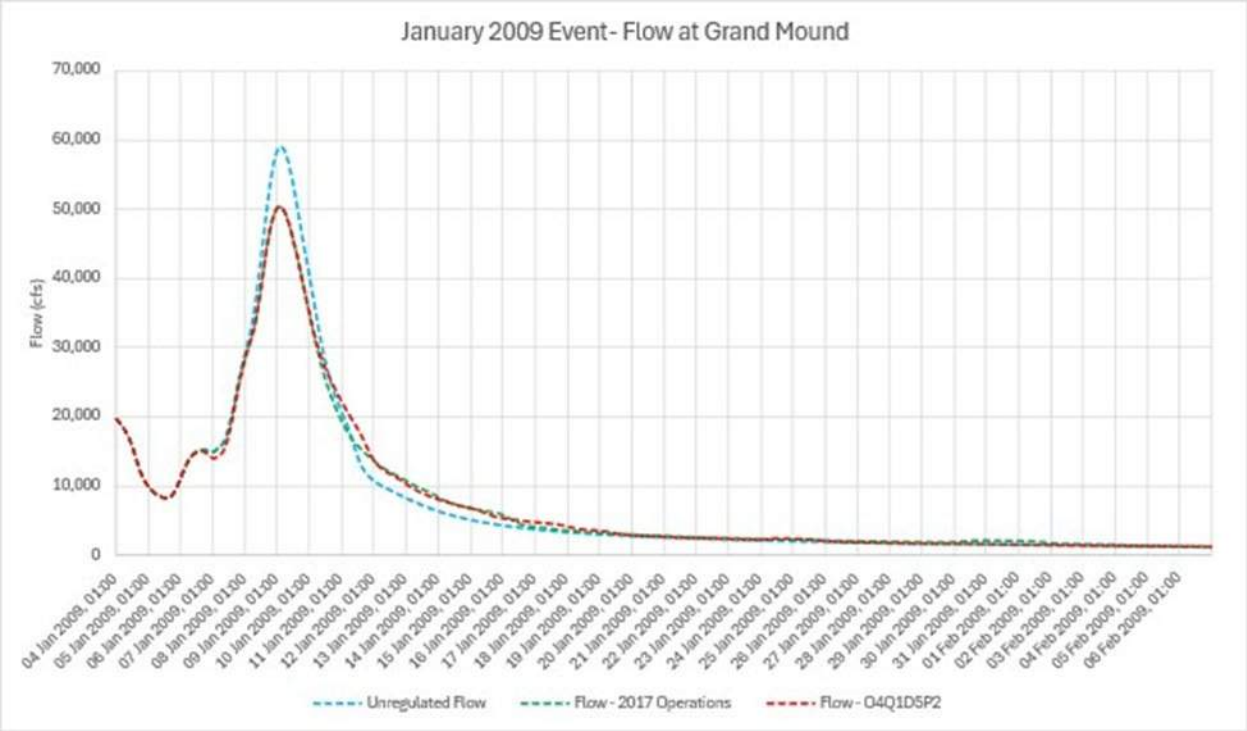


Figure 3. Flow at Grand Mound – Unregulated, 2017 Operations, and O4Q1D5P2 Operations



In general, the two new proposed operation sets outperform the 2017 Operations by providing the same or greater level of flood protection while significantly reducing inundation pool durations.

The explanation above summarizes an extended analysis of operations sets that considered the current period of record and potential future storm conditions through the late century, including anticipated climate change effects. For a more rigorous explanation of the modeling, please see the attached Reservoir Operations Analysis Technical Memorandum (Attachment 2).

6.0 Redd Inundation and Updated Vegetation Analysis

The above-described reservoir operations refinements produced operations rule sets that would inundate less area than the original 2017 Operations and would drain the temporary inundation pool faster. The District selected one of these rules sets (O4Q1D5P2, called the “2025 Operations” in the analysis below) to examine its impacts on redd and vegetation survival.

When the most comprehensive redd survey data available (2018) was analyzed with respect to the 2025 Operations, it was evident that less than a quarter of each species’ redds were located within the temporary inundation pool. The 2025 Operations improved upon the 2017 Operations in two ways. First, the 2025 Operations would not inundate a portion of the redds that would have been inundated under the 2017 Operations. Second, for those redds that would still be inundated, more would be in the Initial Evacuation Zone which drains faster, making those redds less likely to be inundated at harmful levels.

The 2025 Operations' reduction in inundation area and duration would also reduce vegetation mortality. The area inundated for longer than 7 days was reduced by 0.4 river miles in a catastrophic flood (about 10%) and about 1 river mile in a major flood (about 64%). This corresponds to between 0.4 and 2.1 miles of riparian forest that would remain viable, which under 2017 Operations would not have survived. This increased tree viability will result in a taller canopy and increased shade, the temperature effects of which are described in the next section.

The explanation above summarizes a more extended analysis of redd inundation and vegetative effects. For a more rigorous explanation of the analysis, please see the attached Inundation Analysis with 2024 Project Design and O4P2 Operational Scenario Technical Memorandum (Attachment 3).

7.0 Water Temperature Model

The data from the above-described inundation analysis concerning tree viability served as the basis for modeling how the 2025 Operations would affect a canopy cover and height in major and catastrophic floods with and without the Proposed Project's VMP and downstream riparian shade mitigation. These canopy height estimates were then used to inform a CE-QUAL-W2 model to determine water temperatures associated with the same scenarios. The modeling included new topographic data around Crim Creek that more accurately reflected current conditions than the District's previous temperature modeling.

The results showed that 2025 Operations resulted in the unmitigated project having less of a temperature impact on the Chehalis River near the project facility. In contrast, at the mouth of Crim Creek before it reaches the project, the updated topographic data revealed Crim Creek to be cooler without the project than previously modeled, meaning that the project was having a greater warming effect on the lower reaches of Crim Creek than previously expected. Nevertheless, by the time the water reaches the Chehalis River, the overall water temperature impact for the 2025 Operations was less than for the 2017 Operations.

Results including the proposed VMP and downstream riparian planting were similar. Although the impact at the mouth of Crim Creek was more than previously expected, by the time the water reached the Proposed Project site, the temperature impact was reduced. The 2017 Operations were modeled resulting in a maximum 7-day average warming of 1.2^{o}Celsius (C) at the project site, whereas the 2025 Operations resulted in only 0.8^{o}C of such warming, representing a 33 percent impact reduction.

Downstream, the 2025 Operations reduced water temperature impacts as well. Including the proposed VMP and downstream riparian planting, the 2017 Operations' 1.2^{o}C modeled temperature increase at the project site gradually dropped to 0.2^{o}C by Jones Creek; by Elk Creek, the river would be cooler (-0.3^{o}C change), and by Adna the river would be substantially cooler (-1.2^{o}C change). For the 2025 Operations including the VMP and downstream riparian planting, the 0.8^{o}C modeled increase at the project site dropped more rapidly downstream: by

Jones Creek the river would already be cooler (-0.5°C change) and continued substantially cooler at Adna (-1.2°C change).

The explanation above summarizes a more extended analysis of canopy height and cover and temperate effects. For a more rigorous explanation of the analysis, please see the attached Riparian Shade Temperature Model with 2024 Project Design and 2025 (O4P2) Operations Technical Memorandum (Attachment 4).

8.0 Conclusion and Future Analysis

The updated debris management and reservoir operations analysis resulted in a flood operation system that would inundate less area and drain the temporary inundation pool faster. These changes would result in fewer redds being inundated and greater tree and shrub viability upstream of the Proposed Project. The ensuing increase in canopy height and cover would reduce the Proposed Project's potential temperature impacts, and in combination with its proposed downstream riparian planting would reduce downstream temperatures faster.

In the future, the debris management, reservoir operations, redd inundation, vegetation management, and temperature data will all feed into updated EDT and life cycle analyses to demonstrate reduced fish impacts in the project vicinity compared to the 2020 SEPA draft EIS and 2025 SEPA revised draft EIS.

9.0 References

HDR Engineering, Inc. (HDR)

2024 *Revised Project Description Report: Flood Retention Expandable Structure*, Chehalis River Basin Flood Control Zone District, Lewis County, Washington. April 2024.

2025 *Draft Preliminary Design Report: Flood Retention Expandable Structure*, Chehalis River Basin Flood Damage Reduction Project, Lewis County, Washington, June 30, 2025.

10.0 Acronyms/Abbreviations

DEIS	SEPA Draft Environmental Impact Statement
District	Chehalis River Basin Flood Control Zone District
EDT	Ecosystem Diagnosis and Treatment model
EIS	Environmental Impact Statement
FRE	Flood Retention Expandable
HDR	HDR Engineering, Inc.
PDR	draft Preliminary Design Report
Proposed Project	Proposed Chehalis River Basin Flood Damage Reduction project
RCC	roller-compacted concrete
SEPA	State Environmental Policy Act
TM	Technical Memorandum
VMP	Vegetation Management Plan

Attachment 1 – Debris Management During Flood Retention Report (Draft)

February 4, 2026

Debris Management During Flood Retention Report (Draft)

Chehalis River Basin Flood Damage Reduction Project

Lewis County, Washington

January 9, 2026

Chehalis River Basin
Flood Control Zone District

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Appendices

Appendix A. USACE MMD Site Operator Meeting Notes

Acronyms and Abbreviations

cfs	cubic feet per second
District	Chehalis Basin Flood Control Zone District
Ecology	Washington State Department of Ecology
FRE	Flood Retention Expandable
HDR	HDR Engineering, Inc.
HEC-RAS	Hydrologic Engineering Center River Analysis System
LWM	Large Woody Material
PDR	Preliminary Design Report
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

1 Background

The Proposed Chehalis River Basin Flood Damage Reduction project (Proposed Project) objective is to implement a series of measures aimed at reducing damage to the communities of the Chehalis River Basin from Pe Ell to Centralia during major flood events. Among these measures is a proposed Flood Retention Expandable (FRE) structure on the Chehalis River, south Pe Ell, Washington.

The Chehalis River Basin Flood Damage Reduction, draft Preliminary Design Report (PDR) documents development of the preliminary design of the FRE facility and related elements. Development of the draft PDR began following submittal of the Revised Project Description Report (HDR Engineering, Inc. [HDR] 2024), which was used as the baseline for the draft PDR. This draft PDR reflects design development that has occurred since submittal of the June 30, 2025 draft PDR (HDR 2025a).

The draft PDR documents the design basis for each Proposed Project element, including a record of design decisions, assumptions, and methods related to the development of the design of the FRE structure and related elements. The draft PDR also presents the technical details of the main features of the Proposed Project elements.

2 Introduction

The proposed FRE structure on the Chehalis River is projected to accumulate woody debris and upstream of the structure during normal flow-through operation and flood retention operation. Smaller woody debris will be captured on trashracks during flow-through design. Larger flow events will transport bedload downstream to the dam, some of which will be small enough to pass through the trashrack; larger diameter bedload will accumulate upstream of the trashrack. Flood retention operations will occur during large storm events and result in a temporary inundation pool above the structure. The pool area and elevation will depend on the size of the storm. Heavy rain in the upper watershed will move large woody material (LWM) to the Chehalis River and cause occasional mass wasting events that will also input LWM to the Chehalis River. LWM will move downstream causing accumulation of LWM in the inundation pool and at the FRE. Accumulated debris at the trashrack and in the inundation pool needs to be managed to avoid debris damage at the structure and excess accumulation of LWM in the Chehalis River that would affect normal flow-through operations. Work boats and log broncs towing log booms will be used to corral LWM from the reservoir and move it to debris storage areas where it will be kept in place with log booms until the temporary pool recedes and the LWM can be removed from the Proposed Project area by land-based equipment and personnel.

In 2021, HDR prepared a *Large Woody Material Downstream Passage and Placement Clarification Technical Memorandum* to inform the impacts analysis for the Final Environmental Impact Statements (EISs; HDR 2021). The 2020 Draft EIS prepared by the Washington Department of Ecology (Ecology) and the USACE identified impacts to aquatic habitats downstream of the proposed FRE facility from the reduction of LWM

inputs from the upstream reach of the Chehalis River. HDR identified temporary storage, staging, and distribution of LWM for downstream habitat enhancement.

This previous study noted the debris would be contained within a single debris storage area during temporary storage. The area would be located between river mile 109.6 and 109.9, approximately 4.5 acres, where processing would occur following flood events. An estimate of the debris that could be generated was not used at this time for the selection. The location was based on a desktop study of the river geomorphology, drawdown elevations, relative flatness, and access of the area.

As described further below, a single debris storage area was determined to be inadequate for the estimated debris volume generated through various flood events during operation and drawdown. Therefore, multiple debris storage areas were examined to determine their ability to provide the area needed for most flood events and allow the operations team to adapt to the unique flood and debris conditions during each event. Additional potential storage areas were also examined to determine their ability to be used for contingency if more LWM is transported to the proposed structure than expected.

This report summarizes the methodology used to develop estimates of the volume of LWM in the inundation pool during flood events. Based on the estimated debris volume calculation results, this report also describes ways in which the expected LWM in the inundation pool may be managed; explains how potential debris storage areas upstream of the proposed structure were identified and evaluates their respective values; identifies two recommended debris storage areas for the Proposed Project, one of which would be needed only for initial flood events; provides a high-level analysis of LWM staging and sequencing which will be used for future operations and sequence planning; and identifies recommended locations and expected function of debris fences upstream of the inundation pool area.

3 LWM Volume Estimation Background

Empirical data and theoretical models were used to estimate LWM volume. The Mud Mountain Dam (MMD) project was used as a template for debris management and as a volume generation empirical data point. To understand debris collection, storage, and management, MMD functions similarly to the proposed FRE facility and has more available empirical data compared to other facilities. Except for the MMD project, typical LWM management practices are not consistently documented for other comparable facilities and there is a lack of published literature specific to debris estimates for such flood storage management systems or even natural river systems.

Section 3.1 provides MMD background data that is used to scale LWM volume estimates to the proposed FRE structure. Several approaches calculating LWM estimates for the proposed FRE project rely on the comparative hydrology of the White River watershed above MMD and the Chehalis River basin above the proposed FRE facility. The hydrology for both sites applicable for the calculations is outlined in Section 3.2. For theoretical methods of determining estimated debris volumes, the estimated debris volume is converted to acreage of debris when collected into holding areas (Section 3.3).

3.1 Mud Mountain Dam

MMD, located near Buckley, Washington, is a flood control dam protecting the lower White and Puyallup River valleys by storing inflows during flood events and then slowly releasing water back into the river. The project is managed for flood operations by staff in the Reservoir Control Center of the U.S. Army Corps of Engineers' (USACE) Seattle District. The reservoir is not used for water supply, and it is typically kept empty until flood events occur. When full, the reservoir stretches 5.5 miles upstream of the dam and covers 1,200 acres at maximum full pool (at the spillway crest elevation). Though the dam has an uncontrolled emergency spillway situated on the right abutment of the dam, it has never spilled since original construction completion in the late 1940s. All flows are released through three large sluice gates at the base of an outlet tower at the base of the dam.

MMD was primarily selected for developing debris estimates and debris management given its similar operations to that planned for the Chehalis FRE Proposed Project. Similar to how the proposed FRE structure would operate, MMD creates a temporary inundation pool to attenuate downstream flooding, and as a consequence accumulates large volumes of LWM that must be collected, stored, and disposed. Though MMD and the proposed FRE facility are comparable in function, their respective watersheds differ in soil type, geology, hillslopes, channel slope, hydrology, sinuosity, vegetation, and land management aspects, all of which affect the volume of LWM generated during flood events. For instance, MMD watershed has a larger percentage of unmanaged forest land cover than the Chehalis basin above the proposed FRE structure. The basin above the proposed FRE structure is primarily managed for commercial timber production and is in regular rotation of harvest and growth cycle. In addition, the Chehalis River upstream of the proposed FRE structure is highly confined by bedrock compared to the White River which flows through more erodible alluvial deposits. The LWM in the Chehalis River may not be sourced as readily if it is rooted in bedrock. Finally, the White River upstream of MMD is less sinuous than the Chehalis River upstream of the proposed FRE structure. At lower flows, more LWM would be captured in the banks and terraces in the Chehalis River compared to the White River but could have a higher build-up of log jams released at high flows. Hence, if basin sizes were the same the amount and type of LWM generated within each basin would differ based on basin characteristics. The specific differences of soil, geology, vegetation composition, land management, and flow duration were not quantified because models approximating LWM quantities based on characteristics and data comparing each of the basins were not available. The general differences used to scale the LWM values include basin size, stream length and peak flows. Equations were developed to quantify the LWM accumulation based on these general, readily available basin characteristics. The general results were used in planning and management of LWM accumulations herein, but are independent from the specific, non-quantifiable differences listed above.

3.1.1 Empirical Data

To develop empirical estimations of LWM areas and rates of removal at MMD, HDR conducted an interview via a video conference with the USACE MMD project operations staff on March 25, 2025. Appendix A contains the interview meeting notes and follow-up

emails, which provide estimates of LWM and operational procedures. During floods, LWM accumulates in the MMD reservoir as a temporary inundation pool forms. The MMD operators work quickly to collect and move the LWM to storage pens contained within floating log booms along the reservoir shoreline near the dam using log bronc boats and floating booms while there is sufficient stored water to accomplish the debris management operation. The LWM volume and debris storage pen areas estimates from operators are imprecise but provide a general estimate of debris storage pen areas typically observed at the Proposed Project. MMD uses three debris storage areas (basins) within the reservoir limits for debris management, mediated by the storage pool elevation achieved during each flood event. The lower basin can contain 5 acres and is used for temporary storage, when needed. The middle and upper basins can contain 13 and 17 acres of debris, respectively. Overflow debris storage areas at the upper basin is used to expand basin capacity by as much as an additional 15 to 20 acres during emergencies. If only the middle and upper basins are used, approximately 30 acres would be available. With additional temporary and emergency storage areas activated, up to 55 acres of storage would be available. Based on an internal debris management plan written by USACE (R. Emry, personal communication, May 5, 2025), debris varies based on frequency and scale of inflow peak flows but between 40 and 60 acres of LWM is expected during larger flood events. Maximum debris loading at MMD is limited to about 60 acres of actively utilized storage area, which has only infrequently been generated at MMD.

Data correlating the amount of LWM stored to flood events or recurrence intervals is limited and based primarily on three flood events observed by USACE (MMD) operators within the past three decades. Previous historical debris estimates for eras prior to the mid-1990s are not available. These three recorded large flood events occurred in 1996, 2006, and 2009, respectively. The USACE operators estimate that in 2009 (the 2009 flood event correlates to a 75-year return interval), between 35 and 40 acres of LWM were generated and stored. For this report, the 2009 flood-generated debris loading was assumed to be approximately 40 acres. The other two floods in 1996 and 2006 used all available storage with debris containment booms expanding into the upper basin emergency storage overflow areas. USACE estimates more than 40 acres of LWM were generated in both the 1996 and 2006 flood events. With emergency storage used and based on the highest gage inflows during these two flood events, the 1996 and 2006 floods were estimated to have generated about 50 and 60 acres of LWM, respectively (refer to Table 4-4 for peak inflow correlations). These LWM acreage estimates at MMD and the White River watershed basin characteristics are used to correlate LWM loadings at the proposed FRE structure.

3.2 Hydrologic Comparison of the White and Chehalis Rivers

Basin hydrologic data and flood event return intervals are used in three of the LWM area estimation approaches. The hydrology of the White River above MMD and the proposed FRE structure on the Chehalis River is described in the subsequent sections for comparison. Additionally, inundation pool elevations observed during flood events where estimated LWM loadings were documented at MMD were roughly correlated to

approximate hydrologic flood recurrence intervals. However, it should be acknowledged that maximum reservoir inundation elevation is not necessarily directly correlated with the inflow event recurrence interval given the variable dam regulation operations that might have been conducted during those events.

3.2.1 Mud Mountain Dam on the White River

U.S. Geological Survey (USGS) gage number 12098000, located at MMD near Buckley, Washington was used to collect water surface elevation data. The gage is currently active with continuous data dating back to 2007. This data was used to form an approximate return interval - flood stage relationship (Table 3-1; HDR 2024b).

Table 3-1. Mud Mountain Dam Flood Stage

Return Interval (year)	Flood Stage (ft)
10	986
20	1,027
50	1,076
100	1,096
500	1,143

Inflow to MMD are recorded at the USGS gage (gage #12097850) located 4.5 miles upstream of USGS gage 12098000. This gage has a continuous period of record from 1974 to 2014. For this analysis, we assumed the inflow at MMD itself is slightly higher than the flow at the upstream USGS gage 12097850, therefore the gage records were scaled up proportionally by the difference in basin size of 6.6 percent. Table 3-2 provides the discharge related to return interval at USGS gage 12097850, which was pulled from StreamStats and multiplied by a factor of 1.066 (USGS 2019).

Table 3-2. Mud Mountain Dam Peak Flows

Return Interval (year)	Flow (cfs)
2	13,511
5	19,468
10	23,404
25	28,511
50	32,340
100	36,170
200	40,106
500	45,319

cfs: cubic feet per second

3.2.2 Proposed FRE Structure on the Chehalis River

The USGS does not have gages on the Chehalis River above the FRE structure's proposed location, but records from the nearby downstream gage at Doty include significant flood events with approximately 40 years of data. Projected inflows at the FRE were calculated by scaling the Doty gage records 80 percent as described in the HDR report *Chehalis River Above Ground Mound: Unregulated Flood Frequency and Record Extension Analysis (Draft)*. Table 3-3 outlines the flows at the proposed FRE structure from HDR (2024c).

Table 3-3. Chehalis Proposed FRE Dam Peak Flows

Return Interval (year)	Flow (cfs)
5	15,500
10	20,200
25	26,800
50	32,200
100	38,000
500	53,500

3.2.3 FRE Inundation Pool

Inundation water surface elevations at the proposed FRE structure were developed using a Hydrologic Engineering Center River Analysis System (HEC-RAS) flow files and a reservoir routing analysis. This was developed by Watershed Science & Engineering and Anchor QEA (HDR 2020). Since development of these inundation water surface elevations in 2020, the Proposed Project design has been updated, and new hydrologic data is available. Future iterations of this report will update the proposed inundation stage elevations accordingly. However, this iteration relies on the 2020 proposed surface elevations, which provide a conservative view of potential stage elevations and are therefore appropriate for use at this phase of design.. These previously developed elevations are assumed accurate for this current level of analysis and provided in Table 3-4.

Table 3-4. Chehalis Proposed FRE Structure Inundation Stage Elevations

Return Interval (year)	Inundation Pool Elevation (ft)
10	568
20	582
50	590*
100	604
500	620

*Interpolated

3.3 Volume to Area Assumption

USACE provided MMD's recorded observations data to HDR in acres (Appendix A). To maintain consistency across results and estimate wood that will fit in debris storage areas, all LWM quantities are reported in acres. Theoretical volume estimates for the Chehalis basin were converted to acres for comparison, assuming the following:

- The assumed height of the debris when stored is on average 2 feet. This is based on visual inspection from a typical debris storage area such as a reservoir on Ross Lake (Photo 3-1) and the average diameter of LWM in the Chehalis basin.
- Based on the *Chehalis Basin Strategy; Operations Plan for Flood Retention Facilities* document, the average diameter of LWM in the upstream reach is 13.6 inches (Anchor QEA 2017).
- Assumed that debris is stacked two logs high as shown in Photo 3-1, accounting for root wads, the average height is assumed to be 2 feet.
- Based on visual inspection from the example at Ross Lake, the void space is estimated to be 80 percent, calculated by multiplying the area estimates by 0.2 to get only the area formed by stacked in line LWM.

Photo 3-1. Ross Lake LWM Storage Yard

4 LWM Area Estimation

Six different approaches were considered to estimate the acreage of LWM that could be transported to the FRE's inundation pool during a flood. The first two approaches outlined in sections 4.1.1 and 4.1.2 are theoretical and assume landslides are the primary source of LWM. Sections 4.1.3 through 4.1.6 outline four approaches that correlate to MMD's empirical data to the proposed FRE facility to estimate LWM acreage.

An additional seventh approach was initially considered but not ultimately adopted. It uses empirical data to predict volumes of debris flows generated by recently burned basins in the western United States. Though this approach is relevant because it uses equations to calculate acreage of LWM based on basin characteristics, the data is sourced more broadly from the western United States. In addition, the burned basins from the study are not relevant to the basin upstream of the proposed FRE facility. These results were so widely varying this method was not used in the analysis (Gartner et al. 2008).

4.1 Methodology

The six approaches used to estimate LWM are described in Sections 4.1.1 to 4.1.6.

4.1.1 Debris from Landslides (Previous Geomorphology Study)

This approach considers LWM inputs from landslides as The *Chehalis Basin Strategy; Geomorphology, Sediment Transport, and Large Woody Debris Report* states that most LWM in the Chehalis basin is sourced from landslides (Watershed GeoDynamics and Anchor QEA 2017). As described in the 2017 report, the LWM volumes are based on past inventoried and digitized landslides from aerial photographs from 1955 to 2008 (Figure 4-1; Watershed GeoDynamics and Anchor QEA 2017). These estimates based on historical data are conservative because future volumes will be based on LWM from forests that will have benefited from improved timber harvest practices. Improved timber practices reduce the risk of initiating mass wasting events such as landslides and debris flows, with potentially less LWM transported to the reservoir. From this report, it is assumed the landslide volume of debris captured by aerial photography occurs during the highest flow recurrence interval flood that year. For instance, in 1978 a 21-year recurrence interval flood event occurred, and the aerial photos in 1978 captured 14,000 cubic yards of debris delivered from landslides. Therefore, the 21-year recurrence interval flood is directly associated with 14,000 cubic yards.

Figure 4-1. Estimated Volume of Wood and Debris Based on Past Storms

AERIAL PHOTOGRAPH YEAR	VOLUME OF WOOD AND DEBRIS (CUBIC YARDS)	HIGHEST FLOW RECURRENCE IN AERIAL PHOTOGRAPH PERIOD
1955	5,800	5
1965	10,000	5
1978	14,000	21
1987	2,300	5
1993	25,000	42
1996	36,000	75
2008	3,300,000	500 +/-

Source: Watershed GeoDynamics and Anchor QEA (2017)

The landslide data was then processed for this report to correlate LWM loadings in acreage to return intervals. Unit conversions and the assumptions from Section 3.3 were used to adjust from cubic yards to acres. Table 4-1 provides the data showing a relationship between acres of LWM sourced from landslides and return intervals. The volume of wood and debris assumed is based on all landslides that occur in the basin upstream of the proposed structure, with all the debris conveyed to the structure. This again conservatively estimates the amount of LWM that may be delivered. Based on past observations at MMD on the White River, the material that mobilizes due to landslides would be deposited on lower-gradient slopes and terraces instead of entering the river (Ecology 2020).

A 5-year recurrence interval flood event occurred three times (1955, 1965, and 1987) resulting in three different volumes associated with the 5-year event. In order to arrive at a singular value for the 5-year recurrence interval data from the 2017 report, these three volumes were averaged. In addition, the largest debris flow that occurred in 2008 is beyond 1.5 times the interquartile range, so it was not used as a data point. As a result, only the data before 2008 was used to form a recurrence interval relationship.

Table 4-1. Area of LWM Based on Return Interval

Return Intervals from Data Excluding Outlier (year)	LWM Loading (acres)
5	0.4*
21	1
42	2
75	2

*Averaged

Plotting the values from Table 4-1 gives a linear regression of y = 0.0266x+0.3046, which was used to develop standard return intervals and LWM loadings as discussed in Section 4.2.1.

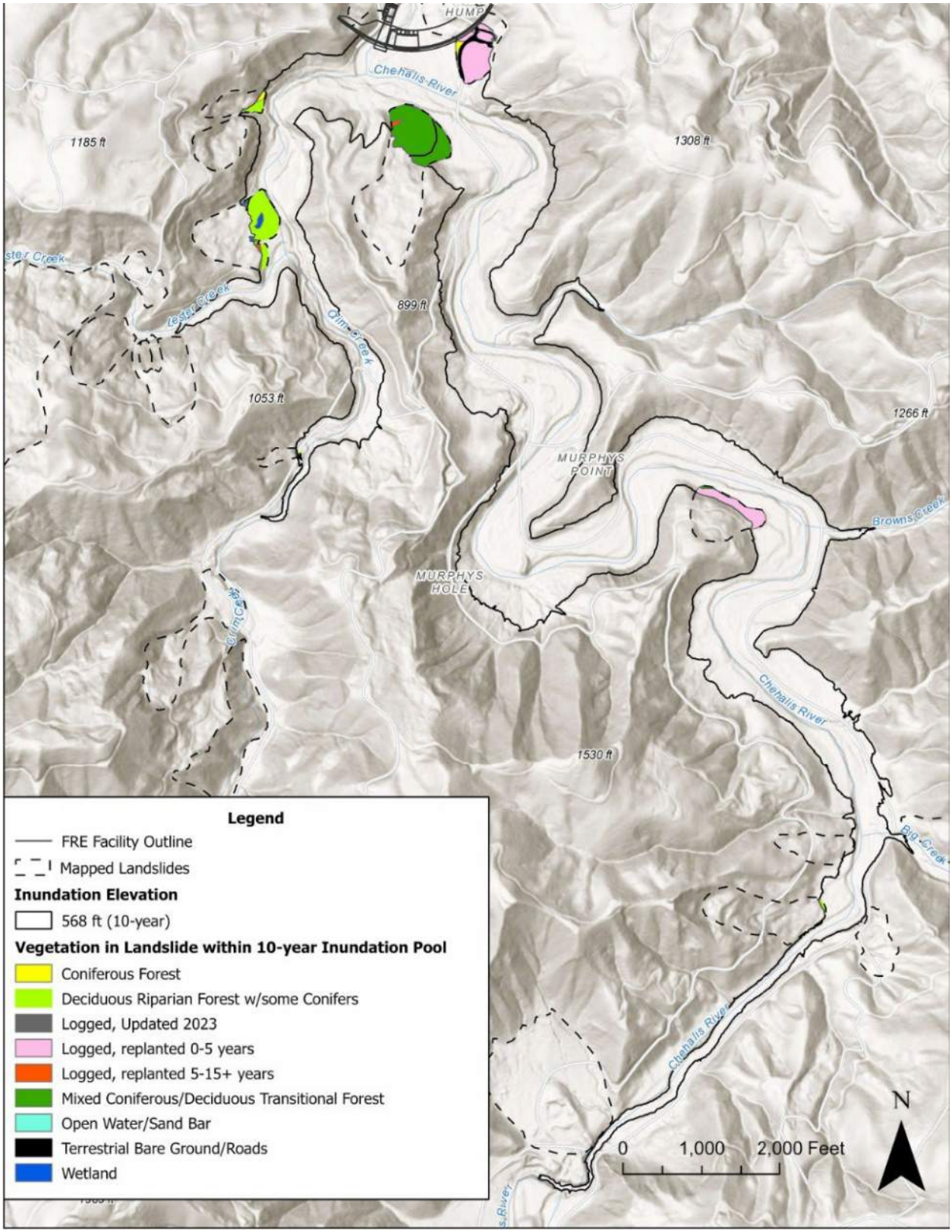
4.1.2 Debris from Landslides (Desktop Analysis) and LWM from the Chehalis River

This method also quantifies debris from landslides similarly to that described in Section 4.1.1, but does not use the established volume correlation based on past inventoried and digitized landslide aerial photographs. Instead, it analyzes the intersection of previously developed data on landslides, vegetation, landslide debris and LWM density.

Landslides previously mapped near the FRE site (HDR 2023) and inundation pools were used to locate areas that could contribute LWM to the Chehalis River. Inundation pools correlated to return intervals for 10-, 20-, 100-, and 500-year events are provided in Table 3-4, in Section 3.2.3. The vegetation composition within each landslide area for each inundation pool was used to estimate the amount of debris that could enter the river at the corresponding return interval.

For this analysis, the amount of debris that enters a river is dependent on how much an area slides and vegetation composition in the slide area. It is assumed the entire landslide area that gets inundated during a large flow event slides into the Chehalis River. An example of this is shown in Figure 4-2, which displays where the mapped landslide and 10-year inundation elevation overlap. It is assumed the landslides close to the structure are not removed and will contribute to LWM loading. It is conservatively assumed for this analysis that the entirety of the identified vegetation areas would result in landslides. These areas within the inundated landslide overlap are further grouped by vegetation classes. For instance, the 10-year event inundates classes of vegetation that include coniferous forest, deciduous riparian forest with some conifers, mixed conifers/deciduous transitional forest, logged areas replanted 0-5 years, and logged areas replanted 5-10 years. These vegetation classes are taken directly from the vegetation management plan (Kleinschmidt 2024).

Figure 4-2. Vegetation Contributing to LWM at 10-year Inundation Pool



Each of the vegetation classes have a different density of LWM per acre of land, which dictates how much LWM gets transported to the river. Densities of vegetation are based on the 2017 geomorphology report, but assumptions were used to assign densities to all classes of vegetation from the vegetation management plan.

The highest density described in the 2017 geomorphology report of 10,000 cubic feet of LWM delivered per acre is assumed to describe the coniferous forest class from the vegetation management report. This assumption of 10,000 cubic feet per acre is made from the 2017 geomorphology report. This value corresponds to estimates of the volume of harvestable wood in 40-year-old second growth Douglas fir stands, an average of 237 to 276 trees per acre and a diameter breast height of 12.1 to 12.2 inches (Watershed GeoDynamics and Anchor QEA 2017). The lower density vegetation classes were scaled down based off the starting 10,000 cubic feet as show in Table 4-2. The assumptions used to scale down from the coniferous forest were based on stand age and vegetation composition.

Table 4-2. Vegetation Class LWM Density Relationship

Vegetation Class (Kleinschmidt 2024)	LWM (cubic foot per acre*)
Coniferous forest	10,000
Deciduous Riparian Forest with some Conifers	5,000
Mixed Coniferous/Deciduous Transitional Forest	5,000
Logged and Replanted 5-15+ years	2,000
Logged and Replanted 0-5 years/Logged Updated 2023	500
Deciduous Riparian Shrubland	0
Herbaceous/Grass	0
Open Water/Sand Bar	0
Terrestrial Bare Ground/Roads	0
Wetland	0

*Based on Watershed GeoDynamics and Anchor QEA 2017

Using GIS, the areas where the inundation pool and landslide overlap were calculated. These areas were then grouped into the various vegetation classes and multiplied by their associated density from Table 4-2. This results in a total volume of LWM. This volume of LWM was then converted to acres of LWM based on the assumptions in Section 3.3. This method was applied to all return interval years analyzed. An example calculation is provided below during a 10-year flood event for the Deciduous Riparian Forest with some Conifers vegetation class. Five acres of this class are estimated to slide based on the GIS analysis, and the density is 5,000 cubic feet per acre.

$$5\ acres * 5{,}000 \frac{ft^3}{acre} = 26{,}700\ ft^3$$

This volume is converted to acres of LWM based on the assumptions in Section 3.3.

$$\frac{26{,}700\ ft^3}{2ft} * 0.2\ (desnity\ factor) = 2{,}670\ ft^2$$

$$\frac{2{,}670\ ft^2}{43560 \frac{ft^2}{acre}} = 0.1\ acres$$

Therefore, in this 10-year event scenario approximately 0.1 acres are delivered to the FRE facility for that vegetation class. The summation of all contributing vegetation classes results in total acreage for each recurrence interval.

After computing the LWM contribution from landslides, contributions from LWM in the river were added. Contributions from the river are based on the density of wood in the river based on field surveys detailed in Watershed GeoDynamics and Anchor QEA (2017). Using this data, it is assumed the average volume of LWM per river mile is 2,032 cubic feet. The density per river mile was then multiplied by the river mile reached by the inundation pool at each return interval to find LWM loading volumes. The flood events corresponding to the 10-, 20-, 50-, and 100-year return intervals have inundation pools that extend to river miles 5, 5, 5.5, and 6 respectively as provided in Table 4-3.

Table 4-3. Vegetation Class LWM Density Relationship

Return Interval (year)	Chehalis Flood Stage (ft)	River Miles Inundated Upstream of FRE Structure
10	568	5.0
20	582	5.0
100	604	5.5
500	620	6.0

An example calculation for the 10-year event is provided below:

$$5\ miles * \frac{2{,}302\ ft^3}{river\ mile} = 10{,}160\ ft^3$$

This volume is converted to acres of LWM based on the assumptions in Section 3.3.

$$\frac{10{,}160\ ft^3}{2\ ft} * 0.2\ (density\ factor) = \ 1{,}016\ ft^2$$

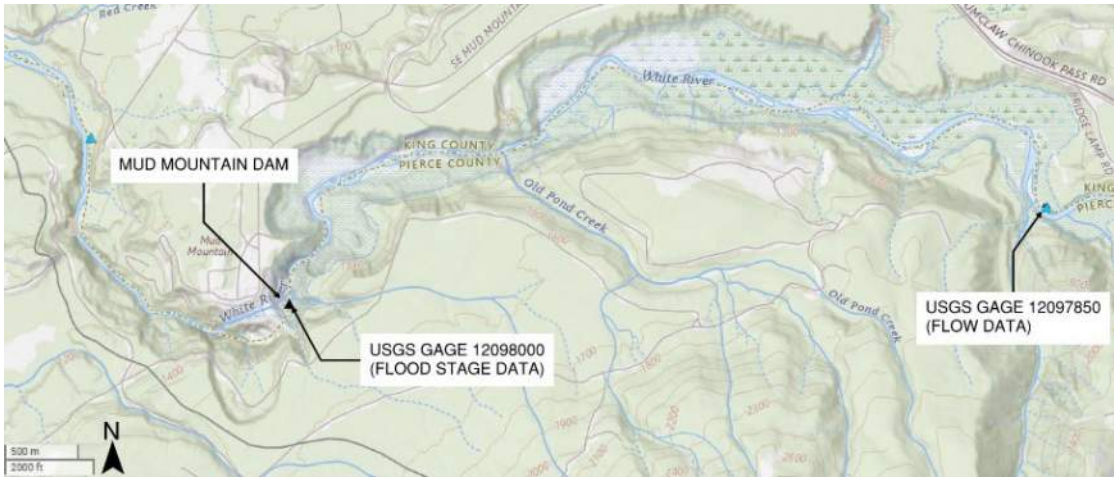
$$\frac{1{,}016\ ft^2}{43{,}560 \frac{ft^2}{acre}} = 0.02\ acres$$

For each recurrence interval, the acreage from the landslides and river mile calculation are added together. Results are shown in section 4.2.2.

4.1.3 Peak Flows correlated to LWM Loading

This method uses empirical data from MMD operators, flood stage gage data at USGS gage 12098000, recurrence intervals for flood stage based on gage 12098000, flows at MMD from USGS gage 12097850, and recurrence intervals associated with flow at the proposed Chehalis FRE facility (Table 3-3). See Figure 4-3 for locations of each gage on the White River.

Figure 4-3. USGS Gage Locations on White River at and Upstream of MMD



These gages are used for estimating LWM loading based on a return interval at the Chehalis FRE facility. The following is assumed in this methodology:

- The MMD reservoir flood stage recurrence intervals from USGS gage 12098000 are correlated directly to flood flow recurrence intervals from USGS gage 12097850. Therefore, flood stage at a specific recurrence interval are associated with a specific flow event at that recurrence interval.
- Large LWM events that occurred in 1996, 2006 and 2009 are assumed to have delivered that LWM when the highest daily flood stage occurred. This highest daily flood stage is obtained from USGS gage 12098000. Therefore, each LWM loading is associated with one stage elevation (Table 4-4).
- The peak flows-to-LWM scaling factor described in this section is the same for MMD and the proposed FRE facility. Therefore, the same flow is estimated to deliver the same LWM acreage at MMD and the proposed FRE facility independent of basin characteristics.

Based on empirical data from MMD operations, the largest LWM loading events occurred in 1996, 2006, and 2009. The largest daily flow events from 1996, 2006, and 2009 were pulled from USGS gage 12098000. The 2006 flood event was not used as it was evident that the USGS reservoir elevation gage failed to accurately read the actual reservoir level. With daily USGS gage data from 1996 and 2009, the peak flood elevations recorded for those years were 1,196 and 1,160 feet, respectively.

These peak flood stages from 1996 and 2009 at MMD were correlated with a recurrence interval. A power function was fit to flood stage recurrence intervals from Table 3-1 to best model the relationship between flood stage and recurrence interval. Using this power function, a theoretical recurrence interval for the 1996 and 2006 flood stages of 1,196 and 1,160-feet were calculated. The flood stages in 1996 and 2009 are both larger than the known flood stage that occurs at the 500-year event, so the correlated recurrence intervals are larger than a 500-year event. The flood event that occurred in 1996, for instance, was calculated to have a 1,148-year recurrence interval. This recurrence interval is associated with delivering 50 acres of LWM as provided in Table 4-4.

A logarithmic relationship was then fit between peak flow and recurrence intervals from Table 3-2 (from USGS gage 12097850). The logarithmic relationship captures the observed data well and was applied to the theoretical recurrence intervals in Table 4-4 to calculate a flow for two specific return intervals in 1996 and 2009. The full relationships between the flood year, LWM loadings, flood stage, recurrence interval, and flow are provided in Table 4-4.

Table 4-4. Known LWM Loadings correlated to Peak Flows and Recurrence Intervals at Mud Mountain Dam

Flood Year	Known LWM Loading During Flood Year (acres)	Highest Flood Stage on Record During Flood Year (ft)	Theoretical Recurrence Interval (year)	Correlated Flow (cfs)
1996	50	1,196	1,148	49,856
2009	40	1,160	521	45,339

The flows based on return interval at the proposed Chehalis FRE dam were then correlated to LWM loadings at MMD based on Table 4-4. The LWM was scaled by relating the LWM loading to the flow at MMD. The relationship between LWM acreage and flow at MMD was calculated to be 0.00094:

$$\frac{LWM\ Loading\ in\ 1996}{Flow\ in\ 1996\ during\ the\ LWM\ loading\ event} = \frac{50\ acres}{49{,}856\ cfs} = 0.00088$$

$$\frac{LWM\ Loading\ in\ 2009}{Flow\ in\ 2009\ during\ the\ LWM\ loading\ event} = \frac{40\ acres}{45{,}339\ cfs} = 0.0010$$

$$Average = 0.00094$$

With this scaling factor of 0.00094, the flows from return intervals for the 10-, 20-, 50-, and 100-year from Table 3-3 were each multiplied by 0.00094 to get the LWM acreage at each return interval. This scaling factor overestimates LWM loading because basin characteristics differences are not fully captured when only scaling LWM estimates off peak flows. Peak flows in the basin upstream of the proposed FRE structure are similar to the peak flows upstream of MMD. Though the basin size above MMD is much larger

than the basin upstream of the proposed FRE structure, peak flows in the Chehalis River are high because it is a flashier system.

4.1.4 Peak Flows Correlated to LWM Loading Scaled by River Mile

Peak flows at the proposed Chehalis FRE structure are larger than peak flows at MMD, yet the basin receiving these flows is six times smaller that the White River basin above MMD. In addition, the river above MMD is three times longer than at the Chehalis River upstream of the proposed FRE facility. The following are assumed for this approach:

- LWM loadings scaled only from peak flow result in an overestimation at the proposed Chehalis FRE structure. The LWM loading is expected to be less at the proposed Chehalis FRE structure than at MMD.
- Basin size and river length are accurate indicators of LWM transport and are used to scale LWM loadings in sequence after scaling LWM from peak flows.

LWM loadings that have been previously scaled by flow (Section 4.1.4) are then scaled again based on river mile. River mile is used instead of basin size because river mile scaling results in a more conservative estimate. The sample calculation below represents the LWM during the 10-year event:

$$\frac{LWM\ at\ Chehalis\ FRE\ Structure\ from\ Peak\ Flow\ Correlation\ (Section\ 4.1.3)}{LWM\ at\ Chehalis\ FRE\ Structure\ (Section\ 4.1.4)} = \frac{River\ Length\ Upstream\ of\ Mud\ Mountain\ Dam}{River\ Length\ Upstream\ of\ Chehalis\ FRE\ Structure}$$

$$\frac{19\ acres}{LWM\ at\ Chehalis\ FRE\ Structure\ (Section\ 4.1.4)} = \frac{60\ miles}{19\ miles}$$

$$LWM\ at\ Chehalis\ FRE\ Structure\ (Section\ 4.1.4) = 6\ acres$$

This methodology is applied to all return intervals, and results are provided in Section 4.2.4.

4.1.5 Basin Area versus LWM Loading

This method results in one value for the maximum expected LWM loading based on a correlation of basin areas. The basin area upstream of MMD is compared to the area upstream of the proposed FRE dam to scale LWM loading from the Chehalis River. Though the specific basin characteristics within the two basin areas differ, this scaling compares a general, quantifiable basin characteristic between MMD and the proposed FRE structure. The MMD has a basin area of 400 square miles (USGS 2019) with no anthropogenic structures in the river to obstruct wood conveyance. Similarly, no obstructions are upstream of the proposed FRE structure, which has a basin area of 69 square miles (HDR 2024c). With an assumed maximum LWM loading of 60 acres at MMD, the equation used in this method to solve for LWM at the proposed FRE facility is:

$$\frac{Basin\ Area\ Upstream\ of\ Chehalis\ FRO\ Structure}{LWM\ at\ Chehalis\ FRO\ Structure} = \frac{Basin\ Area\ Upstream\ of\ Mountain\ Mountain\ Dam}{LWM\ at\ Mud\ Mountain\ Dam}$$

This scaling results in a singular LWM acreage that represents the largest acreage that is delivered based on this approach.

4.1.6 River Length versus LWM Loading

This method results in one value based on a correlation of river length. The river length upstream of MMD is compared to the river length upstream of the proposed FRE structure to scale LWM loading from the Chehalis River. Similarly to basin size, though the riverine characteristics within the two basin areas greatly differ, this direct scaling can serve as a preliminary reference point between MMD and the proposed FRE structure. USGS river miles created by Ecology were used to estimate the length of the main forks for the Chehalis and White Rivers. The White River is 46 miles long (Ecology 2023). In addition, the western tributaries to the White River are assumed to convey LWM and added to the length of the main river. This western tributary to the White River was estimated in GIS to be 14 miles long, so the overall length of river contributing to LWM loading upstream of MMD is assumed to be 60 miles. The Chehalis River upstream of the proposed FRE structure is 19 miles (Ecology 2023). With an assumed maximum LWM loading of 60 acres at MMD, the equation to solve for LWM at the proposed FRE facility is:

$$\frac{River\ Length\ Upstream\ of\ Chehalis\ FRE\ Structure}{LWM\ at\ Chehalis\ FRE\ Structure} = \frac{River\ Length\ Upstream\ of\ Mountain\ Mountain\ Dam}{LWM\ at\ Mud\ Mountain\ Dam}$$

4.2 Results

Results from the methodologies outlined in Section 4.1 are presented in the following sections.

4.2.1 Debris from Landslides (Previous Geomorphology Study)

The linear regression developed from the geomorphology report results in the following LWM loadings based on standard return intervals (Table 4-5):

Table 4-5. LWM from Debris (Previous Geomorphology Study)

Return Intervals (year)	LWM Loading (acres)
10	1
20	1
50	2
100	3
500	14

4.2.2 Debris from Landslides (Desktop Analysis) and LWM from River

Adding together the debris acreage from landslides and the river inputs results in the following LWM loadings (Table 4-6):

Table 4-6. LWM from Landslides and Density in Chehalis River

Return intervals (year)	LWM Loading (acres)
10	0.2
20	0.3
100	0.4
500	0.4

4.2.3 Peak Flows correlated to LWM Loading

Using linear regression and interpolation, Table 4-7 presents the LWM loading results.

Table 4-7. LWM correlated from Peak Flows

Return Intervals (year)	Flow (cfs)	LWM Loading (acres)
10	20,200	19
20	23,200	22
50	32,200	30
75	35,100	33
100	38,000	36
500	53,500	50

4.2.4 Peak Flows Correlated to LWM Loading Scaled by River Mile

Using linear regression and interpolation, Table 4-8 presents the LWM loading results scaled by river mile.

Table 4-8. LWM Correlated from Peak Flows Scaled by River Mile

Return Intervals (year)	Flow (cfs)	LWM Loading (acres)
10	20,200	6
20	23,200	7
50	32,200	10
75	35,100	10
100	38,000	11
500	53,500	16

4.2.5 Basin Area versus LWM Loading

Using the equation from 4.2.4, the LWM loading results in 10 acres.

4.2.6 River Length versus LWM Loading

Using the equation from 4.2.6, the LWM loading results in 19 acres.

4.3 Summary of Results

The results are summarized into two main categories: theoretical (Sections 4.2.1 and 4.2.2) and empirical data (Sections 4.2.3, 4.2.4, 4.2.5, and 4.2.6). Not distinguishing between categories, four methods (Sections 4.2.1, 4.2.2, 4.2.3, 4.2.4) result in acreages associated with recurrence intervals and two methods (Sections 4.2.5 and 4.2.6) result in singular LWM acreage values. The recurrence intervals inform how the expected LWM acreages align with proposed FRE structure operations. Knowing how much LWM a 10-year flood versus a 100-year flood will deliver will assist in dam planning operations. Singular acreage values do not distinguish how various flows affect LWM loadings but are used as reference data points to understand if the overall results have similar orders of magnitude to increase confidence of the results.

The two theoretical methods use landslide models and result in LWM acreage estimates associated with recurrence intervals (Sections 4.2.1, 4.2.2). The landslide models are specific to the Chehalis basin above the proposed FRE structure and based on several assumptions:

- The landslide volume of debris captured by aerial photography occurs during the highest flow recurrence interval flood that year and does not account for other smaller events (slower processes or lower flow events) that may have occurred and recruited LWM.
- Past amounts of LWM transported will occur in the future, which may not be the case if land management improvements increase soil stability.
- Most or all LWM is sourced from landslides. Though the landslide methods provide a representation of what would be transported during these singular mass wasting

events, it does not account for additional ways LWM could be transported. In addition to landslides, debris loading during floods could come from wind fallen trees, localized hillslope erosion that creates transport pathways for LWM from higher up in the basin, or LWM in or near the river.

This list is not exhaustive and many more methods of LWM recruitment could occur. Aside from the recruitment and transport of LWM from typical river hydraulics, hydrologic impacts, and basin characteristics, how the inundation pool interacts with the surrounding land will affect landslide potential. The surface area of the pool, how high up the pool is on basins' hillslopes, and the reservoir evacuation rate will affect how the LWM interacts with bank stability. These aspects affect LWM buoyancy forces that dictate how LWM will move in an inundation pool but were not modeled. The landslide approaches are based on landslide volume models specific to the basin, but are limited by the lack of empirical data, the assumption that past events are direct indicators of future events, and the uncertainty of how the LWM will be transported.

The four empirical methods (Sections 4.2.3, 4.2.4, 4.2.5 and 4.2.6) use MMD data previously described in Section 3.1. They incorporate documented observations over the last few decades instead of theoretical data based on past landslides and assumptions. The empirical methods does not address the question of how LWM may be recruited and transported within the basin. How LWM is recruited and transported is affected by specific basin differences such as soil composition, vegetation differences, method of LWM transport, hillslope, landslide occurrences and land management. Though these affect transport methods, these specific methods do not have readily available models or equations with adequate basin data to quantify LWM acreage. Instead, these empirical methods are limited to quantifying LWM acreage with more general basin characteristics that may or may not account for the specific differences. To account for basin differences, the methods correlate LWM observed at MMD during large flow events to the proposed FRE structure by scaling off of one or more basin characteristics: peak flows (Section 4.2.3), peak flows and river miles (Section 4.2.4), basin area (Section 4.2.5), and river miles (Section 4.2.6).

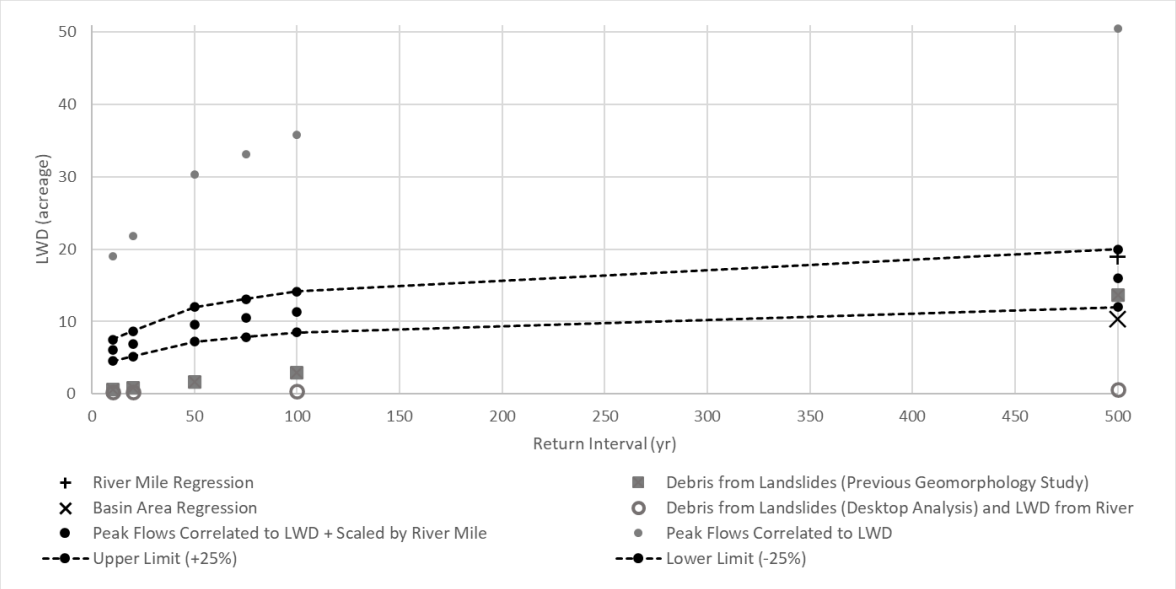
The method from Section 4.2.3 uses peak flows to scale LWM acreage estimates at MMD to the proposed FRE structure. It results in LWM acreage associated with a recurrence interval. The limitation with this result is that the peak flows do not accurately reflect the difference in basin size or river length between MMD and the proposed FRE structure. MMD has a river length three times as long as the river upstream of the proposed FRE structure, and a basin area six times as large as the basin upstream of the proposed FRE structure. Basin hydrology upstream of the proposed FRE structure is much flashier than the basin upstream of MMD, so the peak flows are similar even though the basin sizes and river length vary greatly. The LWM acreage from this method is likely an overestimate because the peak flows at MMD are approximately the same magnitude as flows at the proposed FRE facility.

Scaling off basin area (Section 4.2.5) and river mile (Section 4.2.6) result in lower LWM acreage at the proposed FRE facility than at MMD. This is expected because the basin upstream of MMD is bigger than the basin upstream of the proposed FRE structure, and the White River upstream of MMD is longer than the Chehalis River upstream of the proposed FRE facility. Both methods result in a singular LWM acreage estimate.

The final empirical method (Section 4.2.4) uses the peak flow scaling from Section 4.2.3 and re-scales the LWM acreage estimates by river length capturing specific data for the proposed FRE facility. This method was chosen to approximate acreage at the proposed FRE structure because it is based on empirical evidence from MMD, and accounts for peak flows and river length. This method results in the same order of magnitude of LWM acreage as all other methods, and accounts for uncertainties in transport method by scaling from empirical data and outputs data based on recurrence intervals.

A contingency of 25 percent was applied to the results from Section 4.2.4 to provide an estimate of lower and upper limit bounds of how much storage area is needed based on methodology uncertainties. All results and the upper/lower contingency limits are plotted on Figure 4-4. These uncertainties include how LWM recruitment between MMD and the proposed FRE structure vary and for specific methods of transport that are not modeled. The upper range for the 25 percent contingency is used to size storage areas needed for LWM as provided in Table 4-9.

Figure 4-4. Return Interval Data Summary



NOTE: For flood events in which the spillway is activated, a significant portion of the debris would pass over the spillway and not collect in the reservoir.

Table 4-9. Final LWM Loadings

Return Intervals (year)	LWM Loading- Upper 25 Percent Limit (acres)
10	8
20	9
50	12
100	14
500	20

5 FRE Potential Debris Storage Areas

After a flood occurs and transports LWM to the proposed FRE structure, the LWM must be transported away from the structure to reduce loading on the structure, block the spillway, or cause blockages along the natural river flow. The LWM will be stored in debris storage areas similar to the storage basins at MMD. After the LWM is stored, and the area dries out enough for vehicles to operate in each storage area, the LWM will be removed and managed as described in the Mitigation Plan (Kleinschmidt 2024). Debris storage area locations and sizes were determined with a desktop analysis and refined during a site visit.

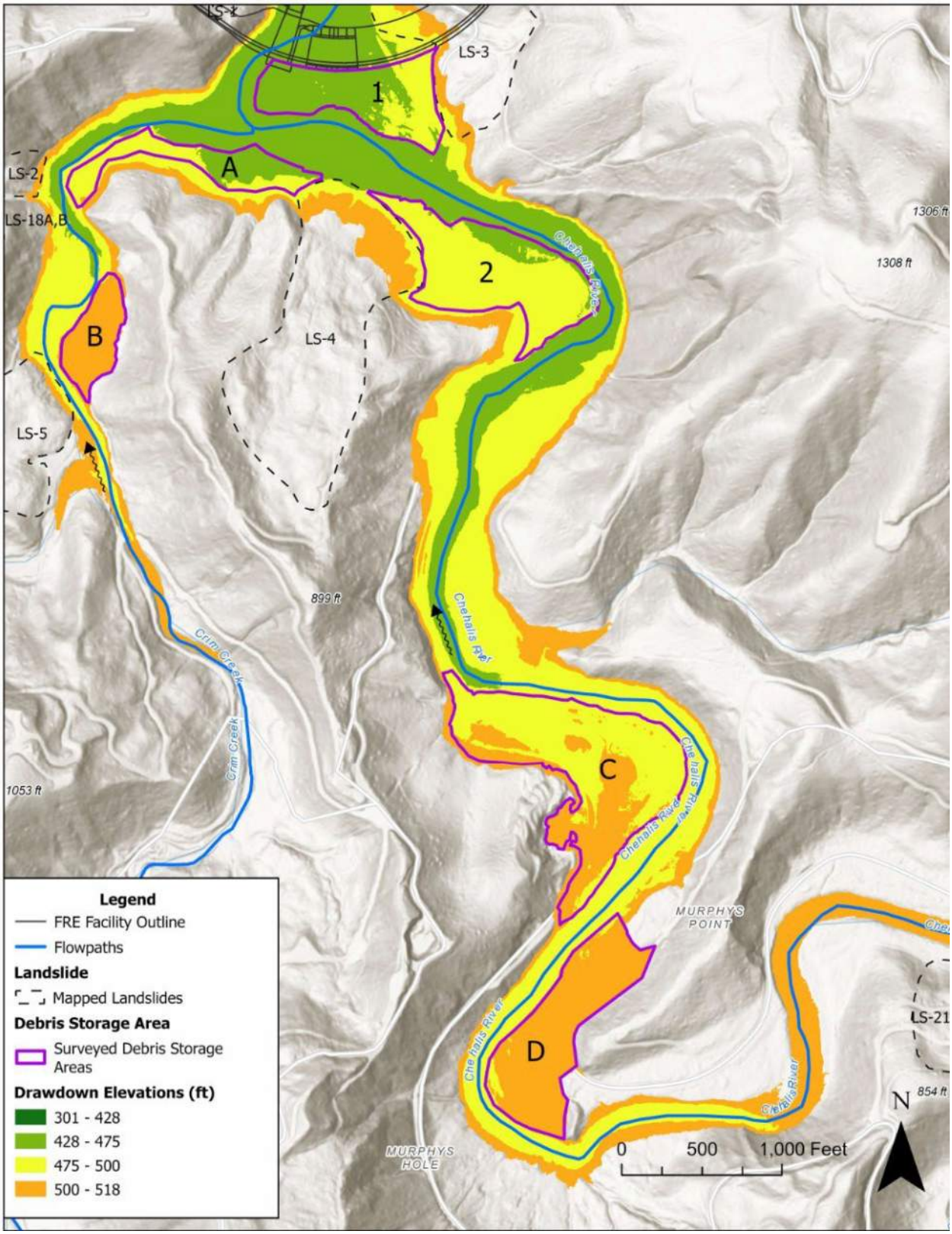
From the desktop analysis, storage areas were determined suitable based on characteristics from the existing MMD storage areas. These areas had continuous land accessible by road with slopes less than 5 percent and were accessible by boat after floods.

Debris storage areas need an estimated minimum of 10 feet of water above the ground surface to be navigable by the log broncs. A log bronc is a small, rugged tugboat used to maneuver and corral floating logs. For the Chehalis River, the debris storage areas were initially located based on elevations below 518 feet. This was chosen as the highest elevation possible because the drawdown process was anticipated to begin at a water surface elevation of 528 feet (Anchor QEA 2017). The debris storage areas also were chosen to be located above the bankfull width, so they are not affected by normal run-of-river operations. The bankfull width is based on topographic breaks, vegetation composition and sediment observed in the field as well as LiDAR and aerial imagery. Applying these criteria and evaluating 2-foot topographic LiDAR contours, preliminary debris storage areas were developed remotely. A site visit on May 21, 2025 with HDR and Northwest Hydraulic Consultants was conducted to ground truth the preliminary locations. The locations of six potential yards for LWM storage are depicted in Figure 5-1 and identified as areas 1, 2, A, B, C and D. As described further in Section 7.3.3, areas 1 and 2 are the recommended debris management areas for the Proposed Project. These areas are densely forested and must have trees and shrubs cleared from the area to be used for LWM storage areas. Areas A, B, C, and D are not recommended or necessary for debris management purposes as further described in Section 7.3.3.

The mapped landslide area between debris storage areas 2 and A, noted as LS-4 in Table 7-1 of the draft PDR (HDR 2025a), was not included as a debris storage option at this time. The landslide area will be evaluated for stabilization and further evaluation for its use as a storage yard performed.

The following sections outline details on each storage area’s topography, vegetation, accessibility, elevation, and area.

Figure 5-1. Potential Debris Storage Areas from Reconnaissance Survey



5.1 Debris Storage Area 1

Debris storage area 1 is located immediately adjacent to the proposed FRE structure on the right bank of the Chehalis River. The landslide immediately at proposed FRE structure will be removed during construction, so this landslide was ignored when selecting this area as a debris storage area. A road that cuts through the middle of this storage area is accessible from the main logging road (1000 Road). The area mildly slopes towards the river and is densely forested with an understory. Photo 5-1 shows the edge of the forested area where it meets the Chehalis River. The total storage capacity of this yard is 9.2 acres and elevations range from 447 to 495 feet.

Photo 5-1. Typical Vegetation in Debris Storage Area 1

Note: Southwestern edge of yard looking at the Chehalis River

5.2 Debris Storage Area 2

Debris storage area 2 is located approximately 1,700 feet upstream of the proposed FRE structure location on the left bank of the Chehalis River. It is located immediately south of the Panesko Bridge and can be accessed directly from 1000 Road. Half of this proposed storage area is east of 1000 road and half is west. It occupies 13.2 acres and elevations range from 467 to 495 feet. The area west of 1000 Road is flat with some cleared areas and some densely forested areas as depicted in Photo 5-2. The upper elevations of this

debris storage area are located at the toe of a hillslope that borders this storage area to the west. The eastern portion of this debris storage area slopes slightly to the Chehalis River and is forested with a dense understory of shrubs and ferns. Photo 5-3 depicts the Chehalis River from the perspective of the eastern edge of the storage area.

Photo 5-2. Western Portion of Debris Storage Area 2

Photo 5-3. Eastern Edge of Eastern Debris Storage Area 2

Note: Looking at the Chehalis River.

5.3 Debris Storage Area A

Debris storage area A is located at the confluence of the Chehalis River and Crim Creek. It runs parallel to Crim Creek's right bank, and a small portion of the Chehalis River left bank. An old road runs through the middle of the potential storage area and splits it into northern and southern areas (Photo 5-4). This road will need to be reconstructed for access to this storage area. While this debris storage area was not scouted during the May 21, 2025 site visit, the road was observed. The area was later determined remotely from the original desktop criteria. It occupies more than 4.7 acres and elevations range from 458 to 503 feet.

Photo 5-4. Old Road Cutting Through Debris Storage Area A

Note: At the Most Eastern Edge of the Yard Looking West.

5.4 Debris Storage Area B

Debris storage area B is located on the right bank of Crim Creek, approximately 2,500 feet from the proposed structure. The road that cuts through debris storage area 3 is the same road that would need to be reconstructed to access debris storage area B (Photo 5-5). This potential storage area is located on a flat bench approximately 30 feet above Crim Creek's bank toe. This area has a young forest with a low growing understory of ferns and shrubs (Photo 5-6). It occupies 4.1 acres and elevations range from 495 to 518 feet.

Photo 5-5. Access Road to Yard Storage Area B

Note: Looking North.

Photo 5-6. Flat Bench Above Crim Creek in Debris Storage Area B

Note: With Young Trees and Fern Understory.

5.5 Debris Storage Area C

Debris storage area C is located approximately 5,300 feet upstream of the proposed FRE structure on the left bank of the Chehalis River and along 1000 Road. A portion of this proposed storage area is west of 1000 Road, but most is on the east side. It occupies 20.6 acres and elevations range from 485 to 518 feet. The area west of 1000 Road has already been cleared (Photo 5-7), and the flat area to the toe of the hills to the west can be used for LWM storage. Part of the eastern portion of this debris storage area has also already been cleared (Photo 5-8). The rest of the eastern portion slopes slightly toward the Chehalis River and is forested with a dense understory of shrubs and ferns. Photo 5-6 shows the eastern edge of the debris storage area from the Chehalis River where the bank is approximately 10 feet high.

The debris storage area (approximately 4.5 acres) originally identified in Anchor QEA (2017) as the single debris storage area for the Proposed Project and described in additional detail in HDR (2021), is located within debris storage area C.

Photo 5-7. West Side of Debris Storage Area C

Photo 5-8. Cleared Eastern Side of Debris Storage Area C

Note: Facing Northwest.

5.6 Debris Storage Area D

Debris storage area D is located on the right bank of the Chehalis River, approximately 7,100 feet upstream from the proposed FRE structure. It is located on 1000 Road upstream of debris storage area C. Approximately half of this proposed storage area is west of 1000 Road, but the other half is on the east side. It occupies 12.7 acres and elevations range from 494 to 518 feet. The area east of 1000 Road has been partially cleared with a road (Photo 5-9). The area west of 1000 Road is flat with grass and a dense young forest (Photo 5-10). This western portion slopes slightly toward the Chehalis River from 1000 Road.

Photo 5-9. Eastern Side of Storage Area D

Note: Partially cleared.

Photo 5-10. Western Side of Debris Storage Area D

Note: Young forest with grass ground cover.

5.7 Summary of Results

Together these six potential storage areas can provide approximately 64.5 acres of LWM storage area, however estimated LWM volumes provided in Table 4-9 indicate that much less storage area is needed. In addition, during larger storm events in which the spillway crest is overtopped, storage operations will be paused to allow LWM to be transported over the spillway. Current hydraulic and hydrologic analyses indicate the spillway will overtop at less than a 100-year flood event. Therefore, the highest estimated LWM load requiring debris storage will be approximately 14 acres.

Storage areas 1, 2, and A located lower in the reservoir and closer to the FRE structure are preferred compared to B, C, and D. These areas reduce the distance required for transport of LWM following collection, keep equipment closer to the Proposed Project site, and allow more of the inundation area to be drained quickly, reducing potential environmental impact. Areas 1 and 2 provide sufficient storage area for 14 acres of LWM delivered during a 100-year flood event and are located closest to the FRE structure and lower in the temporary inundation area.

Figure 5-2 shows the debris storage areas 1 and 2 which are recommended to be included as part of the Proposed Project. Figure 5-3 shows road features and access to debris storage areas 1 and 2. Areas A, B, C, and D are not planned as part of this Proposed Project but are included herein to document they were studied and found to be unnecessary.

Figure 5-2. Proposed Debris Storage Areas

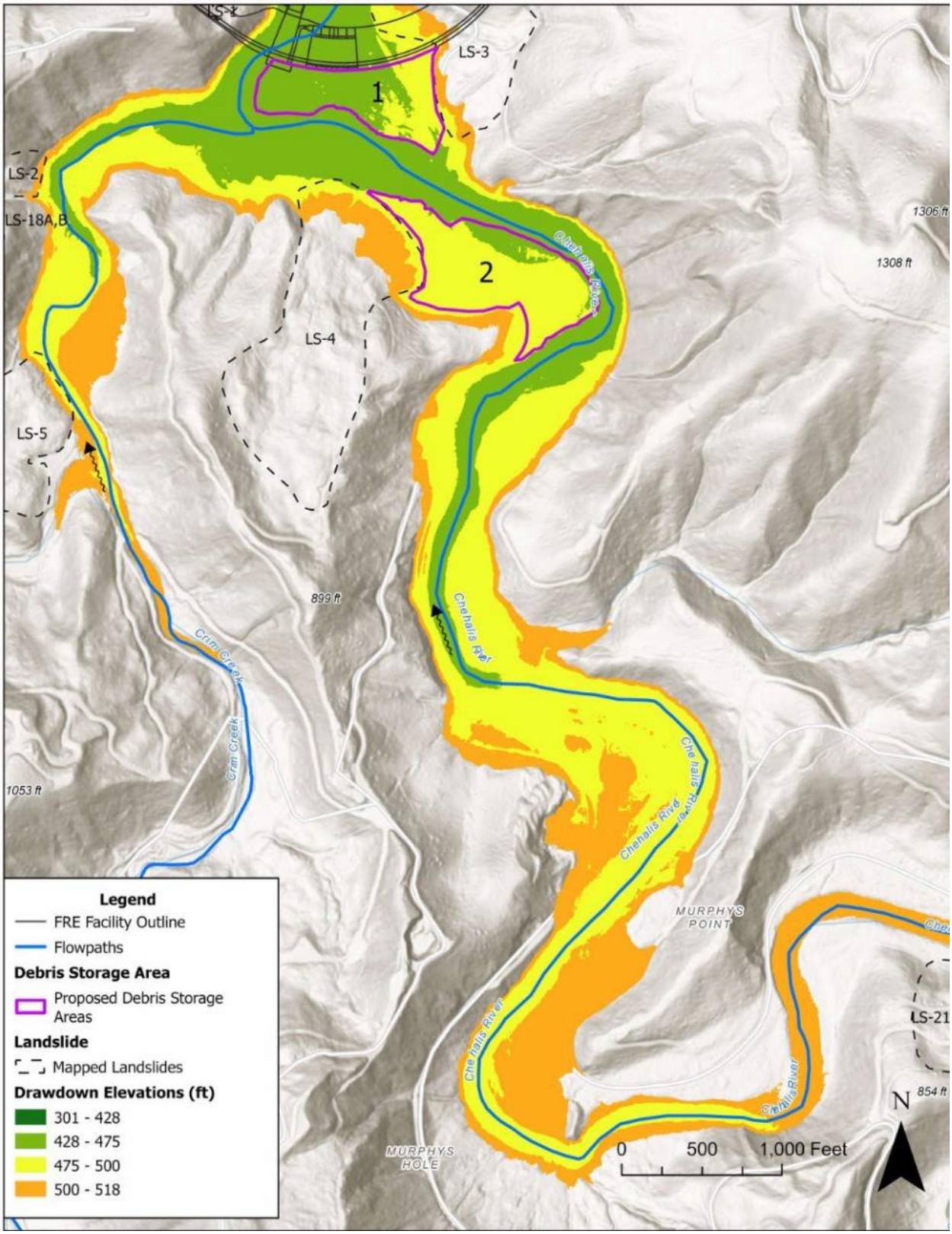
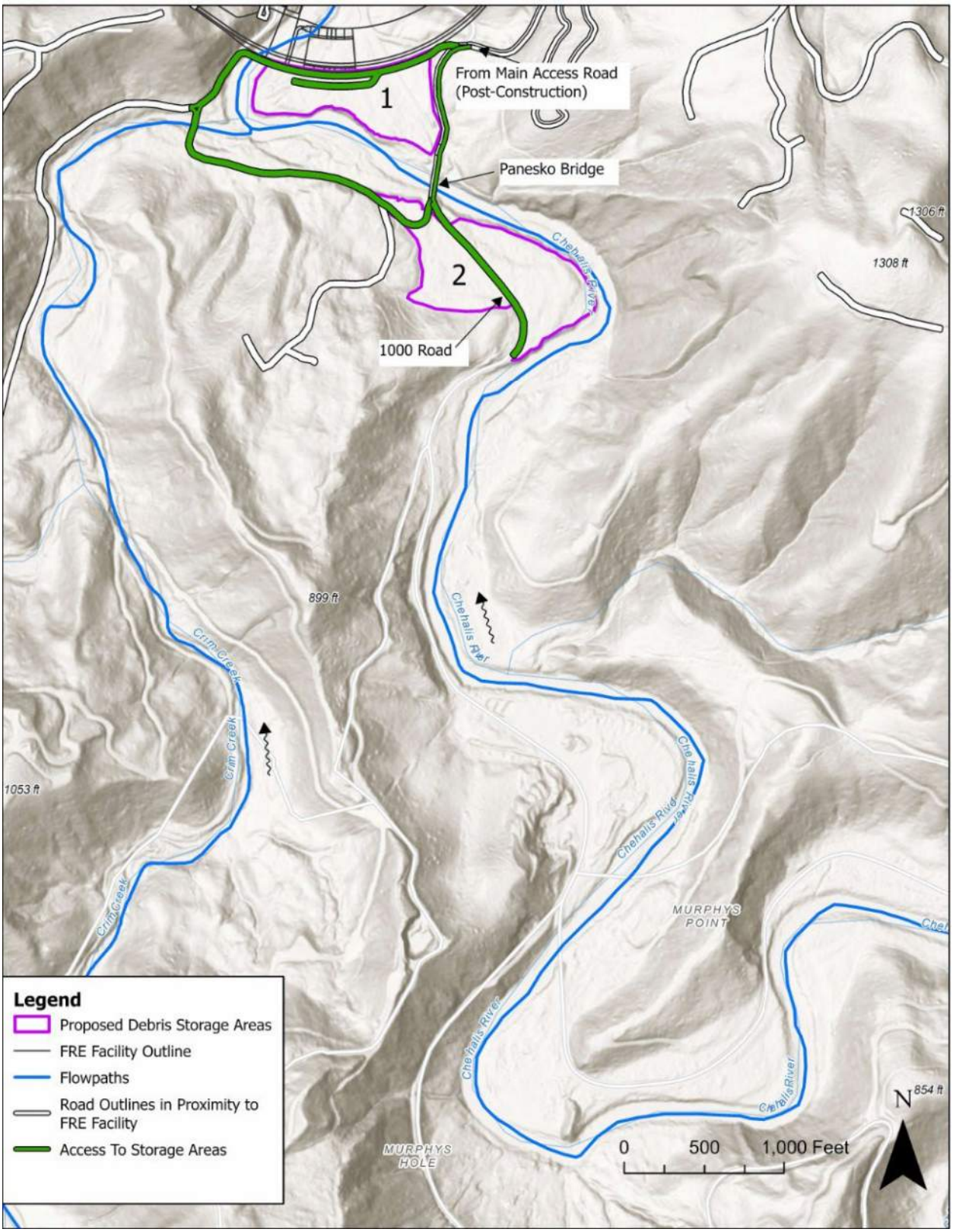


Figure 5-3. Access to Proposed Debris Storage Areas



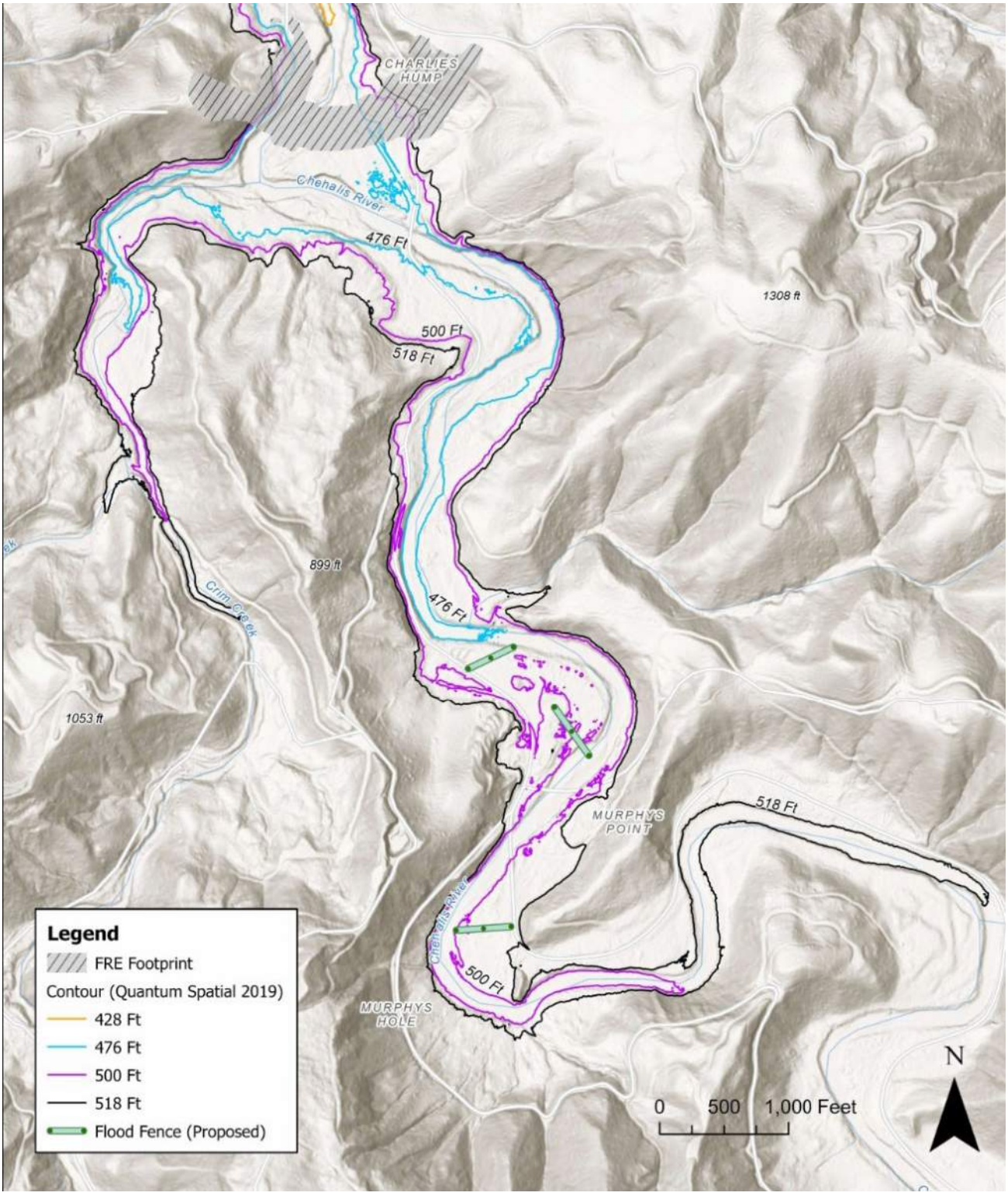
6 Debris Fences

During flood operation, debris will also be recovered from the water during drawdown from road accessible debris fences. The debris fences will trap floating debris at different elevations as the temporary reservoir water level recedes. This will also help reduce the time needed for in-water debris removal.

Figure 6-1 presents the proposed layout of debris capture/retention fence locations and alignments that could be implemented to help trap floating debris during flood events when the FRE structure's outlet regulation is triggered. The proposed upstream debris capture fences would not be engaged by the pool inundation except during large flood events. The intent of these fences is to capture woody material upstream to limit LWM at the proposed FRE structure. To avoid boat safety issues, the proposed debris fences are placed beyond the navigable area used by boats to corral LWM.

If the proposed debris fences successfully limit the amount of LWM transported to the proposed FRE structure, more debris fences can be installed during adaptive management. If more debris fences are installed in the navigable areas near the proposed FRE structure, safety and visibility of the fences must be considered. The vertical piles comprising the debris fences in the most upstream locations should extend above the estimated high reservoir water level, given the shallow submergence of the debris storage area during these events, potential for debris boat safety issues during the anticipated inclement weather, and likely ambient conditions during debris clearing operations. Within the adaptive management downstream debris fence capture areas, the height of the fence support piles should not exceed more than about 8 to 10 feet above the ground surface. These piles should be clearly marked and/or delineated to indicate their submergence, to minimize the risk of grounding or collision of the debris management boats with the submerged piles. The debris management boats would require at least 7 to 8 feet of clearance above the vertical piles for safe operation and to prevent debris tows from hanging up on the piles as they are maneuvered into position.

Figure 6-1 Proposed Layout of Debris Fences During Reservoir Drawdown



7 Operations

Debris management actions can be broken down into two periods corresponding to the Proposed Project operating periods: Normal, Flow-Through Operation and Flood Retention Operation. The LWM estimates and storage areas described in Sections 4 and 5 are used to determine debris management actions during Flood Retention Operation described in Section 7.1 below. Debris management during normal flow-through operation is described in Appendix J: Operation and Maintenance Considerations TM (HDR 2025a).

7.1 Flood Retention Operation

When the FRE facility is operated to hold back flood water, the conduit gates will close–some fully, some partially–to reduce river flows downstream. The temporary inundation area upstream of the FRE structure will fill with the excess flood water, which will then be evacuated after the storm has passed. During evacuation of the inundation pool, discharge from the FRE structure will be reduced to allow floating LWM in the reservoir to be collected and moved to debris storage areas. When debris storage areas are full or no longer needed for storage, discharge will be increased again to speed reservoir evacuation. When the elevation of the inundation pool is below the storage area elevation, collected material will be removed by operations staff. Removal of woody material from debris storage areas and what happens to the material following removal are described in the Mitigation Plan (Kleinschmidt 2024). Estimated sequencing of LWM removal from the reservoir and removal durations for select storm events are described below.

7.2 Debris Management During Inundation Pool Evacuation

During flood operation events, the estimated LWM acreage summarized in Section 4.3 is expected to be swept into the temporary inundation pool. Debris management procedures will be used to ensure LWM does not impact FRE facility operations or damage the FRE facility. Drawdown and debris management will start when the inundation pool is at a safe level for crews to begin working in the temporary inundation area. If the inundation pool is flowing over the spillway or immediately below the spillway, all debris management will cease. Once the pool falls below the spillway crest to a level that is deemed safe for crews to operate in the pool, debris management will commence. The inundation levels and spillway operations will be closely monitored and communicated with crew members to ensure safe working conditions.

Once the inundation pool is at a safe working condition below the spillway crest, crews will use boats and log broncs as described in Section 7.3. They will move LWM from the temporary reservoir to the debris storage areas described in Section 5. The steel trashrack columns will protect the gated outlets of the FRE facility from LWM that was not removed by the boats and log broncs and from debris that cannot pass through the trashrack to downstream areas when normal flow-through operation resumes. The slowed drawdown rate will continue until the temporary reservoir reaches elevation

500 feet, at which point debris management actions in the reservoir will conclude. Analysis and refinement of elevation at which debris collection begins, and the duration required to corral and move debris are the subject of this section. Refer to Sections 7.3.3 and 8 for recommended refinements to debris collection water surface elevations and durations.

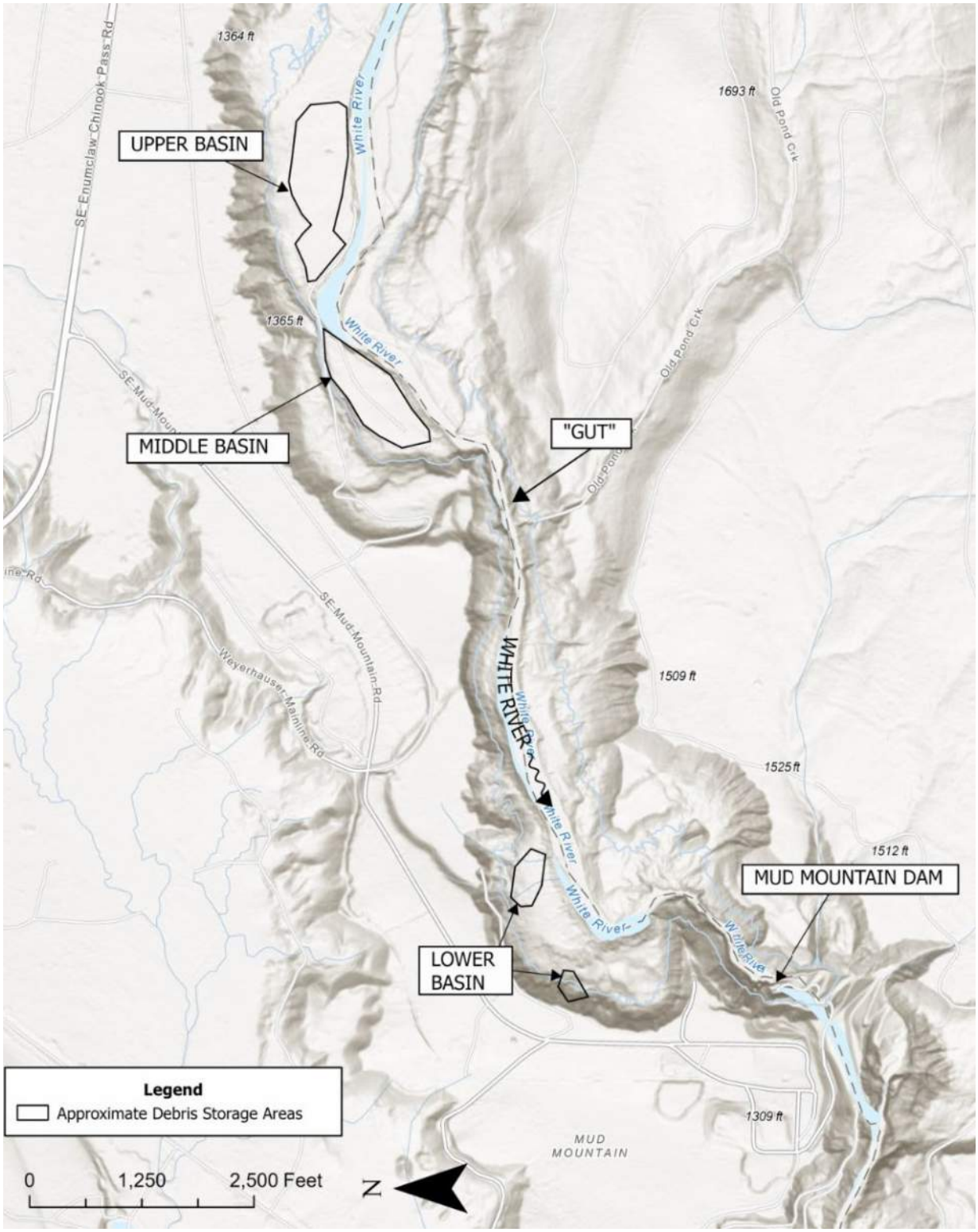
7.3 LWM Sequencing and Removal Rate

The LWM sequencing and storage rate on the Chehalis River at the proposed FRE structure were developed directly from MMD current operating procedures. USACE provided detailed information regarding its LWM storage process from email correspondence and an interview via video conference conducted on March 25, 2025 (Appendix A).

7.3.1 Mud Mountain Dam Sequencing and Removal Rates

MMD uses several debris storage areas: a lower basin, middle basin, and upper basin (Figure 7-1). During high flow events, the reservoir reaches elevations that can transport LWM up to the middle and upper basins. Because smaller flow events do not create reservoir inundation pool elevations high enough to transport LWM to the middle and upper basins, LWM is stored temporarily at the lower basin near the intake. The lower basin is used for temporary storage during high flows, but because it cannot be accessed from land, the final LWM destination must be the middle or upper storage basin.

Figure 7-1. Existing MMD Debris Storage Areas



Large flood events will create a large inundation pool, with equipment on the water needed to transport LWM. Log booms, work boats and log broncs are the main equipment used to manage and sort LWM. Log booms are set up within the debris storage areas to contain LWM in the lower, middle (Photo 7-1), and upper basins. Upstream of the lower basin, operators sometimes also deploy a boom at a narrow section (the “gut”) of the White River to keep LWM upstream of the lower basin. These booms function as containers to aid in storage of LWM while the reservoir inundation pool is high after a large flood.

Photo 7-1. MMD Log Booms at Middle Basin

Note: Inundation elevation 1,030 feet.

Small transportable booms are also used to collect LWM and are mobilized by connecting to log broncs and work boats. The log broncs sort through debris and fill the boom behind them with a teardrop shape of LWM called a “sack.” Once the sack is full, it is transported (pulled) upstream by the work boat and pushed by the log bronc. The sack is transported to either the middle or upper debris storage area and contained by booms. The LWM is towed inside the containment area, released, and then the containment boom is closed behind the boats. This process is repeated until all LWM is transported from the reservoir to storage yards. The log broncs and a work boat at MMD are depicted in Photo 7-2 (after a large flood event ready to be deployed) and Photo 7-3 (when the reservoir does not have an inundation pool).

Photo 7-2. MMD Log Broncs and Work Boat at Dock Ready for Deployment at High Reservoir Inundation Elevation

Photo 7-3. MMD Log Broncs and Work Boat at Dock Stored with No Reservoir Inundation Pool

The LWM storage rate at MMD is dependent on where the LWM starts. It takes approximately 2 hours to transport one sack of LWM from the lower basin near the intake to the upper and middle basins, which covers approximately 8,000 feet. It takes approximately 3 hours to transport one sack from the intake to the middle and upper basins over approximately 12,500 feet. From USACE anecdotal reports, it takes a full day to store 4 to 5 sacks in the upper and middle basins if the debris starts upstream of the "gut." Table 7-1 depicts the storage rates based on correspondence with USACE. These storage rates are based on one log bronc operating at a time and assume that four sacks are equal to approximately 1 acre of LWM. Sack size is based on MMD operator estimations.

Table 7-1. LWM Storage Removal Rates at MMD

Travel Path	Approximate Distance Traveled (feet)	Transport Time for One Sack (hours)	Sack Storage Rate (sacks/per hour)	Acre Storage Rate (acres/day)**
Intake to middle/ upper basins	12,500	3	0.3	0.7
Lower basin to middle/upper basins	8,000	2	0.5	1.0
"Gut" to middle/upper basins	3,000	1.5*	0.7	1.4

*Assumes 5 sacks are stored in 8 hours of work
**Assumes 1 day of storage is 8 hours

7.3.2 Proposed LWM Removal Rate for FRE

For simplicity of calculations at this stage of development, one estimated storage removal rate for the FRE was assumed based on MMD's LWM storage removal rates (Table 7-1). These calculations assume log broncs and work boats will be operating for 8 hours each day.

The rate of transporting LWM anywhere within the inundation pool upstream of the proposed FRE structure is assumed the same as transporting LWM from MMD's lower basin to the upper and middle basins. Therefore, using this singular rate, it will take 1 day to store 1 acre of LWM upstream of the proposed FRE structure. This 1 acre of LWM per day rate is estimated with one log bronc and work boat. Assuming operations can occur at three times the rate by deploying two more log broncs and work boats than currently occurs at MMD, the Chehalis storage rate is assumed to be 3 acres per day. This increased rate will only be possible if there is enough width in the inundation pool for the log broncs with their boom sacks to pass each other. With three boats in operation simultaneously, an upstream traveling log bronc will inevitably pass a downstream traveling log bronc during operations. During peak operations three log broncs with three crews of 1 driver and 2 support staff will be deployed.

Table 7-2 provides days to store different LWM loadings based on return intervals, independent from drawdown rate. For the 10-year return interval, from Table 4-9, 8 acres of LWM are anticipated. Based on the storage rate of 3 acres per day, 8 acres will be

stored in 2.7 days. Rounding up to the nearest whole number gives an approximation of 3 days to store the anticipated LWM loading for the 10-year event. The subsequent approximation of days to store in this table are calculated similarly.

Table 7-2. Final LWM Loadings and Storage Duration

Return Intervals (year)	LWM Loading (acres)	Days to Store (days)
10	8	3
20	9	3
50	12	4
100	14	5
500	20	7

7.3.3 Sequencing and Capacity

The estimated removal rate and debris storage area capacities were used to determine how the LWM storage sequencing would occur. How the storage rate, drawdown rate, navigable elevations, and available storage interact dictates how the debris storage areas will be able to store LWM. As the temporary inundation area drains, the available navigable storage area acreage diminishes, so the highest elevations of the debris storage yards must be prioritized to store the logs first.

Only debris storage areas 1 and 2 will be needed based on the largest debris estimate of 14 acres at the 100-year flood event. Storage areas A, B,C, and D are not needed nor planned as part of this Proposed Project.

The reservoir elevation must follow the depth requirements to navigate areas 1 and 2 during the drawdown period. The reservoir elevation must always be 10 feet above the ground surface where LWM is being stored. Therefore, the highest areas of debris storage areas 1 and 2 should be used first. The highest ground elevation of these storage areas is 495 feet, which needs to be used before the lower elevations of each storage area. The lowest ground elevation of area 1 is 447 feet, and the lowest ground elevation of area 2 is 467 feet. The rate of reservoir drawdown is dependent on how much LWM is left to store in log booms, the debris collection rate, and how much storage area at certain elevations remains. This will be approximated with a desktop analysis, but in addition should be assessed in the field as operations are occurring.

Development of debris storage areas 1 and 2 will include clearing large woody vegetation. Because of the operational considerations for debris storage areas 1 and 2, the vegetation will be cleared and planted with flood tolerant grasses and forbes conducive to use for wood storage. These efforts will aim to minimize potential impacts from tree removal while maintaining the operational requirements of the debris storage areas. HDR's *Dead Wood Management Technical Memorandum* addressed the potential concern about the volumes of dead wood that might be created within the inundation pool, upslope of the riparian buffer as required by the Forest Practices Act, after initial operation of the FRE (HDR 2025b).This analysis considered recent and future expected

rotational harvests practice future stand age and estimated that approximately 128 acres, or 15 percent of the area within the inundation pool, would contain mature standing dead trees and potentially benefit from harvest pre-operation of the FRE. This analysis included forested habitat within areas 1 and 2.

During operations, debris storage sequencing methods will be adjusted in response to real-time flood and debris conditions including modifying debris management operations based on debris areas. The intent of this approach is to ensure storage areas remain functional under variable conditions while reducing operational risk.

8 Conclusion

The temporary inundation pool at the proposed Chehalis FRE facility is anticipated to accumulate LWM during large flooding events. As described herein, it was determined that upstream of the proposed FRE structure, up to 14 acres of LWM during a 100-year flood event will need to be stored and managed. The debris stored near the structure in storage areas 1 and 2, can store up to approximately 22 acres of LWM. The reservoir inundation elevation would range between 457 and 505 feet for debris management in storage areas 1 and 2.

Removal of estimated LWM is expected to take about 3 days for a 10-year storm event and up to 5 days for a 100-year storm event. Some smaller flood events causing activation of the FRE facility might not generate significant debris, and thus the pause or slowing of drawdown rate to manage debris may be truncated or even eliminated. Given the large variability of LWM acreage potential, reservoir operation will need to be flexible, varying the drawdown for each temporary inundation event based on the amount of LWM present in the inundation pool. More specific operating procedures and access to the debris storage areas will be refined with future analyses in coordination with the operations team.

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Appendix A. USACE MMD Site Operator Meeting Notes

Meeting Notes

Project:	Chehalis River Basin Flood Damage Reduction Project	
Subject:	USACE Mud Mountain Dam and Howard Hanson Dam Interview for Debris Management	
Date:	Tuesday, March 25, 2025 3:00–4:00 PM	
Location:	Virtual	
Attendees:	Lindsey Ackerman, HDR Kristin LaForge, HDR Ed Zapel, NHC	Kevin Heape, Operations Project Manager, USACE (MMD and HHD) Rick Emry, Chief of Maintenance, USACE (MMD)

This interview is intended to discuss empirical data from the Mud Mountain Dam (MMD) and Howard Hansen Dam (HHD), primarily focused on MMD, with the United States Army Corps of Engineers (USACE). The interview will be regarding their estimated large woody debris (LWD) volumes, removal rates, and general site operations for removal. HHD is less applicable to the LWD empirical data because it holds an annual reservoir.

USACE (Rick and Kevin) have conducted site visits for HDR Engineering, Inc. (HDR) and Northwest Hydraulic Consultants (NHC) personnel in the past for debris management—but because of work changes within USACE, they could only hold a virtual meeting.
Images provided by USACE are attached to aid in the discussion.

Introductions and Roles

- HDR and NHC
- USACE
  - Kevin Heap: Operations Project Manager for both MMD and HHD
  - Rick Emery: Chief of Maintenance for MMD

Agenda Topics

Question 1: USACE to describe volumes of LWD in past flood events for MMD and HHD

- **HDR:** Do the dams have flood event predictions or have they ever predicted LWD volumes?
  - **USACE:** Use of river forecast (RCC) for flood flows—but LWD predictions are challenging and not predicted or predictable—no way of knowing how much woody debris is coming
    - Challenges are due to durations between events and the level of bank erosion between events

- **USACE:** Every year holding areas are prepared and ready to go year-round; temporary holdings are also prepared for a flood event
    - Logs are pushed ashore for temporary storage in the multiple lower holding areas (not large nor accessible for ground equipment). They are hauled to more accessible areas in the middle and upper holding basins after being temporarily gathered
    - Temporary (lower) basin: high slope angle, trouble with equipment access, use logs tied up on bank with wire rope, can connect two lower storage basins to provide about 5–7 acres
    - Middle + upper (middle) basin: approximately 40 acres total of storage
    - Based on the flood elevation they may use all or just the lower basin (i.e., small pools or bigger pools)
    - Last 5 years they have only had minor flooding
    - They do not have a step by step procedure—they have to think on the fly and adapt to the conditions at hand, taking into consideration of volume of debris, reservoir elevations, flood flows, etc.
        - The 1996, 2006, and 2009 floods were significant—they have debris records, Rick to follow up
- **USACE:** Mowing of vegetation during non-flood events needs to be done (willow)
- **USACE:** HHD has log boom, but a log boom caused more harm than good for MMD—MMD does not have a log boom upstream of the dam
- **USACE:** They do not have records regarding sacks of debris or number of debris piles of the LWD volume
    - 1996 flood had timber sale of debris area, 40 debris piles perhaps
        - Took 2–3 years to clear out the debris
    - Bigger flood events, they need to wait until summer for firmer ground, debris outside of boom grounds can be even longer to get to
- **USACE:** They have a debris to plan for:
    - Floating debris during flood event that can be put into log booms and moved by a log bronc
    - Debris that drops to the bottom and needs to be removed with another piece of equipment when the pool drops
        - Stumps, waterlogged logs that get stuck in sand and as you evacuate the pool it will plug up the trash rack. Use long-reach excavator throughout the summer and use a camera instead of spotters (Hitachi 400, 65-foot reach).

Question 2: USACE to describe the estimated time of removal for MMD and HHD

- **HDR:** When do they start the LWD pickup: visually or with a hydrograph?

- **USACE:** When they have a rising hydrograph (rising pool)
- **USACE:** Need to check roads and culverts, with a rising hydrograph they will check basin areas
- **USACE:** They will note what the current debris load is and debris management becomes the main focus
- **USACE:** Elevations are very important for planning laydown
    - Smaller floods they do not get enough pool to the upper/lower basins to store LWD
    - Smaller floods and large floods each carry their different concerns
- **USACE:** They check for debris on roads and decks, and clean up small floods on the way down

➢ **USACE:** Budget plans for removal and process:

- They have a budget plan for debris (for chipping)
- Budget for the middle basin full of debris every year is 10–15 acres
- Burn if they cannot get it out
- Excavator with slash buster (stump grinder)

➢ **USACE:** The debris basin includes:

- Gate, boom arm tied to chain tied to dead man
- Boom grounds

Question 3: USACE to describe the debris management operations for MMD and HHD

➢ **HDR:** Who are your debris collection contractors?

- **USACE:** USACE for the on-water debris work because contractors are hard to find
    - USACE debris team
    - USACE log broncs, take a while to build skill set
        - Takes years until proficient, even by people being trained by experienced people
- **USACE:** For land work they use contractor
    - Tub grinder
    - During a rising hydrograph, they evaluate the basin area upstream to estimate the magnitude of debris that may be coming downstream. At night four workers are available and seven are available during the day. The night shift is short of personnel to accomplish all the tasks of scouting and removing debris.
        - Smaller floods are of equal importance
        - Remember the floods and debris are not predictable and they need to react to the situation as it develops using experience from past events

- For debris removal they supplement with a few USACE people and USACE equipment
    - Hard to contract out because it takes 3 years of experience under trained experts before new employees are proficient
- Some debris can be turned into habitat logs (conifers with root logs, 30 feet or longer)
    - Brought off road dump truck and stockpile above the flood line, give away for free
- Chipped wood stays to add stability of the basin for equipment access
- Chipper not on hand, so they contract every year

- **USACE:** Further clarification on the removal rates and volumes of removal
    - 4 sacks = 1 acre
    - Bigger floods, run up to the “gut” with other log boom so debris stays in the basin
    - 1 sack = 17.5 steal boom logs tied end to end
        - Encircle one sack and then haul back to the work boat
    - Near the upper/middle basin, it is easier and can haul about four to five sacks every 2 hours
    - Elevation 1,100 is about 2/3 of the way up the trash rack
    - Spring pool, allows to move debris (HHD), MMD does not have a spring pool

Mud Mountain Dam – Shared photographs from USACE interview March 25, 2025

Wood chipping operations (2020)

Chipping at the upper basin (2020)

Note: Soft ground, need to wait for summer to start processing LWD

Middle basin (2020)

Lower: Elev. 1035-1040 ft
Upper (middle) basin: Elev. 1060-1065 ft
Upper (upper) basin: Elev. 1075 ft

MDD log bronc equipment

Note: USACE operates

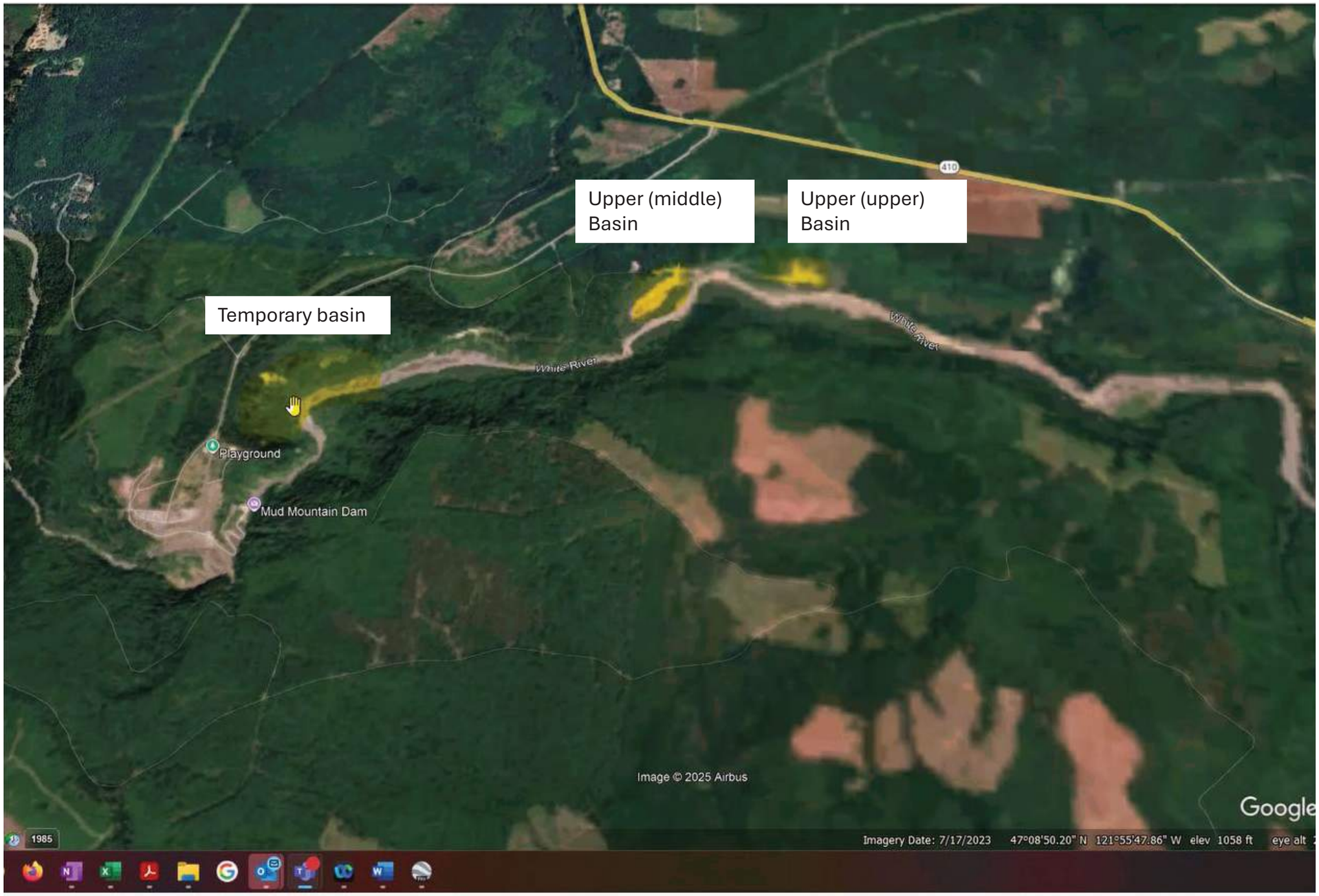
Picking LWD at the trash rack (pick the rack)

Below the trash rack is 8ft of sediment after a big flood. USACE needs to clean the platforms after a big flood to stage the excavator.

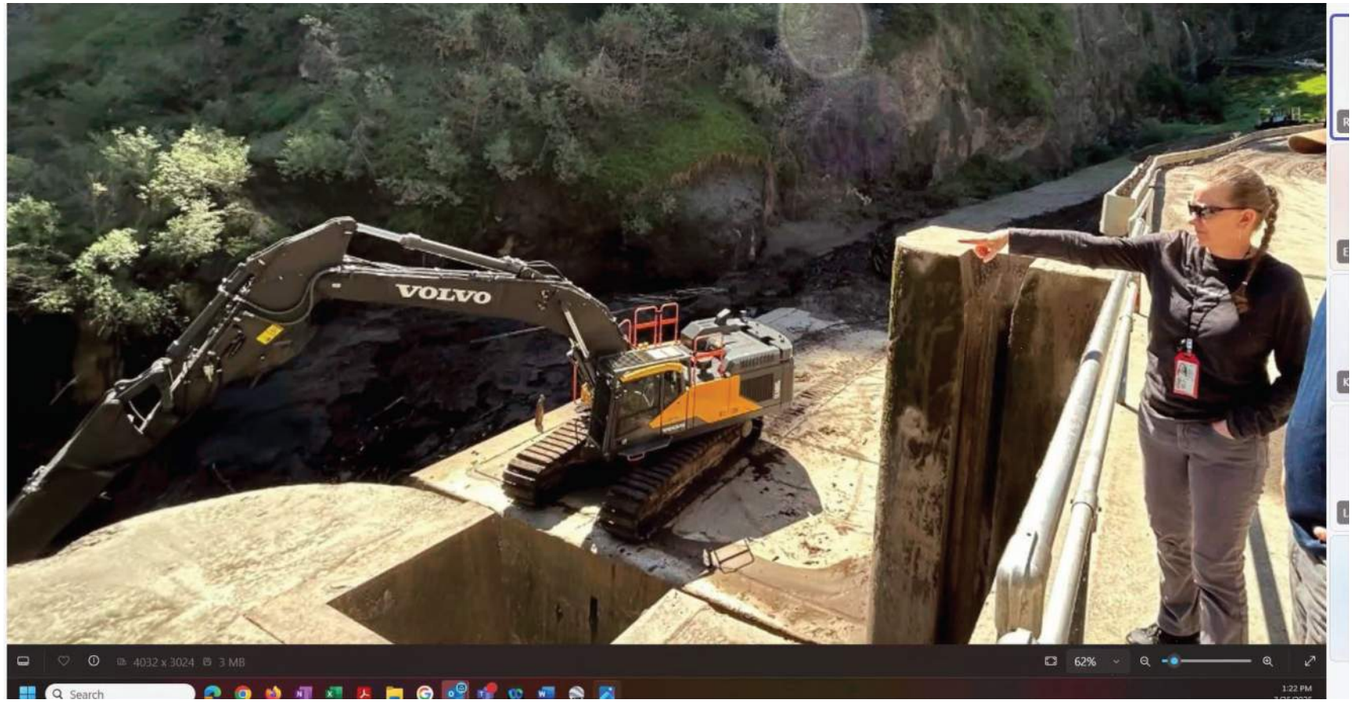
Baldi McDonald

Wood-chipper (2021)

LWD stacking (18 NOV 2021)

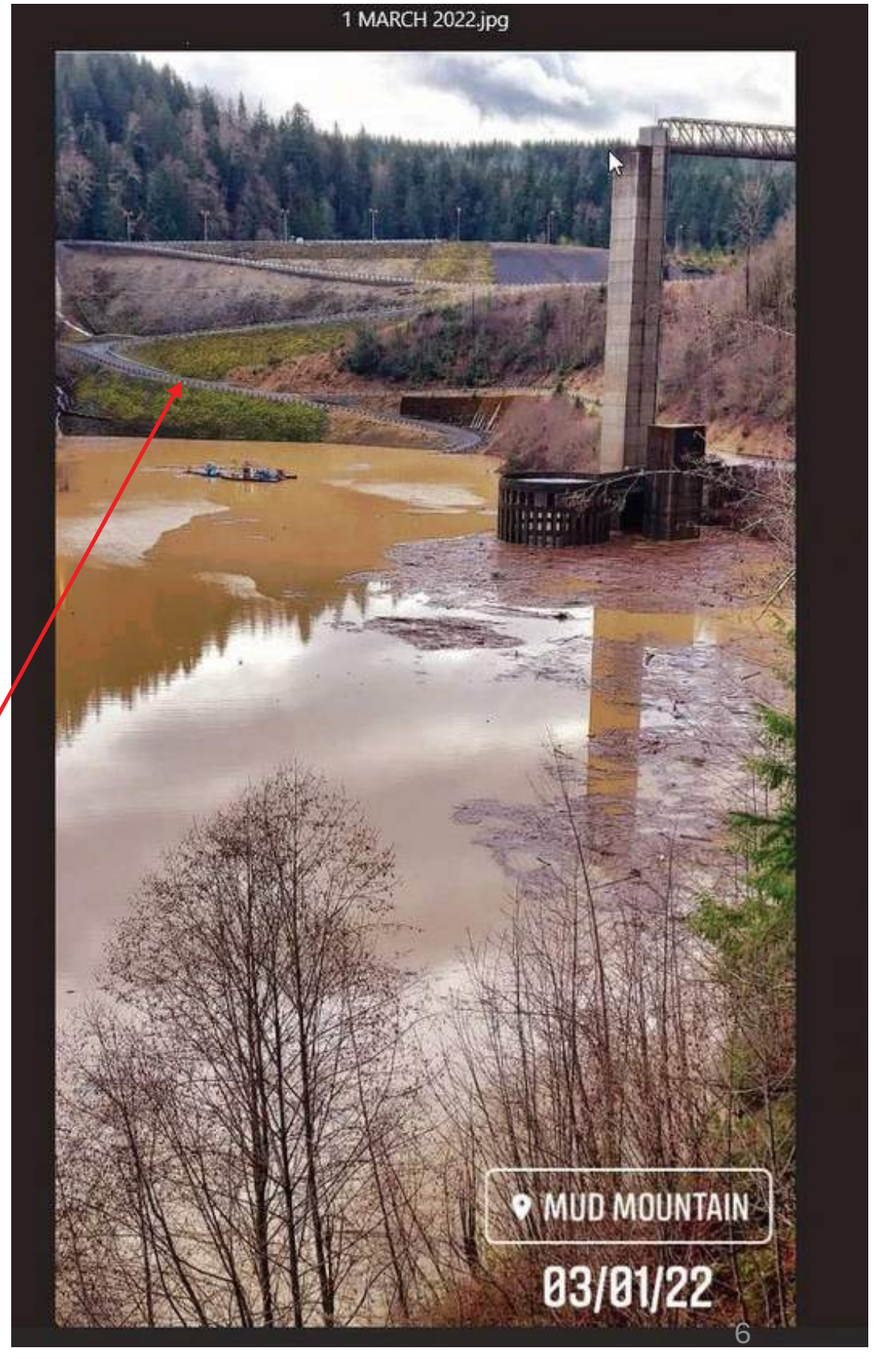


Location of storage basins to estimate distances and sizes



LWD removal at the trash rack w/ excavator (65ft boom arm)

Access road to access the pool at the trash rack



Upper basin and example of debris pile

Rotary cutter at the end of the excavator arm

Image of steel boom logs tied end to end – used to encircle one ‘sack’ and bring to the boat for hauling

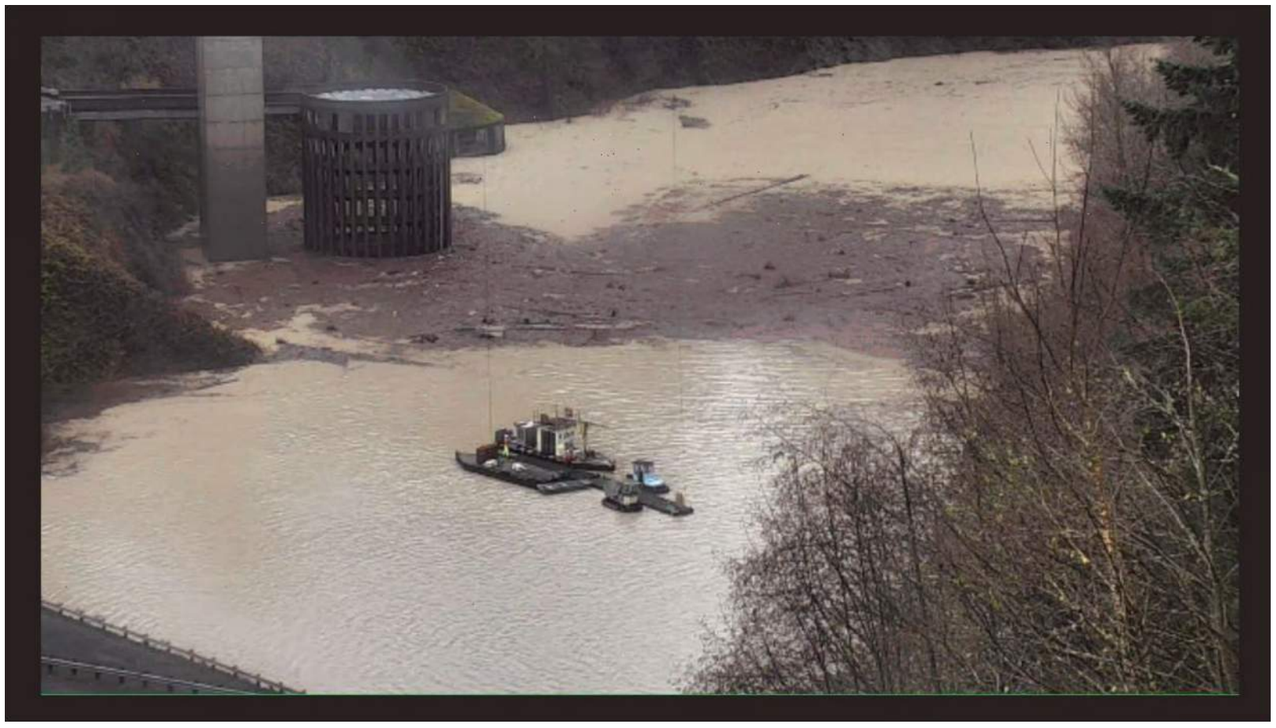


Image of the debris at the trash rack after a flood event

Attachment 2 – Reservoir Operations Analysis Technical Memorandum

February 4, 2026

Technical Memorandum

Date:	February 4, 2026
Project:	Chehalis River Basin Flood Damage Reduction Project
To:	Chehalis Basin Flood Control Zone District
From:	HDR
Subject:	**Reservoir Operations Analysis (Draft)**

1.0 Background

The Proposed Chehalis River Basin Flood Damage Reduction project (Proposed Project) objective is to implement a series of measures aimed at reducing damage to the communities of the Chehalis River Basin from Pe Ell to Centralia during major flood events. Among these measures is a proposed Flood Retention Expandable (FRE) structure on the Chehalis River, south of Pe Ell, Washington.

The Chehalis River Basin Flood Damage Reduction, draft Preliminary Design Report (PDR) documents development of the preliminary design of the FRE facility and related elements. Development of the draft PDR began following submittal of the Revised Project Description Report (HDR Engineering, Inc. [HDR] 2024), which was used as the baseline for the draft PDR, submitted for information-only purposes on June 30, 2025 (HDR 2025). This draft PDR reflects design development that has occurred since submittal of the June 30, 2025 draft PDR.

The draft PDR documents the design basis for each Proposed Project element, including a record of design decisions, assumptions, and methods related to the development of the design of the FRE structure and related elements. The draft PDR also presents the technical details of the main features of the Proposed Project elements.

2.0 Introduction and Purpose

In 2017, Anchor QEA presented a study of the Chehalis River Basin which included a United States Army Corps of Engineers (USACE) Hydrologic Engineering Center Reservoir System Simulation (HEC-ResSim) reservoir operations model (USACE 2021). The analysis was limited in scope and presented a single, simplistic reservoir operations set, which focused solely on reducing peak flood flows at the United States Geological Survey (USGS) Grand Mound gage without consideration for other flood management and environmental impacts within the basin. HDR was tasked to expand this study and develop operational improvements which would reduce peak flood flows downstream, while also minimizing the upstream reservoir pool storage of the Proposed Project to protect critical salmon spawning habitat. Throughout this analysis, the term “reservoir” is used instead of “temporary inundation pool.” The reservoir in question is a

temporary inundation pool, only used during flood detention operations, and not a permanent impoundment.

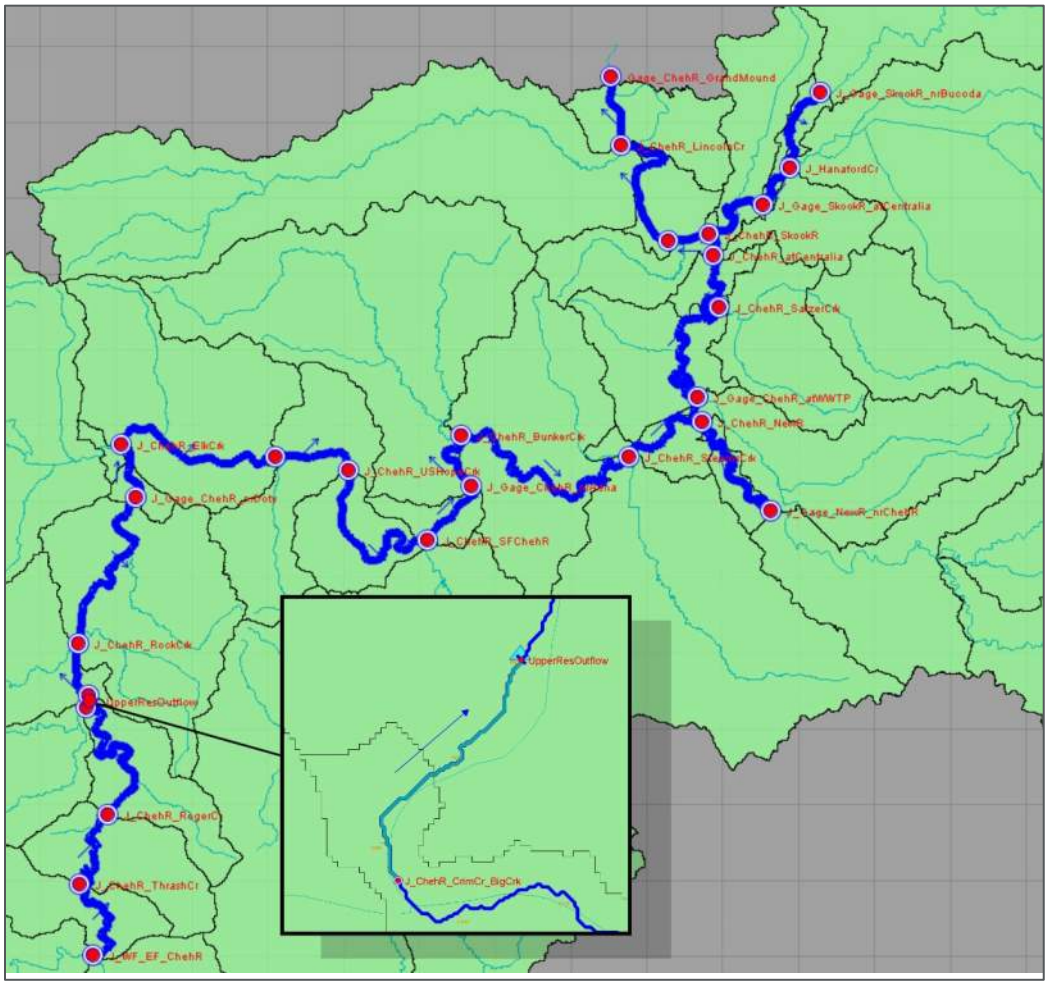
There are six key locations of interest along the Chehalis River, five are USGS gages downstream of the FRE where flood management improvements are desired, and one is the FRE site location. This enhanced HEC-ResSim model expands the extents of the Anchor QEA model using updated hydrology and multiple iterations of alternative sets of flood detention operations. This technical memo summarizes the development, modeling, and resulting discussion of the reservoir operations alternatives.

3.0 Model Development

3.1 Watershed Setup

The first step in creating the HEC-ResSim model of the Chehalis River Basin was defining the watershed setup. Anchor QEA provided HDR with their HEC-ResSim model from 2017, which consisted only of the reservoir reach and its two inflow and outflow junctions. For this study, the model needed to encompass more of the basin, so enhancements were made to update the configuration to HEC-ResSim Version 3.3 and extend the HEC-ResSim model downstream to Grand Mound consistent with the topology (river junction locations and model naming conventions) of the existing HEC-HMS model. The resulting HDR HEC-ResSim watershed consisted of 27 junctions, 25 reaches, 1 reservoir with an outlet group and spillway, and no other hydraulic structures or diversions in the model configuration. The model spans from the confluence of the West Fork and East Fork Chehalis River and ends downstream at the Chehalis River near Grand Mound USGS gage (12027500; Figure 1).

Figure 1. Snapshot of the Chehalis River Basin HEC-ResSim Model, Post-Enhancement



3.2 HEC-ResSim Routing Parameters

Once all junctions were defined, the river reaches that connect each junction were added. Routing parameters from the HEC-HMS (Hydrologic Modeling Software) model were imported and assumed to be an appropriate estimation of the system's hydraulic routing. Of the 25 reaches in the model, 4 used Muskingum-Cunge routing (Table 1), 3 used Muskingum routing, and 17 used Modified Puls routing. The Muskingum-Cunge routing method was applied to reaches without known gage data to better approximate the conditions of the reach using an 8-point cross section sourced from available LiDAR (light detection and ranging). The HEC-ResSim reservoir pool reach does not allow application of routing methods and was automatically set to run with null routing. A storage versus outflow relationship was used to apply the Modified Puls routing to each applicable reach.

Table 1. Muskingum-Cunge 8-Point Channel Routing Parameters

Reach ID	Length (ft)	Slope (ft/ft)	Left Manning's n	Channel Manning's n	Right Manning's n
R_ChehR_RM_116_to_118	17,687	0.00791	0.150	0.035	0.150
R_ChehR_RM_113_to_116	18,370	0.00741	0.150	0.035	0.150
R_ChehR_RM_109_to_113	31,000	0.00398	0.150	0.035	0.150
R_SkookR_RM_4_to_6	16,137	0.00100	0.150	0.035	0.100

3.3 FRE Physical Characteristics

The FRE structure is modeled with a dam that has a pool, spillway, and outlet group. The outlet group reflects the outlet works configuration as of the June 30, 2025 PDR and consists of one low-level 12-foot-wide by 20-foot-high sluice gate with an invert elevation of 427 feet at the riverbed and two pairs of 10-foot-wide by 16-foot-high sluice gates, with invert elevations of 430 feet. Rating curves for the gates were developed for a 94-percent opening using the orifice equation. Vertical datum was North American Vertical Datum of 1988 (NAVD88). The outlet works described in the Hydraulics and Fish Passage sections of the current PDR reflect the current design. Release capacity and reservoir operations should not be impacted by these changes in the outlet configuration. Based on the current reservoir operation sets, minimum releases are expected to be 300 cubic feet per second (cfs) and maximum releases are expected to be no more than 10,000 cfs using the June 30, 2025 conduit configuration. The maximum reservoir inflows observed in the HEC-ResSim model for the historical period of record (POR) that did not trigger reservoir operations was 13,665 cfs in April 2005; no operations took place and the gates remained fully open, but a small, temporary backwater pool developed due to reservoir inflows exceeding the open-channel inlet capacity of the conduits for a short period.

Table 2. Reservoir Physical Characteristics

Variable	Dimension
Elevation at top of dam (ft)	650
Length at top of dam (ft)	1,450
Spillway elevation (ft)	627
Spillway weir coefficient	2.6
Spillway length (ft)	200

3.4 Downstream Stage-Discharge Rating Curves

In addition to the routing parameters from the HEC-HMS model, stage-discharge rating curves were applied to each location of interest on the river where available. Rating curves were developed using 30 design floods modeled in HEC-RAS (River Analysis System) for the 6 key locations on the Chehalis River (Section 5.5.4 of Hydrologic Model Report). These rating curves allowed HDR to calculate water surface elevations (WSEL) and elevation reductions at each location in subsequent analyses.

3.5 Local Flow Development

Local flows used to simulate operations were sourced for the HEC-ResSim model from the updated HEC-HMS model. Operations were simulated with three discrete storms (December 2007, January 2009, and January 2022) and model routings were compared to those in Anchor QEA (2017) to confirm consistency with the original HEC-ResSim model and original 2017 Anchor QEA reservoir operations (2017 Operations). Once this consistency was confirmed, the initial reservoir operations analyses began by using the same three storms with the various operations alternatives to measure their performance against one another and the 2017 Operations. Descriptions of the operations alternatives are in Section 4.0.

3.6 Periods of Record – Historical and Future

After the initial reservoir operations analyses and elimination of most of the operations alternatives, historic POR runs were completed to test operations performance over longer periods. The POR flows simulated in the HEC-ResSim model spanned 42 years, from October 1980 through September 2022. To estimate operational performance under future climate conditions, the HEC-HMS routings of 12 Global Climate Models (GCMs) were then routed through the HEC-RAS model. The future climate GCM POR spans from 1970 through 2100.

4.0 Reservoir Operations Alternatives

4.1 Introduction

A series of brainstorming sessions were held to analyze the 2017 Operations and propose potential areas of improvement for the operations. Performance for any operations alternatives would be measured both at how well the operations reduce the unregulated peak flood flow at Grand Mound and the duration of upstream inundation caused by flood detention operations. A Hydrologic Engineering Management Plan was prepared as a roadmap for the overall operations analysis and a related workshop held to discuss potential alternatives, constraints, and metrics (HDR 2024b). The various operational parameters would be combined, modeled using the three discrete storm events (2007, 2009, and 2022), and compared against one another and the 2017 Operations. Those combinations that performed worst would be eliminated over subsequent modeling rounds until a final set of one to two operational parameters remained. These final combinations would be proposed to the District to be carried forward for future climate analysis and further refinement. The two current recommended operations sets are discussed in Section 6.0.

4.2 Operational Parameters

Four major parameters were studied to test their ability to improve the performance of the original 2017 Operations:

- **Operation Triggers** – The suite of conditions that would cause the reservoir to begin storing water to reduce downstream flows in a flood event.
- **Maximum Releases** – How much water may be released downstream of the reservoir during peak storm flows, while maintaining a minimum flow release of 300 cfs to avoid dewatering the river reach just downstream of the Proposed Project.
- **Pool Drawdown/Debris Removal** – After the storm has passed and downstream flows have begun to recede, the drawdown rate for stored water in the reservoir is constrained by the need to remove any accumulated logs and other floating debris while also maintaining slope stability in the upper reaches of the reservoir.
- **Drawdown Releases** – Releases during the post-storm drawdown period may be temporarily limited to avoid secondary flooding resulting from a second storm closely following the initial storm.

4.2.1 Operation Triggers (O1-O4)

One of the most critical elements of reservoir operations is deciding when to actually go into flood detention operations. The 2017 Operations set a single trigger of 48 hours before the USGS Grand Mound gage is forecasted to exceed 38,800 cfs (corresponding to the National Weather Service major flood stage of 144 feet) to start restricting flows at the reservoir, and this is reflected in the O1 parameter. It was hoped that adding additional trigger requirements, first at Doty and then in the eastern Chehalis basin, would allow reservoir operations to operate only when they would be most effective at reducing flows at Grand Mound. The O2 parameter required that both the original 2017 Operations 38,800 cfs trigger at Grand Mound and a Doty trigger of 24,400 cfs (Moderate Flood at the Doty gage) be fulfilled before flood detention operations would begin. The O3 parameter adds a third trigger requirement that looks at the expected percentage of contribution to the total flow at Grand Mound from two eastern basin USGS gages: Skookumchuck near Bucoda and Newaukum near Chehalis. If 50 percent or more of the forecast flow at Grand Mound is expected to come from those two gages, reservoir operations would not be triggered. By adding these additional flow conditions to the operation trigger, the Proposed Project is not triggered as frequently as the O1 alternative, leading to fewer days of inundation upstream of the project. The O4 parameter was designed to act as many flood management reservoirs are operated, with a downstream maximum flow target (38,800 cfs) set at Grand Mound and a more flexible operation trigger that would factor in the current basin flow conditions and updated travel times between the reservoir and Grand Mound. Operations would not be automatically triggered 48 hours before a certain flow is forecast at Grand Mound, but it could be triggered earlier or later than the 48-hour mark depending on baseflows within the basin just prior to the storm. It was expected that this improved flexibility could allow the reservoir to store less water in small to midsized storms while achieving the same downstream peak flow reduction at Grand Mound by closing slightly later than the 2017 Operations O1 operation trigger. During larger storms, the O4 operation trigger could close at the same time as, or possibly even earlier than, the O1 trigger, but it was expected that the

extra flexibility in operations would be a net positive in reducing the duration of stored water in the reservoir.

Table 3. Operation Trigger Parameters

Parameter	Name	Description
O1	2017 Operations	Flood detention operations are triggered 48 hours before the flow at the USGS Grand Mound gage is forecast to rise above 38,800 cfs.
O2	2017 Operations + Doty Trigger	Adds additional requirement of a required forecast of 24,400 cfs at the USGS Doty gage to trigger operations.
O3	2017 Operations + Doty Trigger + Eastern Basin Trigger	Adds third requirement of a required forecast trigger in the eastern Chehalis basin.
O4	Downstream Flow Control Rule	Attempts to limit flow at Grand Mound to no more than 38,800 cfs by factoring in current basin flow conditions and travel times between the reservoir and USGS Grand Mound gage.

4.2.2 Maximum Releases (Q1-Q4)

The Q1-Q4 parameters dictate how much water may be released during flood detention operations, particularly during the peak of downstream flow. A minimum flow release of 300 cfs will be maintained at all times during operations to provide water for fish in the river reach just downstream of the reservoir. The 3,000- to 7,000-cfs range was developed to avoid significant bed scour downstream and allow adequate sediment to pass through the structure for salmon redds downstream of the reservoir.

Table 4. Maximum Release Parameters

Parameter	Name	Description
Q1	2017 Operations: 300 cfs	The set release of 300 cfs during activation, according to the 2017 Operations.
Q2	Maximum releases during storm event: 3,000 cfs	This increases the maximum release allowed during the storm event to 3,000 cfs while maintaining the 300 cfs minimum.
Q3	Maximum releases during storm event: 5,000 cfs	This increases the maximum release allowed during the storm event to 5,000 cfs while maintaining the 300 cfs minimum.
Q4	Maximum releases during storm event: 7,000 cfs	This increases the maximum release allowed during the storm event to 7,000 cfs while maintaining the 300 cfs minimum.

4.2.3 Pool Drawdown/Debris Removal (D1-D5)

During and after a storm, varying amounts of logs and other floating debris are expected to accumulate in the reservoir pool which will need to be collected to avoid clogging or damaging the conduits of the Proposed Project. This debris removal will involve using boats to drag large pieces of floating debris and logs to onshore collection sites for later removal. The typical drawdown rate of the reservoir pool is 10 feet/day and was chosen to provide soil stability in the upper elevations of the reservoir conservatively; future geotechnical analyses will investigate the possibility of increasing the drawdown rate in the upper reaches of the reservoir to a maximum of 20 feet/day to further reduce the inundation time of upstream salmon redds.

The 2017 Operations (D1) involve a 2-week debris removal period where the drawdown of the stored water behind the dam will be slowed temporarily to a pool elevation drawdown limit of 2 feet/day to allow debris to be removed from the pool before the drawdown continues at its typical, faster pace of 10 feet/day. The D2 parameter includes no pause for debris removal, so the 10 feet/day pool drawdown limit continues until the reservoir is empty, thus reducing the inundation duration upstream of the reservoir. The D3 parameter reduced the 2-week debris removal period to 5 days based on early estimates of the minimum debris removal period needed, and the D4 parameter removed both the debris removal period and the 10 feet/day pool elevation drawdown limit to demonstrate the fastest possible pool drawdown that would not increase downstream flooding. A subsequent refinement known as D5, in consultation with HDR's geotechnical and debris management teams, allows a slightly increased drawdown rate of 20 feet/day below 477 feet as the risk of landslides is reduced due to slope stability measures planned for the lower reaches of the reservoir. This refinement also reduced the duration of the debris management period to 5 days and moved debris management activities lower in the pool to 487-477 feet NAVD88 to support as much of the upper basin returning to free-flowing conditions as quickly as possible. The D5 parameter is reflected in the operations results shown in Section 5.0 herein.

Table 5. Pool Drawdown/Debris Removal Parameters

Parameter	Name	Description
D1	2017 Operations	This is the 2017 Operations pool elevation decrease limit of 10 feet/day with a limit of 2 feet/day from elevation 500 to 528 feet.
D2	Maximum pool elevation decrease of 10 ft/day – no debris removal period	This parameter removes the 2 ft/day slowdown during log/debris removal to demonstrate the drawdown period in cases where captured debris is minimal.
D3	Maximum pool elevation decrease of 10 ft/day – 5-day debris removal period	This parameter reduces the 2017 Operations log/debris removal slowdown from 14 days to only 5 days as debris removal may not be longer than that while in operation.

Parameter	Name	Description
D4	No pool elevation decrease limit	To demonstrate the fastest possible pool drawdown, this parameter removes any pool drawdown rate limit. Downstream flow and physical release limits are still included and modeled.
D5	Updated drawdown rates – 5-day debris removal period lower in the basin	This parameter reduces the debris management period to 5 days and shifts it lower in the pool (487-477 feet). Below 477 feet, the drawdown rate limit is increased from 10 feet/day to 20 feet/day.

4.2.4 Drawdown Releases (P1-P2)

In addition to the Pool Drawdown/Debris Removal parameters (D1-D5), a set of Drawdown Release parameters (P1-P2) also control how quickly flow releases can change when the reservoir is emptying the pool. The P1 parameter is the basic 2017 Operations limit that restricts releases from increasing more than 1,000 cfs/hour once flow has peaked at Grand Mound. During most drawdown periods, maximum releases are dictated by the maximum pool elevation drawdown limits (D1-D5) so the P1 parameter only acts as a limit to prevent releases from increasing too rapidly. The P2 parameter includes this 1,000 cfs/hour limit while also maintaining releases to avoid flow at Grand Mound from rising above the Minor Flood stage (141 feet NAVD88). This allows post-storm recovery downstream of the reservoir to be carried out safely even in the event of a secondary storm occurring soon after the initial major storm. If a secondary storm event occurs, the P2 parameter may limit pool drawdown temporarily or even store additional water in an attempt to keep flow at Grand Mound below the Minor Flood stage.

Table 6. Drawdown Release Parameters

Parameter	Name	Description
P1	2017 Operations	This is the 2017 Baseline operation, which allows post-storm release increases of 1,000 cfs/hour once flow has peaked at Grand Mound. Typically, maximum releases are then dictated by the maximum pool elevation decrease rate.
P2	2017 Operations + Minor Flood stage (141 ft NAVD88) limit at Grand Mound	This operational parameter continues the 1,000 cfs/hour release rate maximum and adds a limit that attempts to maintain downstream flows at Grand Mound at less than the Minor Flood stage (141 ft NAVD88).

4.3 2017 Operations: Baseline Operations Set for Study

The original 2017 Operations for the Proposed Project have not been modified and remain as Anchor QEA configured them in the HEC-ResSim model. Along with its 2017 HEC-ResSim model, Anchor QEA provided HDR its 2017 final operations plan report. The current proposed 2017 Operations use the following five phases which are triggered by hydraulic thresholds established by Anchor QEA (2017).

To demonstrate how 2017 Operations would occur, a walk-through of a typical flood detention operation using 2017 Operations' ruleset is below, including which parameters are guiding the operation at any specific phase:

1. **Operations Prior to the Storm Event (O1)**

   The Proposed Project will be triggered to begin closing its gate(s) when the discharge at the USGS Grand Mound gage is forecast to reach or exceed 38,800 cfs within the next 48 hours. This analysis assumes a perfect forecast at Grand Mound. USGS forms stage-discharge rating curves for their gages, which Anchor QEA was able to obtain for their analysis. Using the National Oceanic and Atmospheric Administration's definition of a major flood, along with the USGS rating curve for the Grand Mound gage, it was determined that when the Chehalis River reached a stage of 17.0 feet (gage datum was 123.65 feet above National Geodetic Vertical Datum of 1929 [the major flooding threshold according to the National Oceanic and Atmospheric Administration]), the discharge was predicted to reach 38,800 cfs. Once a Major Flood is forecast at Grand Mound in the next 48 hours, the sluice gates will begin to close, commencing flood control operations.

2. **Operations During Floods (Q1)**

   When the sluice gates are triggered and begin to close, retaining the flood, releases will decrease at a maximum rate of 200 cfs/hour, until reaching the maximum flood event release of 300 cfs. This maximum discharge is the low flow that typically occurs in winter months when these operations were developed in 2016. The reservoir will continue to release water at a rate of 300 cfs until the flood peak at Grand Mound has passed.

3. **Initial Drawdown (D1)**

   The initial drawdown begins after the flood peak at Grand Mound has passed by increasing reservoir releases by a maximum rate of 1,000 cfs/hour, until a maximum drawdown of 10 feet/day is achieved. After a flood, the drawdown rate is controlled to avoid rapid drawdown, which could potentially cause a landslide or other erosion-related issues to occur. This drawdown rate would allow soils to properly drain, once exposed by the dropping water level, and help to avoid slope failures.

4. **Debris Removal (D1)**

   During flood events, it is expected that large logs and other floating debris will accumulate in the pool and may disrupt reservoir operations. To avoid clogging and the potential for damage, the 2017 Operations incorporate a debris removal period into the drawdown process. When the reservoir pool has been drawn down to an elevation of 528 feet, large debris can be collected from the pool and trashrack. While the debris is being removed from the reservoir, the drawdown rate will be reduced to a maximum of 2 feet/day to provide easier access during debris collection. This debris recovery stage will be in operation for 2 weeks until the reservoir reaches an elevation of 500 feet.

5. Finish Drawdown (P1)

With debris removed from the pool, the reservoir is then able to finish drawing down the remaining accumulated flood storage. Once again, the 2017 Operations limit the drawdown rate to 10 feet/day and increasing outflow to no more than 1,000 cfs/hour. Once the pool has been completely emptied, the project will resume its normal flow-through operations, allowing all water to freely pass through open gates.

5.0 Results

This analysis updated an existing 2017 HEC-ResSim model from Anchor QEA with previously defined reservoir operations to simulate operations alternatives to reduce environmental impacts during flood detention operations. Results from the HEC-ResSim model included inflow/outflow to the reservoir, elevation and flow at each of the five USGS gages of interest, and reservoir pool elevation and storage. The proposed alternatives' performances were evaluated based on how well the operations could decrease flows and WSEL at the USGS Grand Mound gage, while also minimizing environmental impacts by reducing the reservoir pool duration (when the WSEL in the reservoir is above 447 feet).

5.1 Discrete Storms Modeling

To timely assess the initial collection of 128 operations alternatives (the total combinations of the operational parameters described in Section 4.0: O1-4, Q1-4, D1-5, P1-2), initial modeling rounds were restricted to three discrete historical storm events (2007, 2009, 2022). Operations sets are labelled by the operational parameters they employ. The 2017 Operation uses the first parameter in each category and is therefore labelled O1Q1D1P1. One of the two best-performing operations sets used the fourth operations trigger parameter O4, the first maximum release parameter Q1, the fifth initial drawdown/debris management parameter D5, and the second finish drawdown parameter P2, leading to the label O4Q1D5P2. Figure 2 through Figure 7 show modeled reservoir operations during these three storm events with 2017 Operations and alternative operations set O4Q1D5P2. Further discussion of how the collection of operational parameters was evaluated and reduced follows in Section 5.4.

Figure 2. Modeled Reservoir Operations for the December 2007 Flood Event

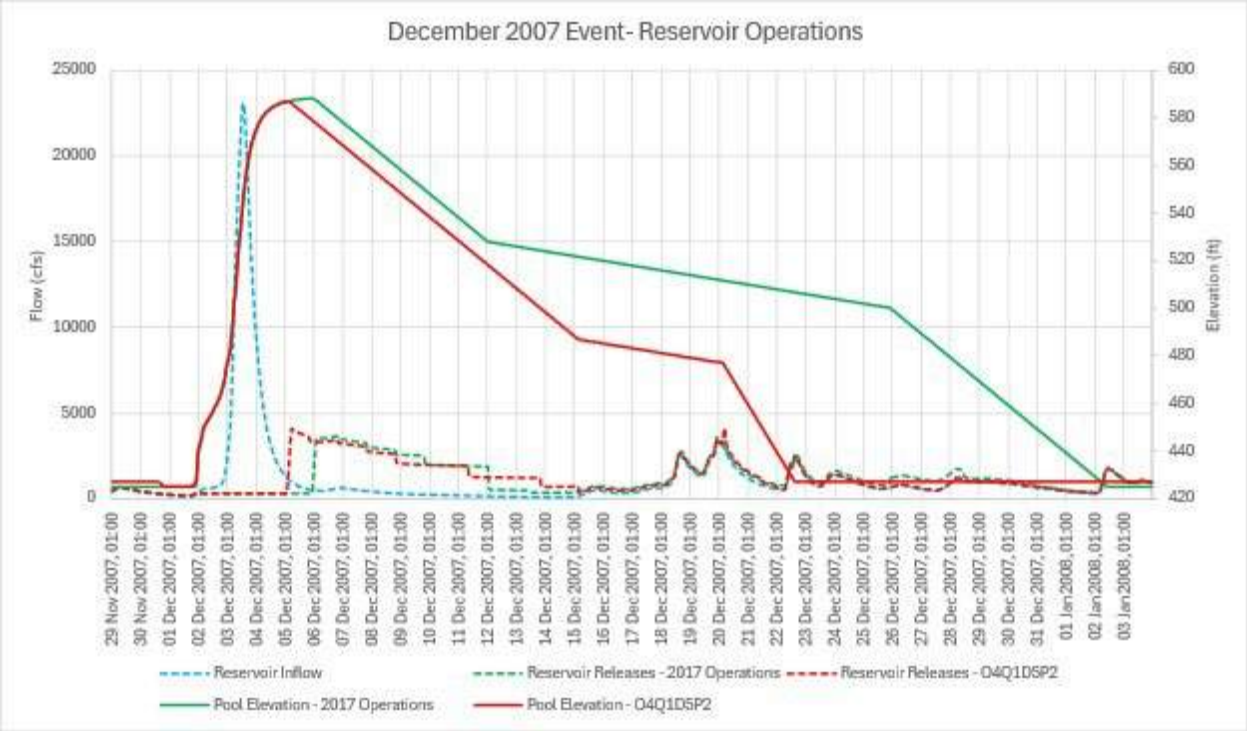
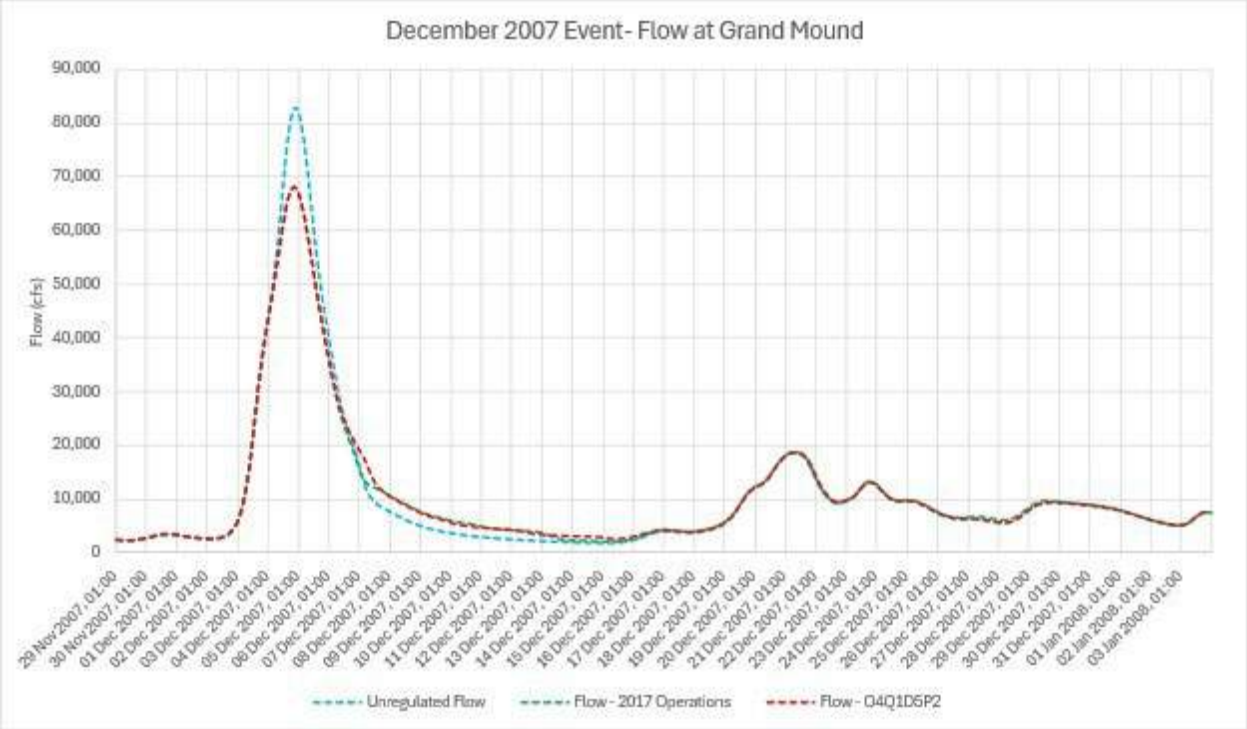


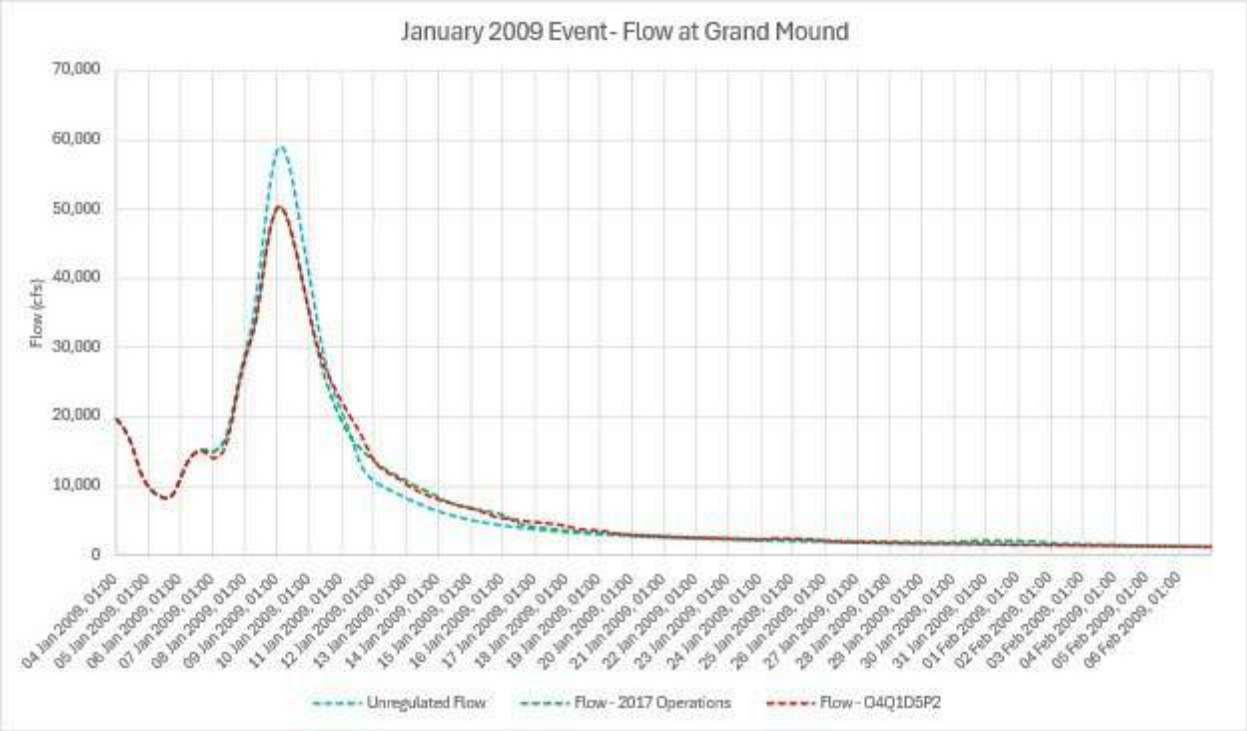
Figure 3. Modeled Flow at Grand Mound for the December 2007 Flood Event



Given the magnitude of the December 2007 storm, both operations sets behaved nearly identically with operations initialization in the first part of the storm event. Both reduced the peak flow at Grand Mound from 82,887 cfs to 68,174 cfs, more than 20 percent lower than the unregulated (without-project) flow. The O4Q1D5P2 operations react quicker to decreasing flow at Grand Mound and begin drawing the reservoir down earlier than the 2017 Operations, and the maximum drawdown rate below 477 feet increases to 20 feet/day as discussed in Section 4.2.3. The O4Q1D5P2 operations set reaches an empty pool on December 22, 2007, with the 2017 Operations trailing by just under 11 days. Stated another way, the O4Q1D5P2 operations set reduces the duration of inundation from 32 days to 21 days, about a 34 percent reduction.

Figure 4. Modeled Reservoir Operations for the January 2009 Flood Event

Figure 5. Modeled Flow at Grand Mound for the January 2009 Flood Event



For the 2009 event, though the O4Q1D5P2 operations set begins storing water almost a day earlier than the 2017 Operations set, the overall pool duration of O4Q1D5P2 ends up almost 11 days shorter than the 2017 Operations (about at 33 percent decrease in inundation time). Both hold Grand Mound to a peak flow of 50,348 cfs (peak Grand Mound flow for O4Q1D5P2 was 50,343 cfs) compared to an unregulated peak flow of 59,010 cfs, a 17 percent decrease. The difference in pool durations is due to O4Q1D5P2 starting drawdown 1 day earlier, having the shorter debris management period, and drawing down at the faster rate of 20 feet/day once the pool is below elevation 477 feet.

Figure 6. Modeled Reservoir Operations for the January 2022 Flood Event

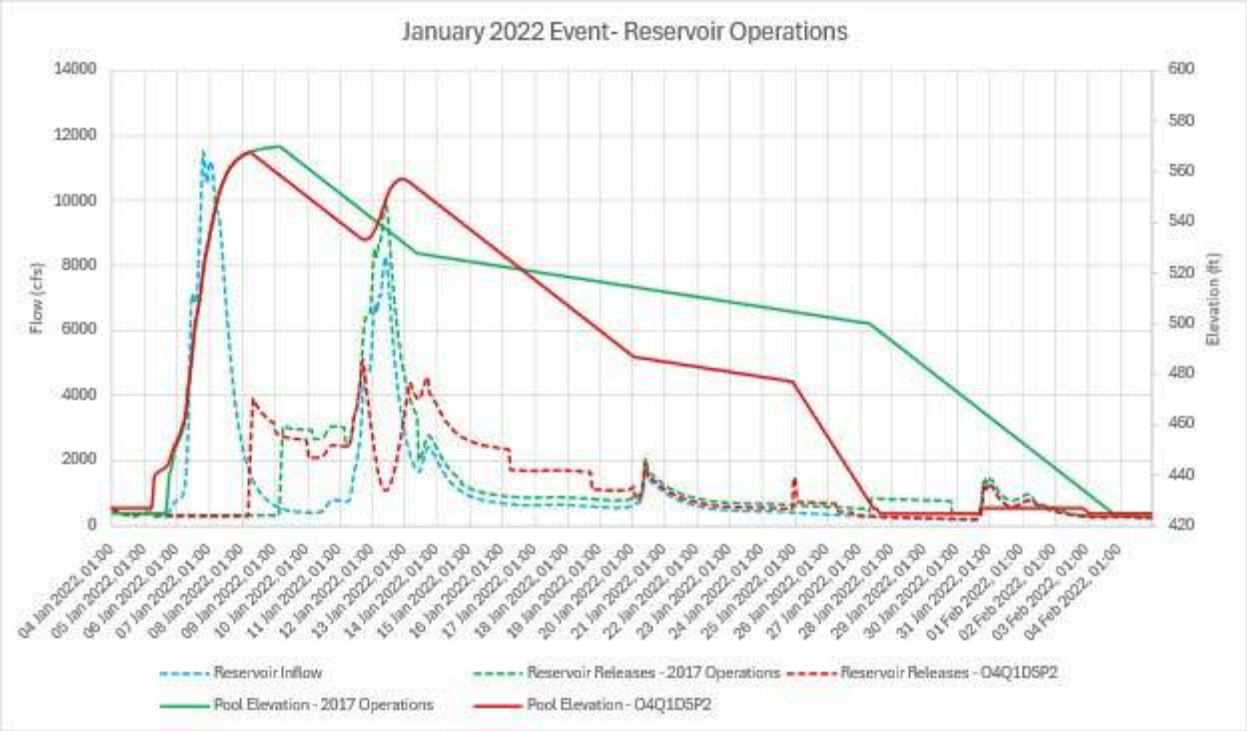
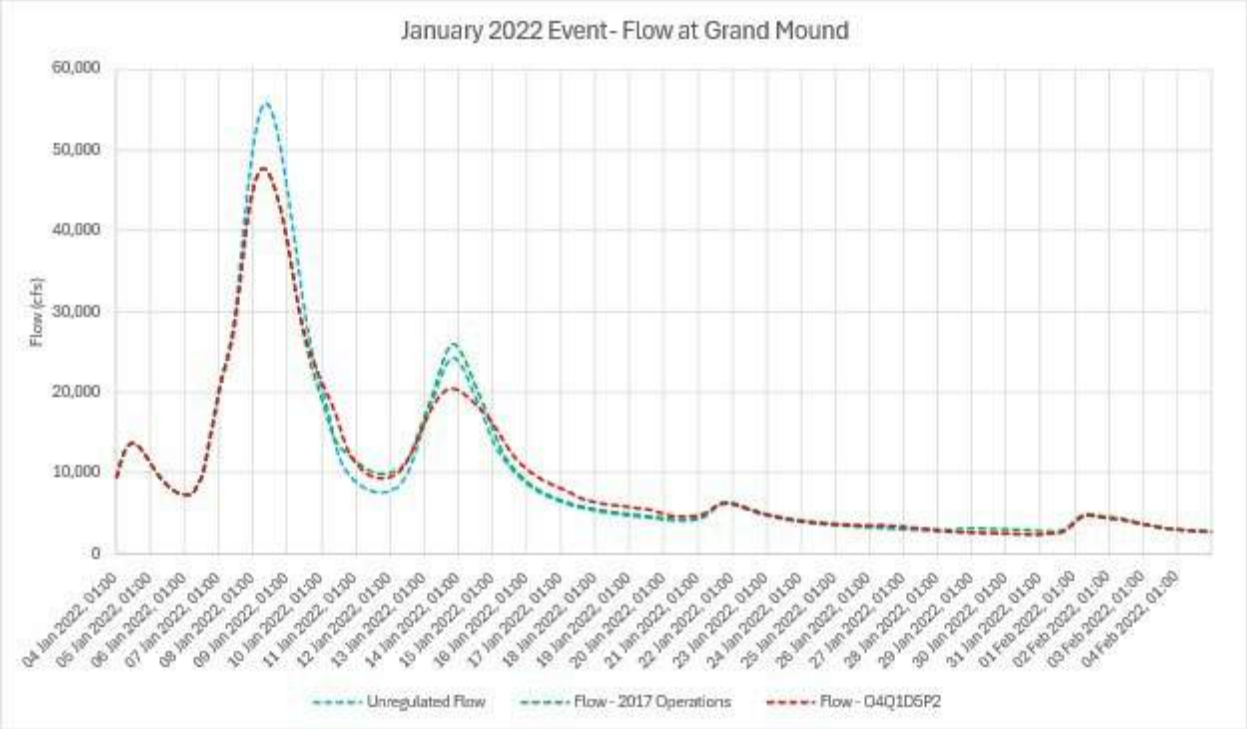


Figure 7. Modeled Flow at Grand Mound for the January 2022 Flood Event



The 2022 event demonstrates the P2 parameter driving the O4Q1D5P2 operations during pool drawdown, after the primary storm has passed. When a large secondary storm struck the basin on January 11 and 12, 2022, the O4Q1D5P2 held back releases to keep flows at Grand Mound below the Minor Flood stage. This resulted in a reduction of the secondary peak at Grand Mound of 5,536 cfs compared to 2017 Operations, which slightly increased the secondary peak flow relative to unregulated flows by continuing to empty the reservoir during the secondary storm. Despite this additional flood protection, the O4Q1D5P2 operations set reduced the inundation period by 7 days compared to the 2017 Operations (about a 24 percent decrease in inundation time). During the main, larger storm, both operations reduced flow at Grand Mound from an unregulated peak of 55,788 cfs to 47,765 cfs, a 16 percent decrease.

Table 7 and Table 8 summarize the performance of two key operations sets, 2017 Operations and O4Q1D5P2, for these three discrete historical storm events.

Table 7. Summary of Historical Event Routing Performance – 2017 Operations

Event	Maximum Reservoir Inflow (cfs)	Maximum Flow at Grand Mound (cfs)	Reduction in Peak Flow at Grand Mound		Duration of Reservoir Pool (days)
			(cfs)	(%)	
Dec 2007	23,100	68,174	14,713	21.6%	32
Jan 2009	11,571	50,348	8,661	17.2%	30
Jan 2022	11,487	47,765	8,023	16.8%	29

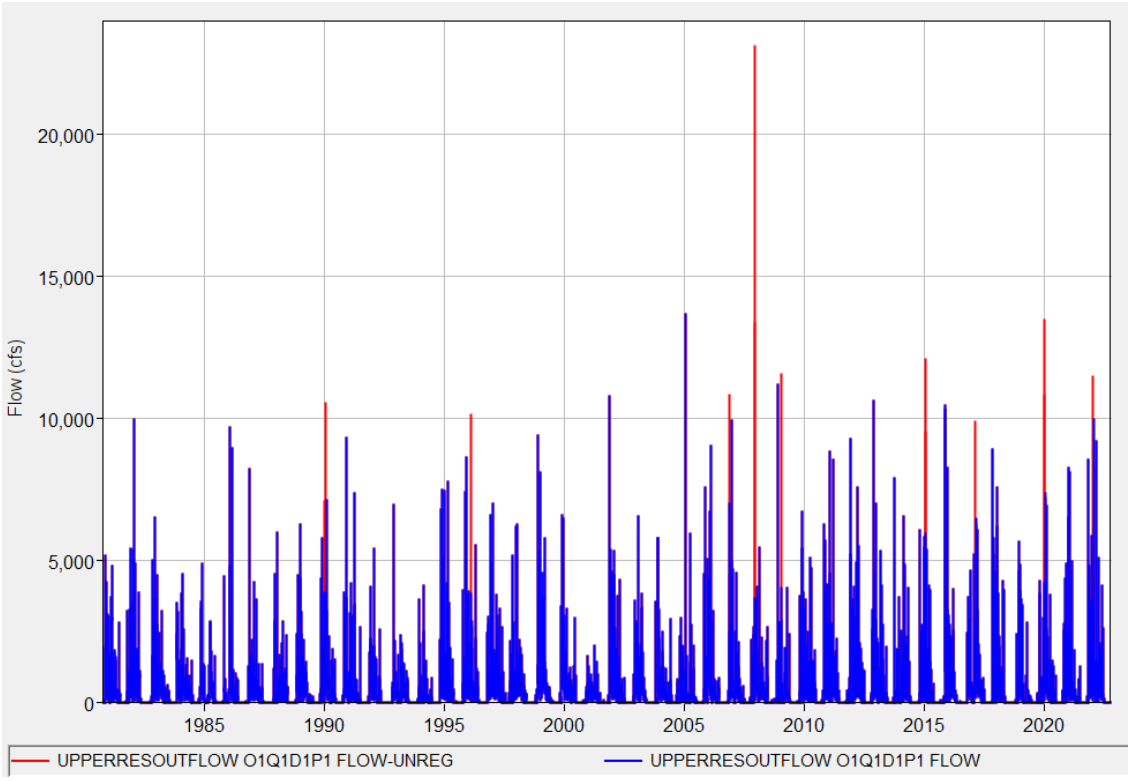
Table 8. Summary of Historical Event Routing Performance – O4Q1D5P2

Event	Maximum Reservoir Inflow (cfs)	Maximum Flow at Grand Mound (cfs)	Reduction in Peak Flow at Grand Mound		Duration of Reservoir Pool (days)
			(cfs)	(%)	
Dec 2007	23,100	68,174	14,713	21.6%	21
Jan 2009	11,571	50,343	8,666	17.2%	20
Jan 2022	11,487	47,765	8,023	16.8%	22

5.2 Current Climate Period of Record Modeling

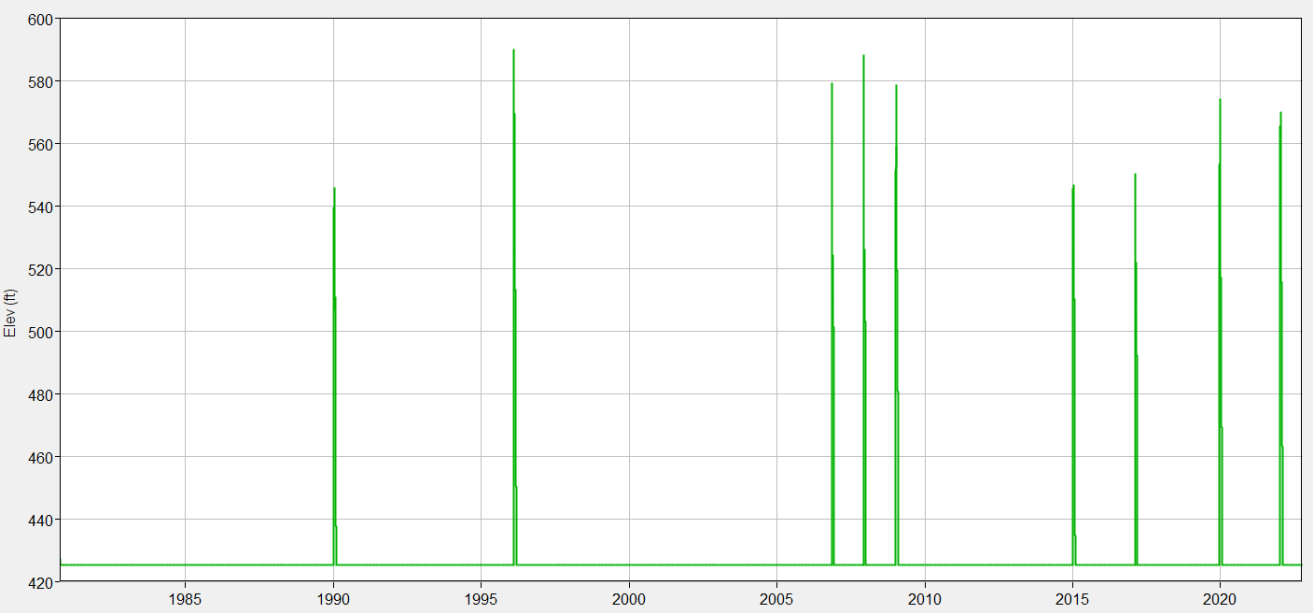
The HEC-ResSim model was run with a 42-year POR local flow time series developed in the HEC-HMS model. Figure 8 shows the results of the unregulated inflows to the reservoir and releases using the 2017 Operations.

Figure 8. Unregulated and Regulated (2017 Operations) Flows Through the Reservoir Site



In Figure 8, the HEC-ResSim model and its associated regulated flows display a reduction in some flood event peaks modeled at the FRE site. Red and blue peaks in the plot represent unregulated flood flows and regulated flows (using 2017 Operations) respectively. Figure 9 shows a plot of the reservoir pool elevation results from the 2017 Operations POR run.

Figure 9. Plot of Regulated (2017 Operations) Reservoir Pool Elevations at the FRE Site



During the 42 historic years of record run in the simulation, the reservoir was triggered to commence flood control operations nine times using the 2017 Operations due to the 38,800 cfs forecast trigger at Grand Mound.[1] Additional flood events that did not trigger flood control events but exceeded outlet flow capacity caused some minor pooling. The dam's spillway, which has a crest at elevation 627 feet, was not used during any events that occurred over the 42-year POR modeling run. The maximum reservoir pool elevation over the POR is 589 feet, which occurred during the February 1996 flood event. This was 1 foot higher than the modeled operations for the 2007 storm due to the longer overall duration of the 1996 storm compared to the 2007 storm, despite the 2007 storm having a higher peak inflow into the reservoir.

5.3 Evaluation of Operational Parameters

Through multiple series of reservoir operations modeling runs, the operational parameters under consideration were evaluated and most were eliminated from the analysis. Some parameters were removed because they did not improve operations. Others would not make sense in real-world operations and were used to set operational boundaries (i.e., how quickly the reservoir pool could be emptied given no drawdown or debris removal restrictions). In summary, these parameters were eventually removed: O2-O3, Q2-Q4, and D1-D4.

5.3.1 Operation Triggers (O1-O4)

The O1 trigger, which starts storing water 48 hours before a forecast flow of 38,800 cfs at Grand Mound, is considered the most conservative operation trigger parameter because it is rigid in its

[1] The actual period of record during this time, according to USGS data, resulted in only 7 years in which peak flows exceeded 38,800 cfs at Grand Mound. Peak flows during some years were close to but under that level. Therefore, the nine triggered operations in this model represent a slight overprediction compared to historical flows, in which some modeled flows are slightly higher than the observed flows, resulting in two additional triggered operations.

operations initiation logic and tends to store more water than other alternatives for similar downstream peak flow reductions based on the siting of the reservoir. This overstoring of water is most apparent during smaller storms that are forecast to just cross the 38,800 cfs trigger at Grand Mound, which results in the O1 operations typically having longer pool durations than the other options.

The O2 and O3 operation triggers were designed to operate the reservoir only when it was expected to be most effective, when the storm is focused on the western side of the basin upstream of the reservoir. These two parameters considered trigger flows at additional gages besides Grand Mound. While such secondary triggers achieved slightly fewer operations, they made the overall operations too insensitive, so flow reduction benefits at Grand Mound suffered and were not achieved often enough for these parameters to be carried forward. Increasing the operation triggers' sensitivities by lowering their respective trigger thresholds only resulted in operations similar enough to the O1 trigger that their value was not apparent. In other words, limiting operations to times when gages other than Ground Mound were high either failed to trigger when flood protection was needed at Grand Mound or (if the other gages' trigger flows were lowered enough to fix that problem) made these secondary triggers irrelevant.

The O4 trigger, which replicates a real-world operation with a live reservoir operator monitoring downstream flows and basin conditions, performed especially well after some extra troubleshooting and programming within the HEC-ResSim model. The O4 operation sets matched the O1 peak flow reduction in major storms and were able to store less water than O1 operations sets in small to moderate storms while not exceeding 38,800 cfs at Grand Mound.

5.3.2 Maximum Releases (Q1-Q4)

The maximum release triggers were designed to understand potential impacts of releasing slightly more water during flood operations to decrease the duration of the reservoir pool. It was evident early on in modeling that any additional water released would only increase downstream flooding by that amount while decreasing the reservoir pool duration by only a few hours. This tradeoff was unacceptable for the proposed flood control structure.

5.3.3 Pool Drawdown/Debris Removal (D1-D5)

Varying the duration of the debris removal period was found to be unrealistic as it made comparing operations sets with different drawdown parameters a difficult prospect; whichever operations set had the shorter debris removal period would inevitably have a shorter reservoir pool duration, regardless of the actual debris conditions after a storm. Given this potential for variation, it was initially decided that using any parameter other than the 2017 Operations D1 parameter would be an unfair and unrealistic comparison. Additionally, the D4 parameter, with no pool drawdown restrictions, is unrealistic in real-world operations where slope stability in the upper reaches of the reservoir would be a concern.

After consulting with the geotechnical team, however, it was decided to allow an increased drawdown rate of up to 20 feet/day below 477 feet in the reservoir. Below 500 feet, all identified landslide areas within the reservoir would be stabilized so the increased drawdown rate was considered acceptable. The debris management team also increased the clarity of expected

debris management operations, reducing the expected duration from 14 days to 5 days. The elevation band for debris management operations was lowered to 487-477 feet to allow important spawning habitat in the upper basin to return to free-flowing conditions sooner than other alternatives. These updated debris management operations became part of scenario D5 and are reflected in the O4Q1D5P1 and O4Q1D5P2 results provided herein.

5.3.4 Drawdown Releases (P1-P2)

Both P1 and P2 parameters performed as expected, with P1 limiting release increases to 1,000 cfs/hour and P2 adding logic to also avoid downstream flows rising above the Minor Flood stage at Grand Mound during pool drawdown. This additional logic was shown to be helpful in cases where a second or third storm followed the primary storm while the reservoir was still being emptied. The P2 parameter could reactivate storage operations, reducing releases and storing water again to reduce downstream flows, while the 2017 Operations P1 parameter would continue drawing the reservoir down until it was empty without considering downstream local flows.

5.4 Future Climate Period of Record Modeling

The variation of frequency of reaching the Grand Mound trigger flow of 38,800 cfs ranged from 11 times to 57 times over the future climate period modeled from 2026-2100, depending on the GCM. The variation in operational frequency between GCMs and operations sets is depicted below in Table 9. In some GCMs, the O4Q1D5P1 and O4Q1D5P2 operations sets show 1 to 2 more operation events (defined as when operations are initiated until the reservoir pool is considered empty, below WSEL 447) than the 2017 Operations, but this is a result of the 2017 Operations having a much longer pool duration compared to the O4 operations, which store less water and empty the reservoir pool sooner. When two large storms occur within 1 month of one another, the 2017 Operations are sometimes still in the midst of emptying the reservoir pool when storage is reinitiated, so this would only count as a single operation event, whereas the O4 operations, which have already emptied the reservoir pool due to storing less water initially, count another operation event when they store water for the second storm in the series. Attachment 1 contains plots of each GCM under 2017 Operations to provide visual context for the frequency of operations of each GCM.

Table 9. Operational Frequency Using 2017 Operations in Future Climate POR

Global Climate Model	2017 Operations	O4Q1D5P1	O4Q1D5P2
Access 1.0	27	28	28
Access 1.3	24	24	24
bcc-csm 1.1	27	27	27
canesm2	13	14	14
ccsm4	22	22	22

Global Climate Model	2017 Operations	O4Q1D5P1	O4Q1D5P2
csiro-mk3.6	40	41	41
fgoals-g2	15	15	15
gfdl-cm3	40	42	42
giss-e2-h	11	11	11
MIROC5	41	43	43
mri-cgcm3	17	17	17
noresm1-m	57	57	57

5.5 Statistical Results

After comparing the performances of the original 128 operations sets and reducing the number of viable parameters, two final candidate operations sets (O4Q1D5P1 and O4Q1D5P2) remained the likely best-performing options. To confirm these results, a series of statistical analyses were performed to compare these operations to the original 2017 Operations under current climate and potential future climate conditions.

5.5.1 Current Climate (Historic) Statistical Results

5.5.1.1 Grand Mound Water Surface Elevation Percent-Chance Exceedance

Comparing the downstream performance of the O4Q1D5P1 and O4Q1D5P2 operations with the 2017 Operations, the percent-chance exceedance indicates the operations sets all show similar WSELs at Grand Mound in the upper WSELs associated with larger storms (Figure 10 and Figure 11). The O4Q1D5P1 and O4Q1D5P2 operations were associated with a slightly higher probability of occurrence in the 143- to 144-foot WSEL range. This is because WSEL 144 feet is equivalent to a flow of 38,000 cfs, which is the target flow that the O4 parameter is not to exceed at Grand Mound. This allows the O4 operations sets (O4Q1D5P1 and O4Q1D5P2) to keep flows at Grand Mound below the 38,800 cfs major flood flow during small to moderate storms while storing much less water than the 2017 Operations and emptying their reservoir pools days or weeks earlier than the 2017 Operations. Despite the higher probability of the O4 operations being triggered as compared to 2017 Operations, the difference is so subtle that it is difficult to see when represented visually (Figure 10), even in the detail view in Figure 11.

Figure 10. Grand Mound Water Surface Elevation Percent-Chance Exceedance

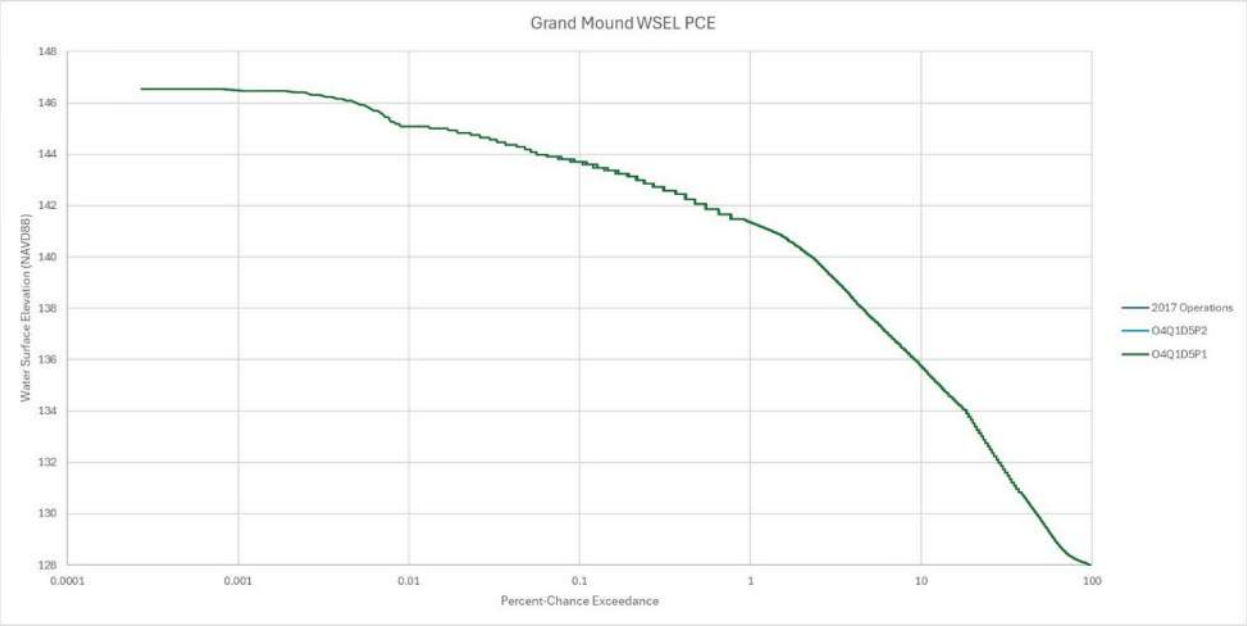
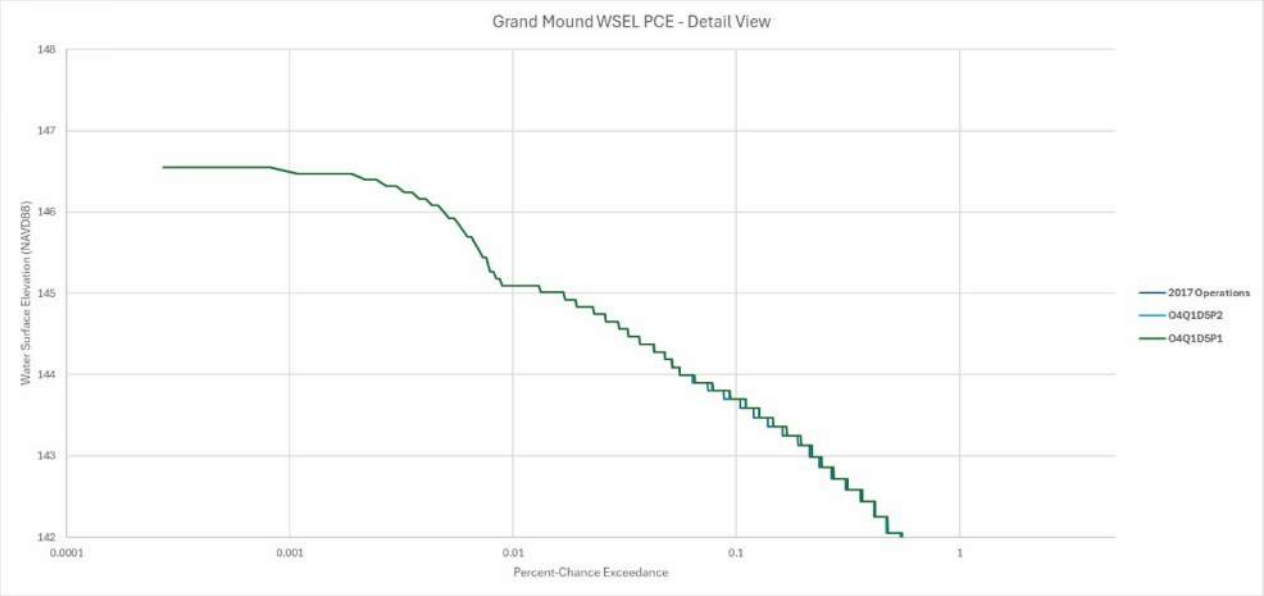


Figure 11. Grand Mound Water Surface Elevation Percent-Chance Exceedance – Detailed View



5.5.1.2 Fisk Falls Spawning Reach Inundation Duration

The majority of salmon spawning habitat in the temporary inundation reach exists in the two river miles below Fisk Falls in the upper areas of the proposed reservoir; the bottom elevation of this habitat is at WSEL 530 feet. For this analysis, inundations of this habitat at less than 2 feet of depth were deemed less impactful. Therefore, determining how long the area above WSEL 532 feet remains inundated is important to understand potential impacts on salmon rearing in the watershed and minimize environmental impacts from reservoir operations. Comparing the 2017 Operations with the O4 operations sets over the current climate POR gives an average of

1.22 days of inundation per year for 2017 Operations compared to 0.85 average days of inundation per year for the O4Q1D5P1 operations set and 1.08 days of inundation per year for the O4Q1D5P2 operations set. These averages are low because the facility does not operate in most years of the POR. The analysis below also considers the specific years in which the facility would have operated.

Over the modeled POR (1980-2022), Fisk Falls was inundated to some extent nine times with 2017 Operations, seven times with O4Q1D5P1 operations, and eight times with O4Q1D5P2 operations. The time of inundation above WSEL 532 for each operations set varied considerably depending on the character and magnitude of the storm, with the durations shown below in Table 10 for each historic storm event and operations set. For two of these nine flood events (1990 and 2022) the 2017 Operations inundate the area downstream of Fisk Falls for a shorter duration than one or both of the O4 operations sets. In 1990, both O4 operations sets started storing water to provide downstream protection a few hours earlier than the 2017 Operations, and in 2022, the O4Q1D5P2 operations set stores additional water to provide additional downstream protection, as shown previously in Figure 6 and discussed in Section 5.1.

Table 10. Fisk Falls Inundation Duration (above WSEL 532) – Current Climate POR

Year	Total Days per Year above WSEL 532		
	2017 Operations	O4Q1D5P1	O4Q1D5P2
1990	2.88	3.17	3.29
1996	8.83	7.67	7.67
2006	7.00	5.63	5.75
2007	8.17	7.17	7.17
2009	7.08	6.13	6.13
2015	3.00	1.83	1.83
2017	3.33	0	2.38
2019	6.00	0	3.46
2022	6.00	4.83	8.58
Average (for Years w/ Facility Operation)	5.81	4.05	5.14

Figure 12 and Figure 13 show the percent-chance exceedance of Fisk Falls inundation between 2017 Operations, O4Q1D5P1, and O4Q1D5P2. The operations sets track closely together, with the O4Q1D5P2 operations set occasionally requiring additional water storage to keep Grand Mound below Minor Flood stage during secondary storms following the primary storm. In all

storm events for the current climate POR, the O4Q1D5P1 operations set has the least inundation of Fisk Falls of the three operations sets. Figure 14 presents the duration of Fisk Falls inundation by calendar year for each operations set. In these modeled results, there was no calendar year in which there were two inundation events; therefore, Figure 14 also shows the duration of inundation per event.

Figure 12. Fisk Falls Inundation (above WSEL 532) Annual Percent-Chance Exceedance for Historic POR (1980–2022)

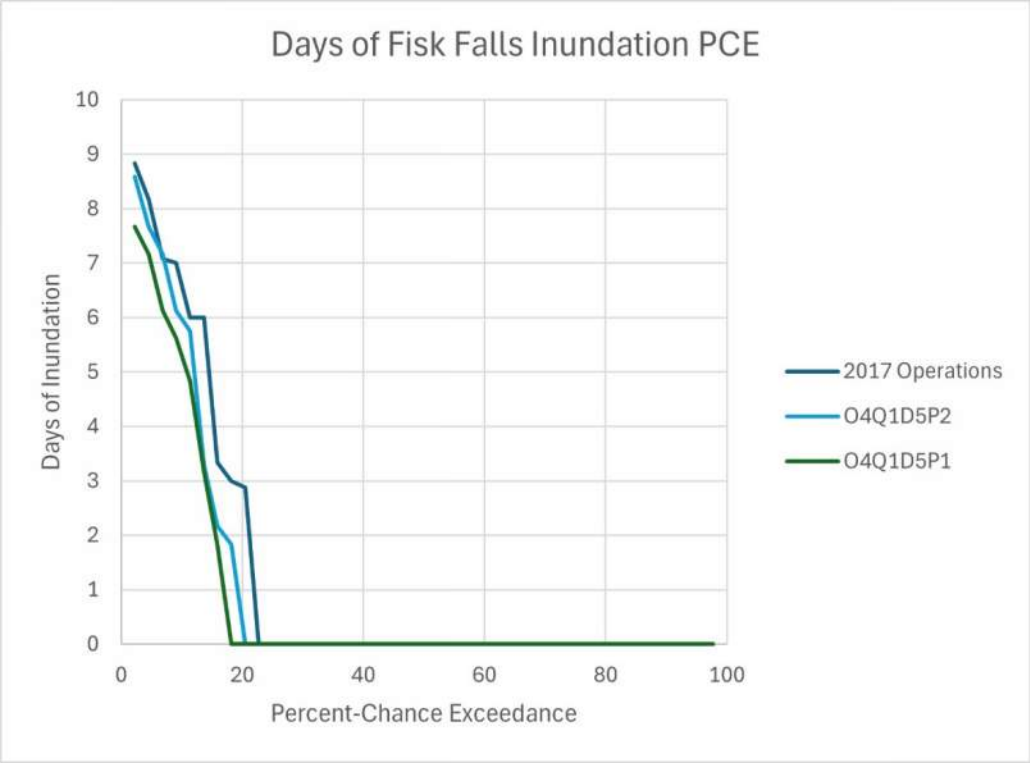


Figure 13. Fisk Falls Inundation (above WSEL 532) Annual Percent-Chance Exceedance for Historic POR (1980–2022) - Detailed View

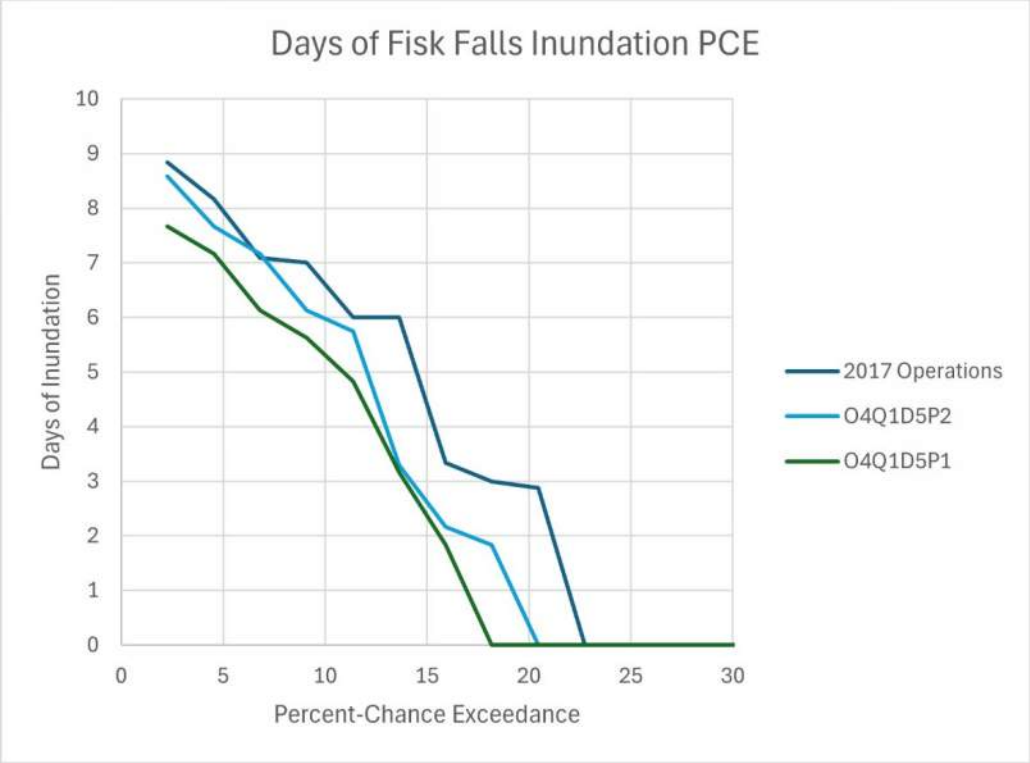
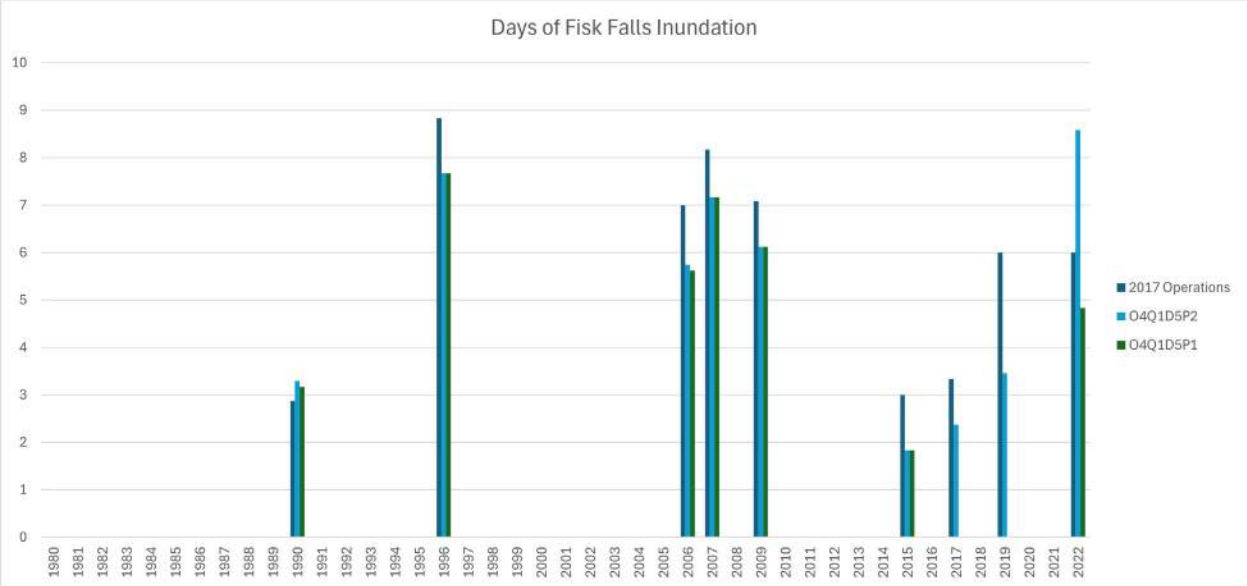


Figure 14. Days of Inundation at Fisk Falls (above WSEL 532) by Calendar Year



5.5.1.3 Reservoir Pool Duration

The O4 operations sets show an improvement in overall reservoir pool duration (when the WSEL in the reservoir is above 447 feet) in comparison with the 2017 Operations, as shown in

Figure 15 through Figure 17. Over the historic POR HEC-ResSim modeling run, O4Q1D5P1 operations held a reservoir pool for 0.9 percent, O4Q1D5P2 operations held a pool for 1.0 percent, and 2017 Operations held a reservoir pool for 1.6 percent of the overall time period. The performance of the O4Q1D5P2 operations set was slightly lower than O4Q1D5P1 due to storing extra water during subsequent storms to prevent secondary flooding.

Figure 15. Reservoir Pool Duration (above WSEL 447) Percent-Chance Exceedance

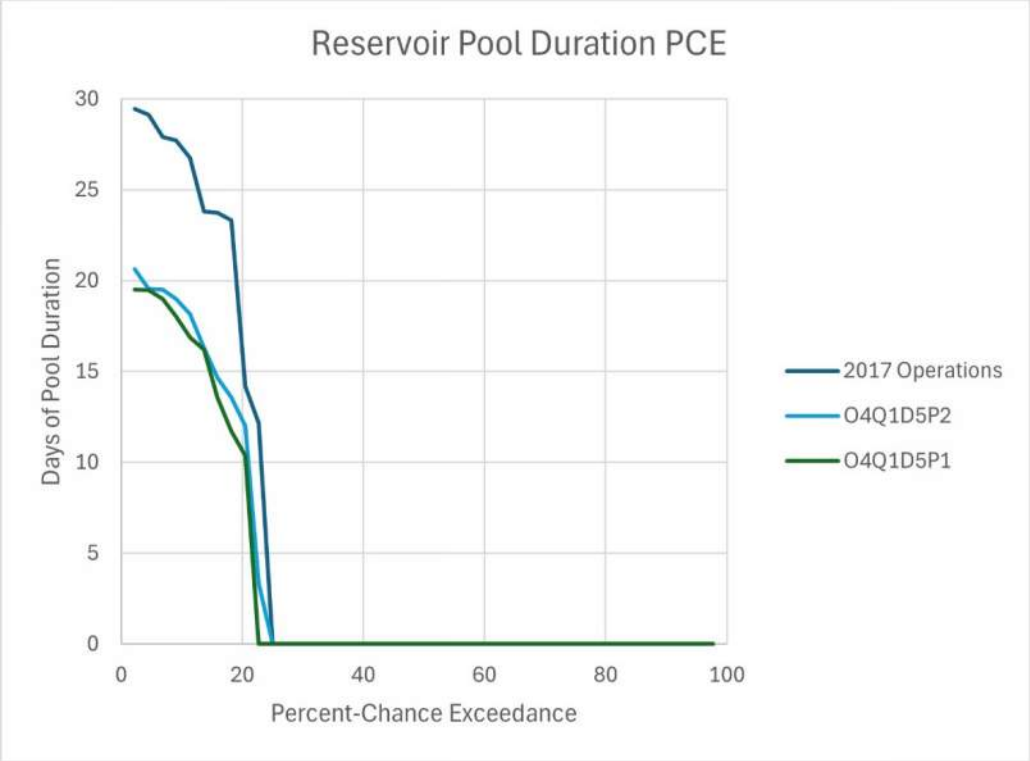


Figure 16. Reservoir Pool Duration (above WSEL 447) Percent-Chance Exceedance – Detailed View

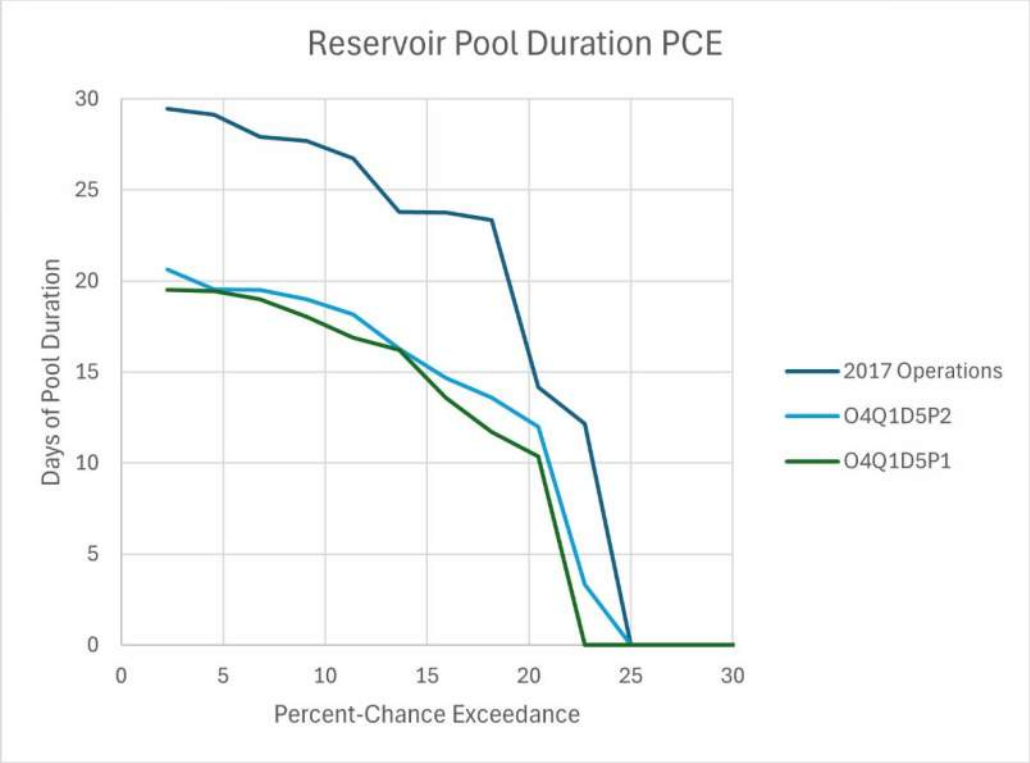
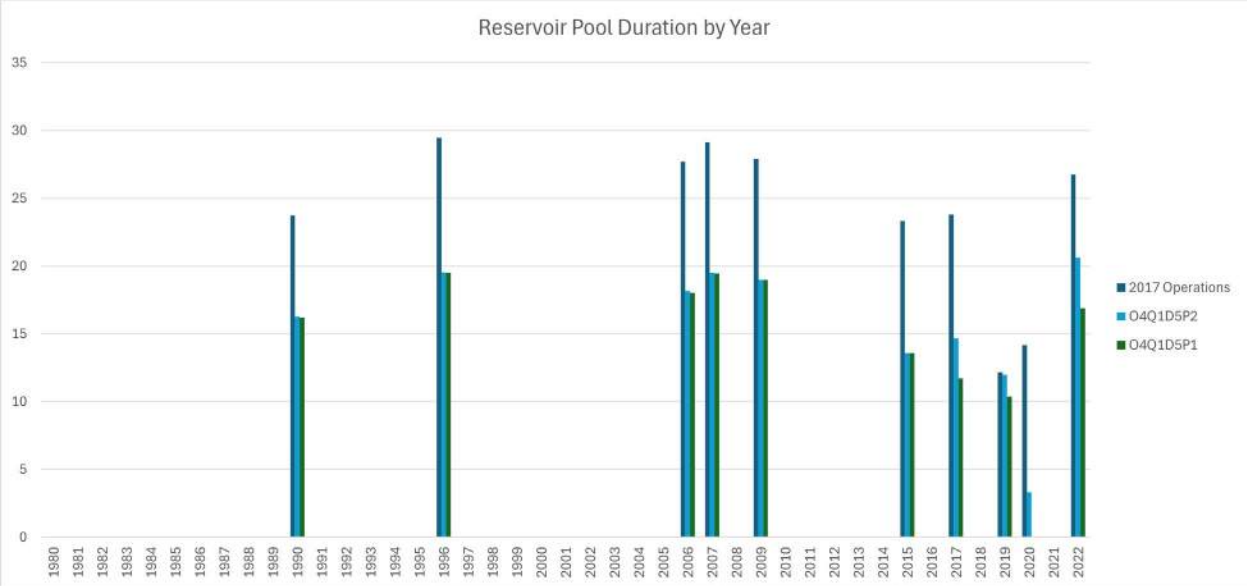


Figure 17. Reservoir Pool Duration (above WSEL 447) by Calendar Year



5.5.1.4 Location-specific Regulated Annual WSEL Maxima

Regulated annual WSEL maxima were developed at the FRE and downstream sites of interest (Doty, Adna, Wastewater Treatment Plant [WWTP], and Grand Mound) using the following procedures:

1. Estimate 1 percent annual exceedance probability (AEP) without-project, unregulated WSELs using the candidate flow-frequency curves and rating curves established.
2. Route historical and scaled reservoir inflows and downstream local flows for the POR using HEC-ResSim.
3. Create post-processed routings to develop an event maximum dataset.
4. Identify the critical duration associated with each location.
5. Develop an unregulated flow to regulated peak flow transform at each location using the event maximum dataset and critical duration information.
6. Combine the unregulated flow-frequency information with the flow transforms to develop candidate regulated peak flow-frequency curves at each location.
7. Estimate 1 percent AEP with-project, regulated WSELs using the candidate regulated peak flow-frequency curves and rating curves established.

With-Project Conditions

With-project, regulated flood frequency curves were calculated using the Information Processing and Synthesis Tool (IPAST) software application following procedures consistent with the Central Valley Hydrology Study (USACE and California Department of Water Resources 2015). The general steps for computing the regulated curves for each location of interest in IPAST are:

1. Input unregulated frequency information.
2. Develop a dataset of maximum unregulated and regulated peak flow and n-day volumes for simulated flood events.
3. Assess critical duration.
4. Develop an unregulated-to-regulated flow transform.
5. Compute regulated frequency curves by combining unregulated flow-frequency information and unregulated-to-regulated flow transform.

Unregulated Flow Frequency

Unregulated flow-frequency information—Log Pearson Type III (LP3) statistics—are configured in IPAST for each analysis point. Table 11 lists the LP3 statistics developed by HDR and input into IPAST.

Table 11. LP3 Statistics Configured into IPAST

Location	Mean	Standard Deviation	Adopted Skew
Doty	4.078	0.251	0.081
Adna	4.318	0.181	0.094

Location	Mean	Standard Deviation	Adopted Skew
WWTP	4.334	0.23	-0.035
Grand Mound	4.437	0.22	0.043

Event Maximum Dataset Development

Scale Historical and Synthetic Flows

To capture the full range of desired flow quantiles in the regulated curves, the historical and synthetic local flow time series with a simulation period of 42 years were scaled by multipliers that ranged from 0.2 to 3.0, in increments of 0.2, consistent with Engineering Manual (EM) 1110-2-1415 (USACE 1993). This yielded 15 scaled sets of local flows to be routed through the HEC-ResSim model that represented 20 to 300 percent of the POR flows. Scaled versions of historical events were used to represent the coincidence and timing of flows for different events that have been observed in the basin. While the unscaled, unregulated events in the historical period of record cover a wide range of event recurrence, unscaled regulated flows are typically not large enough to define the upper end of the regulated frequency curve, requiring the need for scaling. It is important to note that the scaled flow data was not used in the previous unregulated flow frequency curve computations.

HEC-ResSim Routing and Simulating of Scaled Flows

After the flows had been assembled in the Hydrologic Engineering Center Data Storage System (HEC-DSS) collections ranging from 20 to 300 percent of the POR dataset, the flows were routed through the HEC-ResSim model using an ensemble simulation alternative. At each of the USGS gages of interest, stage-discharge rating curves were applied to the regulated flows to calculate regulated stage frequency information.

Identify Floods-of-Record

To select the flood events that would be used in generating the regulated frequency curves, HDR identified a set of four large floods observed in the Chehalis River Basin from the POR dataset (Table 12). These choices were based on peak flows observed at the Chehalis River near Grand Mound and Doty locations.

Table 12. Event Extraction Time Window Groups

Event Name	Start Date	End Date
1996	02/02/1996	03/20/1996
2008	11/29/2007	1/31/2008
2009	12/30/2008	02/19/2009
2022	12/25/2021	02/14/2022

Critical Duration Analysis

Critical duration is the unregulated volume (average flow over a duration) that drives the peak regulated flow, as defined in Central Valley Hydrology Study documentation (California Department of Water Resources 2015). It is also the volume used to assign a probability to a peak regulated flow or storage value. The critical duration for each flood event and scale group was selected based on the duration with a volume ratio between 0.9 and 2.0, and closest to 1.0. If these criteria were not met, the software was set to default to an assumed critical duration of 1 day. At the FRE and Doty locations, the critical duration was locked to 3 days. At all other locations downstream of Doty, the critical duration was determined to be 1 day by using the volume ratio approach described above.

Regulated Curve Development

To verify that all regulated frequency curves are monotonic and increasing, the IPAST software prompts the user to choose an envelope method for smoothing the event-specific curves (USACE and California Department of Water Resources 2015). After visually inspecting the differences between the envelope methods, HDR decided to use a forward-looking trend.

Flow Transform Fitting and Curve Combinations

The last step in generating regulated frequency curves is to fit the flow transforms and combine the unregulated curves with the regulated curves. Fitting the flow transforms was performed using the local weighted scatterplot smoothing (LOWESS) regression method in which a local polynomial is fitted through each point in a scatterplot using weighted least squares. The number of iterations used to fit the curve was set to 100, and a smoothing coefficient of 0.3 was chosen, from a scale of 0 to 1. These parameters were used for each site on the river.

Results

Regulated flow and stage annual maxima applicability is limited to operational alternative comparative analysis only and is not intended for design of risk analysis. Additional refinements are required in future phases for such applications to be appropriate. Results of the 1 percent AEP peak flows are presented below in Table 13. All operations sets successfully achieve a reduction in 1 percent AEP flows. At the FRE and Doty, O4Q1D5P2 results in significantly lower peak regulated flows compared to O4Q1D5P1 and 2017 Operations. At Grand Mound, O4Q1D5P2 reduced the peak flow slightly more than O4Q1D5P1 and 2017 Operations.

Table 13. Estimated 1% AEP Peak Flows

Operation Set Result	FRE	Doty	Adna	WWTP	Grand Mound
Unregulated Flow (cfs)	38,010	47,520	56,500	73,040	90,160
2017 Operations Flow (cfs)	15,780	16,350	33,810	38,950	62,010
O4Q1D5P1 Flow (cfs)	16,220	16,260	33,810	38,950	62,010
O4Q1D5P2 Flow (cfs)	9,720	10,680	33,810	38,950	62,000

Results of the 1 percent AEP peak WSEL are presented in Table 14. Like the peak flows, all operations sets are able to achieve a decrease in 1 percent AEP peak WSEL at all locations downstream of the FRE. At the FRE, 2017 Operations result in the lowest 1 percent AEP regulated WSEL, and O4Q1D5P2 operations result in the highest regulated FRE WSEL. At Grand Mound, the reduction in peak 1 percent AEP WSEL is equal across operation sets.

Table 14. Estimated 1% AEP Peak WSEL

Operation Set Result	FRE (Reservoir Pool Elevation)	Doty	Adna	WWTP	Grand Mound
Unregulated WSEL (ft)	455.3	330.1	215.1	184.5	148.2
2017 Operations WSEL (ft)	629.4	319.9	211.9	181.4	146.1
O4Q1D5P1 WSEL (ft)	629.8	320.2	211.9	181.5	146.1
O4Q1D5P2 WSEL (ft)	631.1	317.8	211.9	181.5	146.1

5.5.1.5 Flow Frequency Analysis

Annual flood frequency quantiles (Table 15) at the FRE location were calculated for the 2017 Operations and the O4 operations sets. Specific time windows used for the Unregulated Flow Frequency Analysis (USACE: July–August, HDR Recommended: July–September, Washington Department of Fish and Wildlife: August) are not shown in Table 15 as no flood events that trigger operations were observed during the specified time windows. Table 16 through Table 18 provide a monthly breakdown of flow exceedance values at the FRE location.

Table 15. Annual Flood Frequency Quantiles for Flow at the FRE Location

AEP	Unregulated Flow (HDR 2025)	2017 Operations		O4Q1D5P1		O4Q1D5P2	
		Regulated Flow	Decrease from Existing	Regulated Flow	Decrease from Existing	Regulated Flow	Decrease from Existing
	(cfs)						
50%	9,496	3,458	6,038	4,482	5,104	4,474	5,022
20%	15,531	4,848	10,683	5,127	10,404	4,791	10,740
10%	20,175	8,346	11,829	8,416	11,759	5,273	14,902
6.7%	23,011	9,718	13,293	9,920	13,091	5,725	17,286
5.0%	25,098	10,755	14,343	10,535	14,563	5,836	19,262
4.0%	26,756	11,683	15,073	11,379	15,377	6,157	20,599
2.0%	32,169	14,310	17,859	14,277	17,892	7,470	24,699
1.0%	38,014	15,777	22,237	16,224	21,790	9,723	28,291
0.4%	46,478	15,980	30,498	17,150	29,328	14,383	32,095
0.2%	53,491	16,818	36,673	17,409	36,082	17,857	35,634

Table 16. Monthly Exceedance Flow Values (cfs) Downstream of the FRE Location – 2017 Operations

Exceedance (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
99	12.9	9.0	13.9	23.4	3.4	0.8	0.1	0.0	0.0	-	0.1	6.0
95	30.3	39.6	57.4	45.9	9.1	1.5	0.2	0.1	0.0	-	6.0	35.8
90	67.7	70.0	90.7	65.7	15.9	2.5	0.4	0.1	0.0	-	16.9	65.4
80	142.6	125.6	150.6	99.9	31.5	5.7	0.7	0.1	0.1	0.3	70.8	140.9
75	180.6	154.4	179.6	122.5	40.9	7.7	0.8	0.2	0.1	0.6	115.9	175.6
50	421.8	349.8	358.6	269.3	109.7	29.2	1.9	0.3	0.3	9.4	384.9	392.3
25	917.7	728.2	674.1	507.1	264.7	100.8	5.2	0.7	2.0	99.6	885.1	886.1
10	1,734.7	1,403.1	1,143.9	853.4	492.3	268.9	15.2	1.6	11.3	487.6	1,765.3	1,725.4
5	2,573.5	2,117.9	1,575.2	1,177.3	696.3	454.4	31.3	3.0	37.3	1,007.9	2,667.6	2,479.8
1	4,810.7	3,950.6	3,044.5	2,488.6	1,234.8	1,039.9	138.5	29.2	265.5	2,675.2	5,307.1	4,537.2

Table 17. Monthly Exceedance Flow Values (cfs) Downstream of the FRE Location – O4Q1D5P1

Exceedance (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
99	13.0	9.0	13.9	23.4	3.4	0.8	0.1	0.0	0.0	0.0	0.0	6.0
95	30.0	37.9	57.4	45.9	9.1	1.5	0.2	0.1	0.0	0.0	6.0	35.8
90	64.0	68.1	90.7	65.7	15.9	2.5	0.4	0.1	0.0	0.0	17.0	65.4
80	138.0	124.6	149.7	99.9	31.5	5.7	0.7	0.1	0.1	0.0	71.0	140.3
75	173.0	153.4	178.4	122.5	40.9	7.7	0.8	0.2	0.1	1.0	116.0	174.6
50	411.0	344.5	354.5	269.5	109.7	29.2	1.9	0.4	0.3	9.0	383.0	393.9
25	922.0	726.8	670.1	507.1	264.8	100.8	5.2	0.7	2.0	100.0	882.0	881.4
10	1,731.0	1,427.9	1,142.3	853.4	492.3	269.5	15.2	1.6	11.3	487.0	1,781.0	1,708.9
5	2,560.0	2,098.8	1,571.9	1,177.3	696.3	454.3	31.3	3.0	37.3	1,008.0	2,683.0	2,478.4
1	4,796.0	4,048.9	3,044.5	2,488.6	1,234.8	1,039.9	138.5	29.2	281.1	2,675.0	5,289.0	4,700.1

Table 18. Monthly Exceedance Flow Values (cfs) Downstream of the FRE Location – O4Q1D5P2

Exceedance (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
99	13.0	9.0	13.9	23.4	3.4	0.8	0.1	0.0	0.0	0.0	0.0	6.0
95	30.0	37.9	57.4	45.9	9.1	1.5	0.2	0.1	0.0	0.0	6.0	35.8
90	64.0	68.1	90.7	65.7	15.9	2.5	0.4	0.1	0.0	0.0	17.0	65.4
80	138.0	124.6	149.7	99.9	31.5	5.7	0.7	0.1	0.1	0.0	71.0	140.6
75	173.0	153.4	178.4	122.5	40.9	7.7	0.8	0.2	0.1	1.0	116.0	174.9
50	413.0	343.6	354.5	269.5	109.7	29.2	1.9	0.4	0.3	9.0	383.0	394.6
25	934.0	729.3	670.1	507.1	264.8	100.8	5.2	0.7	2.0	100.0	883.0	886.5
10	1,739.0	1,438.3	1,142.3	853.4	492.3	269.5	15.2	1.6	11.3	487.0	1,783.0	1,718.1
5	2,560.0	2,122.9	1,571.9	1,177.3	696.3	454.3	31.3	3.0	37.3	1,008.0	2,683.0	2,470.2
1	4,673.0	4,010.8	3,044.5	2,488.6	1,234.8	1,039.9	138.5	29.2	281.1	2,675.0	5,243.0	4,573.3

5.5.2 Future Climate Statistical Results

The performance of each operation set was evaluated under potential future climate conditions for 12 GCMs, as well as mid-century (2060) and late-century (2090) climate conditions.

5.5.2.1 Frequency of Operations

The variation of frequency of reaching the Grand Mound trigger flow of 38,800 cfs ranged from 11 to 57 times over the future climate period modeled from 2026 to 2100, depending on the GCM. The variation in operational frequency between GCMs and operations sets is depicted below in Table 19. In some GCMs, the O4Q1D5P1 and O4Q1D5P2 operations sets show one to two more operation events (defined as when operations are initiated until the reservoir pool is considered empty, below WSEL 447 feet) than the 2017 Operations, but this is a result of the 2017 Operations having a much longer pool duration compared to the O4 operations, which store less water and empty the reservoir pool sooner. When two large storms occur within a month of one another, the 2017 Operations are sometimes still in the midst of emptying the reservoir pool when storage is reinitiated, so this would only count as a single operation event whereas the O4 operations, which have already emptied the reservoir pool due to storing less water initially, count another operation event when they store water for the second storm in the series. Attachment 1 contains plots of each GCM under 2017 Operations to provide visual context for the frequency of operations of each GCM.

Table 19. Operational Frequency in Future Climate POR

Global Climate Model	2017 Operations	O4Q1D5P1	O4Q1D5P2
Access 1.0	27	28	28
Access 1.3	24	24	24
bcc-csm 1.1	27	27	27
canesm2	13	14	14
ccsm4	22	22	22
csiro-mk3.6	40	41	41
fgoals-g2	15	15	15
gfdl-cm3	40	42	42
giss-e2-h	11	11	11
MIROC5	41	43	43
mri-cgcm3	17	17	17
noresm1-m	57	57	57

5.5.2.2 Grand Mound Water Surface Elevation Percent-Time Exceedance

Comparing the downstream performance of the O4 operations sets with the 2017 Operations, the PTE of all 12 GCMs show slight variations in the WSEL 143- to 144-foot range, though in general, the O4Q1D5P1 and O4Q1D5P2 operations have a slightly higher PTE in that elevation range. Similar to the current climate results in Section 5.5.1.1, the O4 operation sets allow flows at Grand Mound to approach, but not exceed, 38,800 cfs in order to store less water in the reservoir to reduce Fisk Falls inundation and the overall pool duration. Within the slight variation of PTE at the WSEL 143- to 144-foot range, the O4Q1D5P1 operation set tends to have slightly higher WSELs than the O4Q1D5P2 operation set. This is due to the P2 parameter avoiding exceedance of the Minor Flood stage of WSEL 141 feet at Grand Mound during drawdown, minimizing impacts of secondary flood peaks. Attachment 2 provides a detailed view of the Grand Mound WSEL PTE of each GCM between WSEL 140 and 148 feet.

5.5.2.3 Fisk Falls Spawning Reach Inundation Duration

As described in section 5.5.1.2, it is important to evaluate the inundation around Fisk Falls (above WSEL 532 feet in the reservoir) to understand potential impacts to salmon rearing in the watershed. Comparing the 2017 Operations with the O4 operations sets over the future climate POR (1970–2100) gives an average of 2.4 days of inundation per year for the 2017 Operations, compared to 1.4 days for O4Q1D5P1 and 2.5 days for O4Q1D5P2 when averaged across the 12 GCMs. Of the 12 GCMs, the highest number of days inundated within a single year for the 2017 Operations was 47 days under the conditions of the MIROC5 GCM. The highest number of days inundated within a single year for O4Q1D5P1 was 35.8 days under MIROC5 GCM conditions. The highest number of days inundated within a single year for O4Q1D5P2 was 51.9 days under noresm-1 GCM conditions. Attachment 3 provides percent-chance exceedance plots of annual days of expected inundation at Fisk Falls. Comparing the percent of days inundated over the entire future climate POR between the operations sets shows that under every GCM condition, O4Q1D5P1 results in the lowest percent of days inundating Fisk Falls. The 2017 Operations and O4Q1D5P2 operations closely align for this metric, with O4Q1D5P2 inundating Fisk Falls for more days than 2017 Operations under the conditions of 7 of 12 GCMs. Averaging the percent days inundated at Fisk Falls across the GCMs shows that O4Q1D5P1 inundates Fisk Falls for 0.4 percent, O4Q1D5P2 for 0.69 percent, and 2017 Operations for 0.65 percent of the time.

Table 20. Percent of Days Inundating Fisk Falls Reach – Future Climate (1970–2100) POR

GCM ID	2017 Operations	O4Q1D5P1	O4Q1D5P2
	(%)		
Access 1-0	0.55	0.33	0.58
Access 1-3	0.42	0.22	0.46
Bcc-csm1-1	0.53	0.26	0.47
canESM2	0.19	0.08	0.19

GCM ID	2017 Operations	O4Q1D5P1	O4Q1D5P2
	(%)		
CCSM4	0.57	0.42	0.63
CSIRO-Mk3-6-0	0.98	0.63	1.01
FGOALS-g2	0.27	0.12	0.36
GFDL-CM3	0.87	0.53	0.82
GISS-E2-H	0.22	0.09	0.22
MIROC5	1.26	0.81	1.38
MRI-CGCM3	0.37	0.14	0.32
norESM1-M	1.53	1.12	1.85
AVERAGE:	0.65	0.40	0.69

5.5.2.4 Reservoir Pool Duration

The reservoir pool inundation duration was evaluated for each GCM. Across the 12 GCMs, the 2017 Operations are, on average, inundated 2.5 percent of the time. The 2017 Operations held a pool the longest when compared to O4Q1D5P1 and O4Q1D5P2, which were inundated 1.5 and 1.9 percent of the time, respectively (Table 21). The norESM1-M GCM returned the highest pool inundation percentages of each alternative, with the 2017 Operations set holding pool for 5.3 percent, O4Q1D5P1 holding pool 3.4 percent, and O4Q1D5P2 holding pool 4.3 percent of the time. O4Q1D5P2 shows a slight improvement over the 2017 Operations, and O4Q1D5P1 shows an even greater improvement across all GCMs.

Table 21. Percent of Days with FRE Pool – Future Climate (1970–2100) POR

GCM ID	2017 Operations	O4Q1D5P1	O4Q1D5P2
	(%)		
Access 1-0	2.4	1.4	1.8
Access 1-3	1.8	1.0	1.4
Bcc-csm1-1	2.3	1.3	1.6
canESM2	1.0	0.5	0.7
CCSM4	2.2	1.3	1.7
CSIRO-Mk3-6-0	3.7	2.2	2.8
FGOALS-g2	1.1	0.6	0.9

GCM ID	2017 Operations	O4Q1D5P1	O4Q1D5P2
	(%)		
GFDL-CM3	3.5	2.1	2.6
GISS-E2-H	1.1	0.6	0.7
MIROC5	4.4	2.8	3.6
MRI-CGCM3	1.6	0.8	1.1
norESM1-M	5.3	3.4	4.3
AVERAGE:	2.5	1.5	1.9

Percent of days spent inundating the FRE pool, on average, is increased for all operation sets, when compared to the current climate analysis in 5.5.1.3. When comparing the current climate POR to the 12 GCMs, 3 GCM routings result in a lower percent of days inundated for the 2017 Operations, 4 result in a lower percent of days inundated for the O4Q1D5P1, and 3 result in a lower percent of days inundated for the O4Q1D5P2 operations sets.

5.5.2.5 Location-specific Regulated Annual Maxima

Regulated flow and stage annual maxima applicability is limited to operational alternative comparative analysis only and is not intended for design of risk analysis. Additional refinements are required in future phases for such applications to be appropriate. Location-specific regulated annual maxima were computed by applying climate change scale factors under mid-century (2060) and late-century (2080) climate conditions to the current climate regulated frequency information. Climate change scale factors were developed for the following USGS stream gage locations: Doty, Adna, WWTP, and Grand Mound. Scale factors were developed for individual recurrence intervals for each of these sites using methods described in the Hydrologic Modeling Report. Table 22 and Table 23 highlight the applied scale factors for the 1 percent AEP mid-century (2060) and late-century (2080) climates. To scale the regulated flows at the FRE location, the Doty scale factors were applied to the unregulated frequency quantiles of the critical duration and the corresponding regulated peak flow as identified using a flow transform.

Table 22. Mid-Century Future Climate 1% AEP Scale Factors

Location	Peak	1-day	3-day	7-day	15-day	30-day
Doty	1.041	1.040	1.039	1.037	1.048	1.077
Adna	1.070	1.103	1.206	1.265	1.176	1.107
WWTP	1.122	1.147	1.223	1.297	1.174	1.094
Grand Mound	1.183	1.180	1.231	1.305	1.167	1.082

Table 23. Late-Century Future Climate 1% AEP Scale Factors

Location	Peak	1-day	3-day	7-day	15-day	30-day
Doty	1.036	1.122	1.124	1.138	1.157	1.136
Adna	1.080	1.146	1.158	1.184	1.188	1.199
WWTP	1.126	1.152	1.171	1.207	1.210	1.201
Grand Mound	1.171	1.200	1.165	1.219	1.208	1.199

Table 24 provides the mid-century estimated 1 percent AEP flow results. Under mid-century climate conditions, all operation sets are capable of providing downstream peak flow reduction when compared to unregulated, without-project, conditions. At the FRE, O4Q1D5P1 and O4Q1D5P2 both result in higher peak regulated flows when compared to 2017 Operations, but at Grand Mound, the two O4 operations sets result in a slightly lower (10 cfs) peak flow at Grand Mound.

Table 24. Mid-Century Estimated 1% AEP Peak Flows

Operation Set Result	FRE	Doty	Adna	WWTP	Grand Mound
Unregulated Flow (cfs)	39,570	49,470	60,450	81,950	106,660
2017 Operations Flow (cfs)	16,090	19,170	37,760	43,810	69,980
O4Q1D5P1 Flow (cfs)	17,240	20,100	37,760	43,810	69,970
O4Q1D5P2 Flow (cfs)	17,170	14,220	37,760	43,810	69,970

Table 25 provides the late-century estimated 1 percent AEP flow results. Under late-century climate conditions, all three operations sets perform similarly at Adna in terms of 1 percent AEP regulated flows. At the FRE and Doty, O4Q1D5P1 performs worse than the other two operations sets but achieves a higher peak flow reduction at Grand Mound when compared to 2017 Operations. The O4Q1D5P2 operations reduces peak flows at the FRE, Doty, and Grand Mound more than 2017 Operations. The O4Q1D5P1 and O4Q1D5P2 operations achieve the same level of peak flow reduction at Grand Mound.

Table 25. Late-Century Estimated 1% AEP Peak Flows

Operation Set Result	FRE	Doty	Adna	WWTP	Grand Mound
Unregulated Flow (cfs)	39,380	49,230	61,020	82,240	105,580
2017 Operations Flow (cfs)	16,310	18,770	38,680	45,480	71,250
O4Q1D5P1 Flow (cfs)	17,030	19,240	38,680	45,480	71,240
O4Q1D5P2 Flow (cfs)	13,520	12,650	38,680	45,480	71,240

Unregulated flow-regulated WSEL transforms were applied to determine the mid-century regulated stages. Table 26 contains the resulting mid-century regulated WSELs at the FRE and downstream locations. As the FRE spillway elevation is 627 feet, all three operation sets are estimated to utilize the spillway in the 1 percent AEP mid-century flood. At Grand Mound, all operations result in the same 1 percent AEP peak WSEL reduction. The O4 sets perform equally well at Adna and WWTP.

Table 26. Mid-Century Estimated 1% AEP Peak WSEL

Operation Set Result	FRE (Reservoir Pool Elevation)	Doty	Adna	WWTP	Grand Mound
Unregulated WSEL (ft)	455.8	330.8	215.6	185.3	149.3
2017 Operations WSEL (ft)	635.5	320.8	212.6	181.9	146.7
O4Q1D5P1 WSEL (ft)	636.7	321.4	212.7	182.0	146.7
O4Q1D5P2 WSEL (ft)	636.3	319.4	212.7	182.0	146.7

Unregulated flow-regulated WSEL transforms were applied to determine the late-century regulated stages. Table 27 contains the resulting late-century regulated WSELs at the FRE and downstream locations. Under late-century climate conditions, the operations sets result in the greatest peak WSEL reductions at Grand Mound, Adna, and WWTP and perform equally well. At the FRE, the O4Q1D5P2 operation results in the highest regulated WSEL. At Doty the O4Q1D5P1 operation results in the smallest peak WSEL reduction. The 2017 Operations have a larger peak reduction at the FRE when compared to the O4 operations sets.

Table 27. Late-Century Estimated 1% AEP Peak Regulated WSEL

Operation Set Result	FRE (Reservoir Pool Elevation)	Doty	Adna	WWTP	Grand Mound
Unregulated WSEL (ft)	455.8	330.8	215.7	185.3	149.2
2017 Operations WSEL (ft)	633.3	321.0	212.8	182.1	146.8
O4Q1D5P1 WSEL (ft)	634.0	321.2	212.8	182.1	146.8
O4Q1D5P2 WSEL (ft)	634.5	318.8	212.8	182.1	146.8

5.6 Current Climate Sensitivity Analysis

The HEC-ResSim model was set up using the reservoir operations developed by Anchor QEA (2017) where reservoir operation effects were not evaluated downstream of the reservoir. Because there are downstream stage reduction requirements for this design, a sensitivity analysis of the reservoir operation set was completed. HDR found that, with flood events exceeding the 38,800 cfs trigger flow at Grand Mound, the reservoir had varying degrees of success in providing downstream flood control benefits based on storm distribution. Of the three discrete storm events (2007, 2009, and 2022) used in testing, the event that returned the largest downstream flood control benefit was December 2007 and the event with the smallest benefit was January 2022.

The 2022 event's peak flow at Grand Mound was decreased from 55,788 to 47,765 cfs, a 16.8 percent decrease using 2017 Operations. The 2022 flood event triggered the reservoir to commence flood control operations with the O1 trigger, but the benefit of closing the sluice gates was only slightly observed at Grand Mound.

In contrast, the December 2007 flood event was identified as having large flood control benefits at Grand Mound when regulated by the reservoir. During this flood, the peak flow at Grand Mound was reduced by 21.6 percent from 82,887 (USGS recorded peak was 68,700 cfs) to 68,174 cfs.

Events that are forecast to meet or exceed the 38,800 cfs trigger flow at Grand Mound are not guaranteed to result in a large flood reduction. Because the December 2007 event precipitation was heavily centered in the reservoir area, the flood control operation results in a large downstream benefit. Floods that are more evenly distributed across the basin or centered further downstream with higher contributions from the Skookumchuck and Newaukum Rivers are more likely to result in less satisfactory flood control reductions.

6.0 Discussion

Based on the HEC-ResSim modeling results provided herein, the O4Q1D5P1 and O4Q1D5P2 operations sets appear to match the 2017 Operations for peak flow reduction at Grand Mound while also reducing the reservoir pool duration, the time of inundation around Fisk Falls, and with the P2 parameter, life safety hazards due to secondary flooding from subsequent storms during downstream flood recovery efforts. The additional flexibility allowed in the O4 parameter better replicates a human reservoir operator following water control guidelines to operate the reservoir and is modeled on how many flood control reservoirs are operated throughout the United States.

The O4Q1D5P1 operation set performs best when considering inundation duration at Fisk Falls and above WSEL 532 feet in the reservoir. However, unlike O4Q1D5P2, it provides no additional flood protection from secondary storms. The O4Q1D5P2 operations set performs similarly to the 2017 Operations set due to the O4Q1D5P2 operations' requirement to provide additional downstream flood protection from more frequent, large secondary storms in future climate scenarios.

With the possibility of more frequent and larger storms, as shown in the modeled future climate results, flexibility in reservoir operations (via both O4 operations sets) show the most benefit during the increasingly frequent storms that are forecast to just exceed the 38,800 cfs target flow (Major Flood) at Grand Mound. In these storms, increased operations flexibility allows the O4 operations sets to store less water than the 2017 Operations while achieving the objective of keeping flows below the downstream Major Flood level, which results in days to weeks of fewer operations and upstream inundation per storm event.

Some additional HEC-ResSim modeling work remains. After deciding on a final proposed reservoir operations set, further modeling may be needed to refine topics such as faster drawdown rates on the upper reaches of the reservoir, and resiliency/sensitivity studies should be completed to test the robustness of the HEC-ResSim model and operations. Finally, known deficiencies in the HEC-ResSim modeling software require additional programming to eliminate minor statistical noise in the bottom 5 feet of the reservoir pool during some low baseflow conditions in long-term modeling runs. This noise does not affect reservoir operations during flood detention operations and is not statistically important to the overall POR runs.

7.0 References

Anchor QEA

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1993 Engineering Manual [EM]-1110-2-1415, Engineering and Design Hydrologic Frequency Analysis. March 5, 1993.

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2015 Information processing and synthesis tool (IPAST), part of Central Valley Hydrology Study.

8.0 Acronyms/Abbreviations

HDR	HDR Engineering, Inc.
FRE	Flood Retention Expandable
PDR	Preliminary Design Report
AEP	annual exceedance probability
cfs	cubic feet per second
GCM	Global Climate Model
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HEC-ResSim	Hydrologic Engineering Center Reservoir System Simulation
IPAST	Information Processing and Synthesis Tool
LiDAR	light detection and ranging
LOWESS	local weighted scatterplot smoothing regression method
NAVD88	North American Vertical Datum of 1988
POR	Period of Record
PTE	percent-time exceedance
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WSEL	water surface elevation
WWTP	Wastewater Treatment Plant

Attachment 1. Future Climate Operation Plots

Figure 1-1. Access 1.0 Unregulated and Regulated (2017 Operations) Flows Through the Reservoir Site

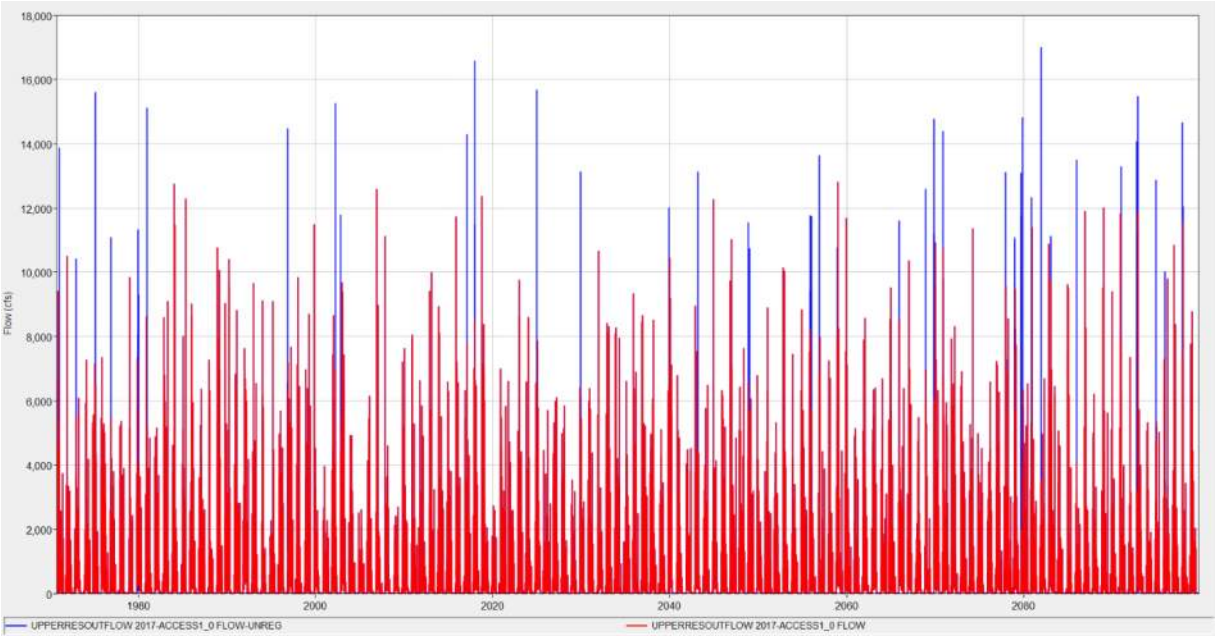


Figure 1-2. Access 1.0 Regulated (2017 Operations) Reservoir Pool Elevation at the FRE Site

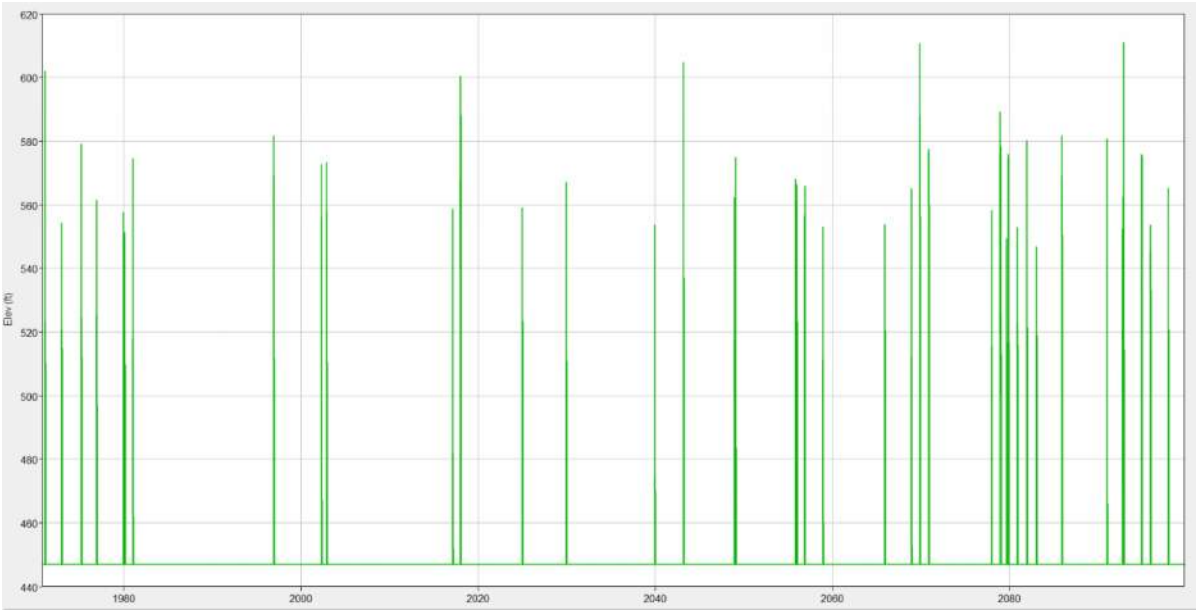


Figure 1-3. Access 1.3 Unregulated and Regulated (2017 Operations) Flows Through the Reservoir Site

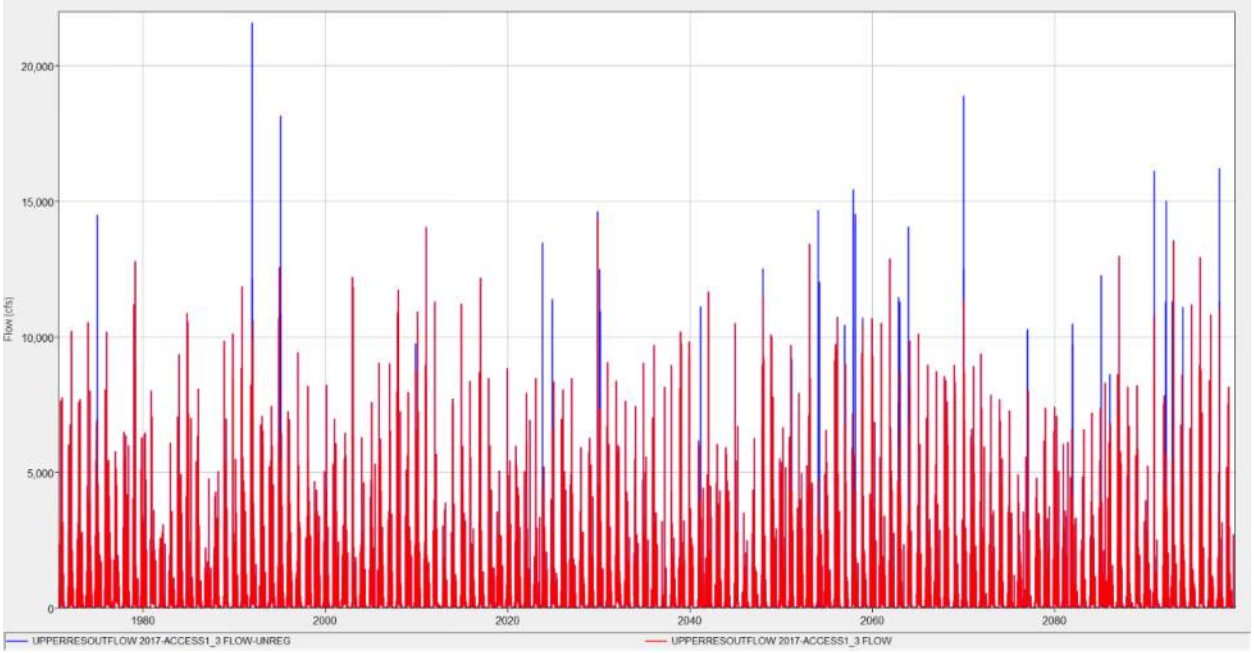


Figure 1-4. Access 1.3 Regulated (2017 Operations) Reservoir Pool Elevation at the FRE Site

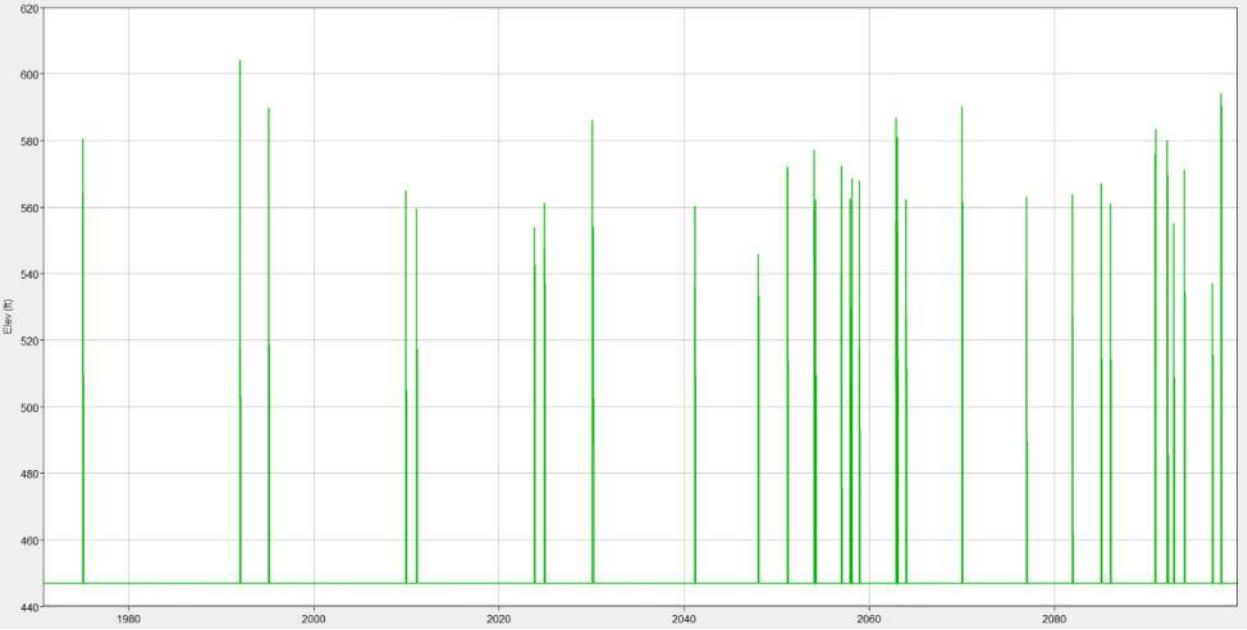


Figure 1-5. BCC-CSM 1.1 Unregulated and Regulated (2017 Operations) Flows Through the Reservoir Site

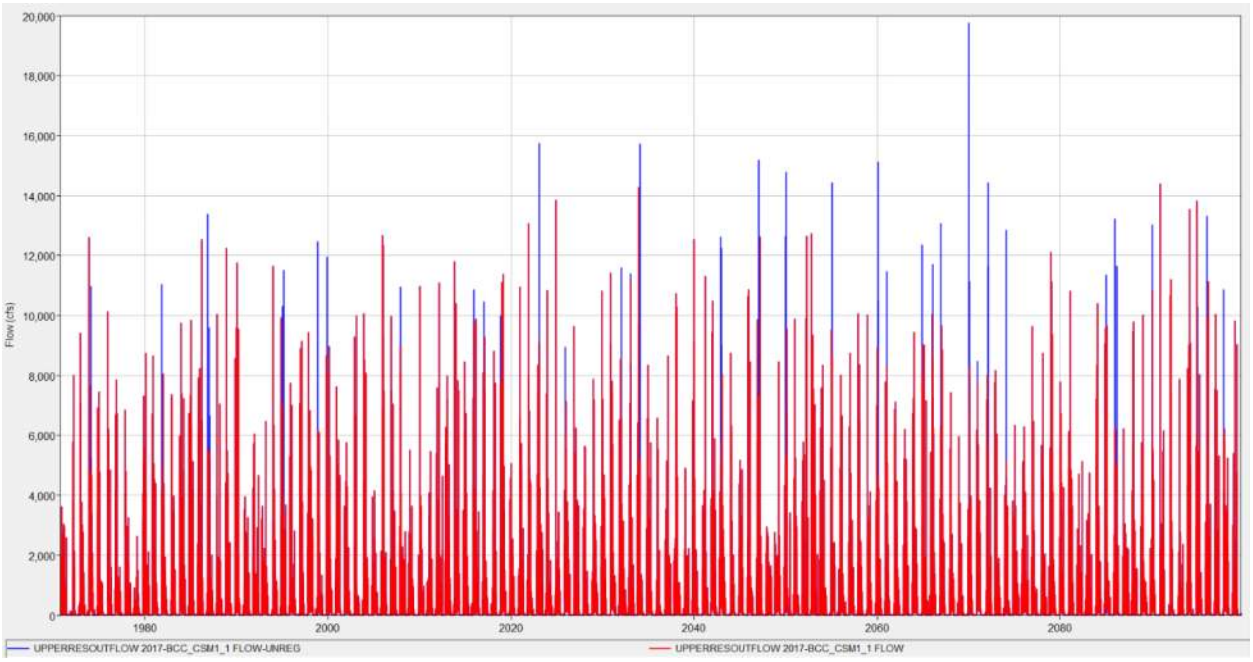


Figure 1-6. BCC-CSM 1.1 Regulated (2017 Operations) Reservoir Pool Elevation at the FRE Site

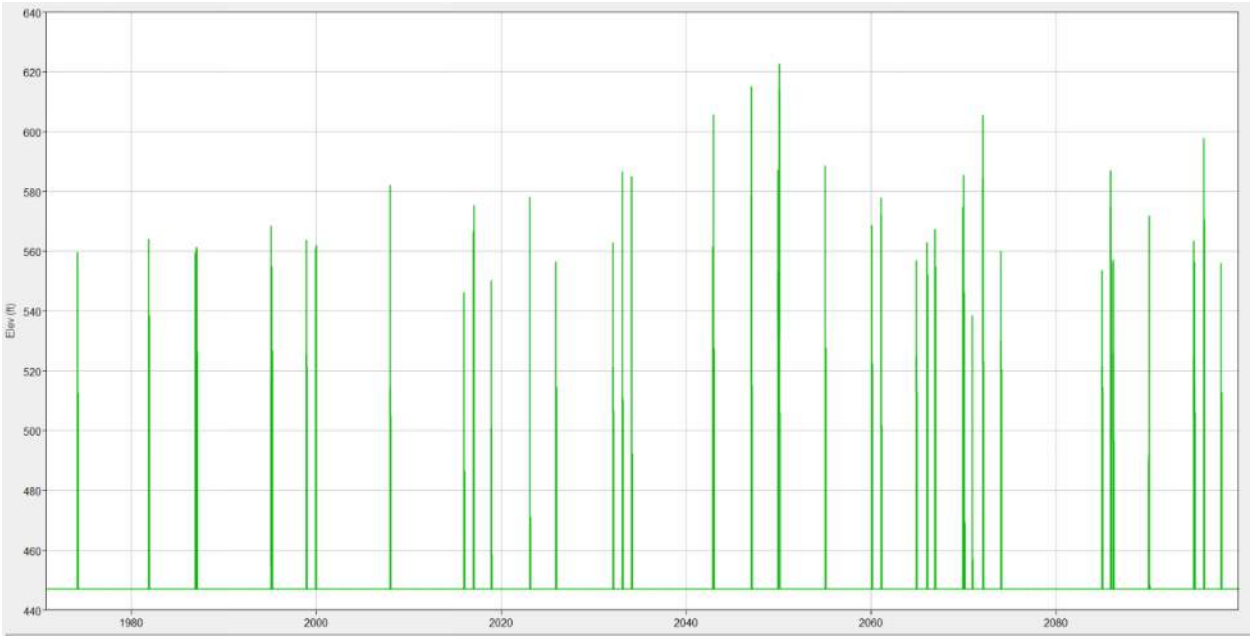


Figure 1-7. CanESM2 Unregulated and Regulated (2017 Operations) Flows Through the Reservoir Site

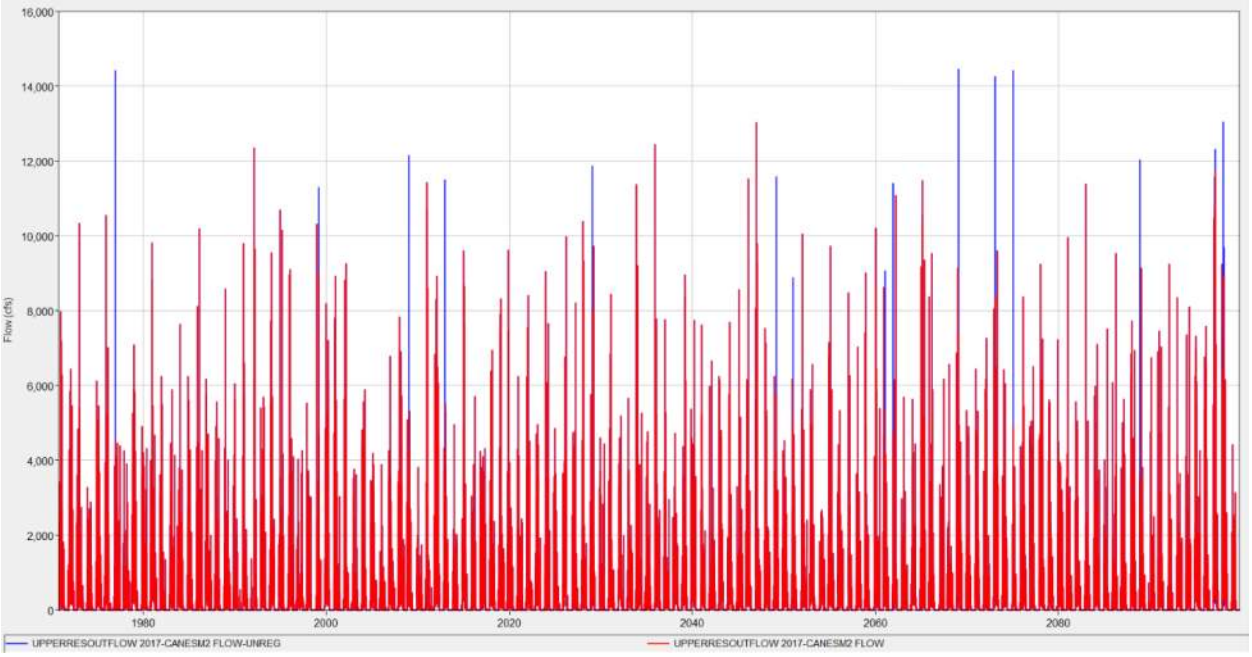


Figure 1-8. CanESM2 Regulated (2017 Operations) Reservoir Pool Elevation at the FRE Site

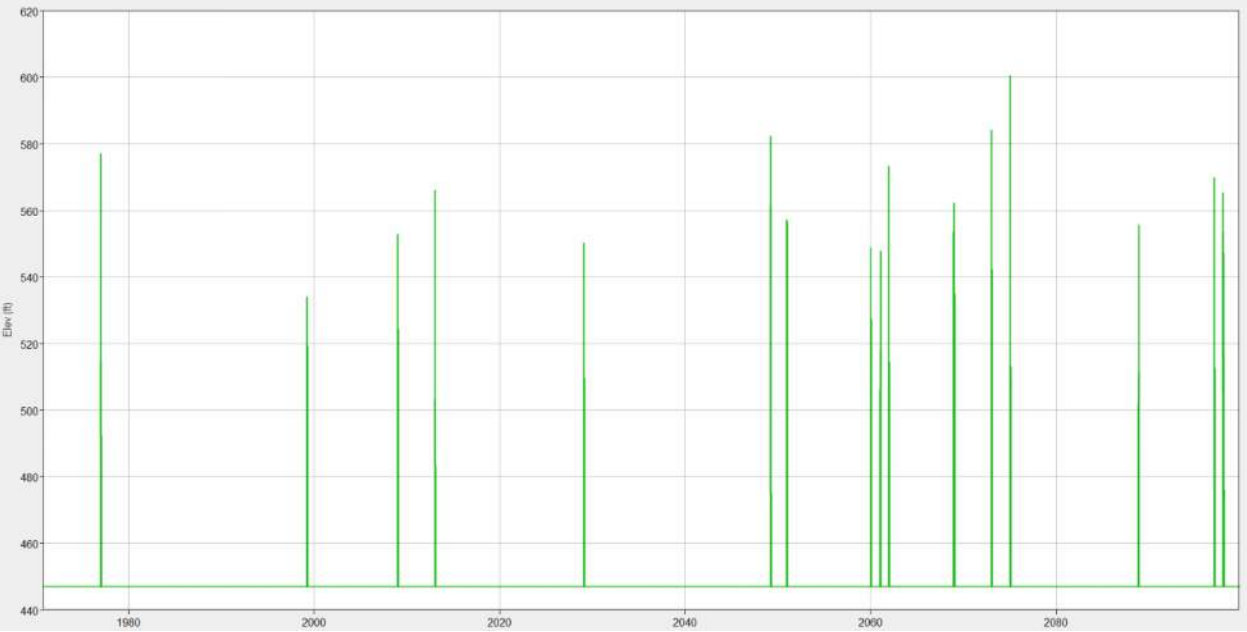


Figure 1-9. CCSM4 Unregulated and Regulated (2017 Operations) Flows Through the Reservoir Site

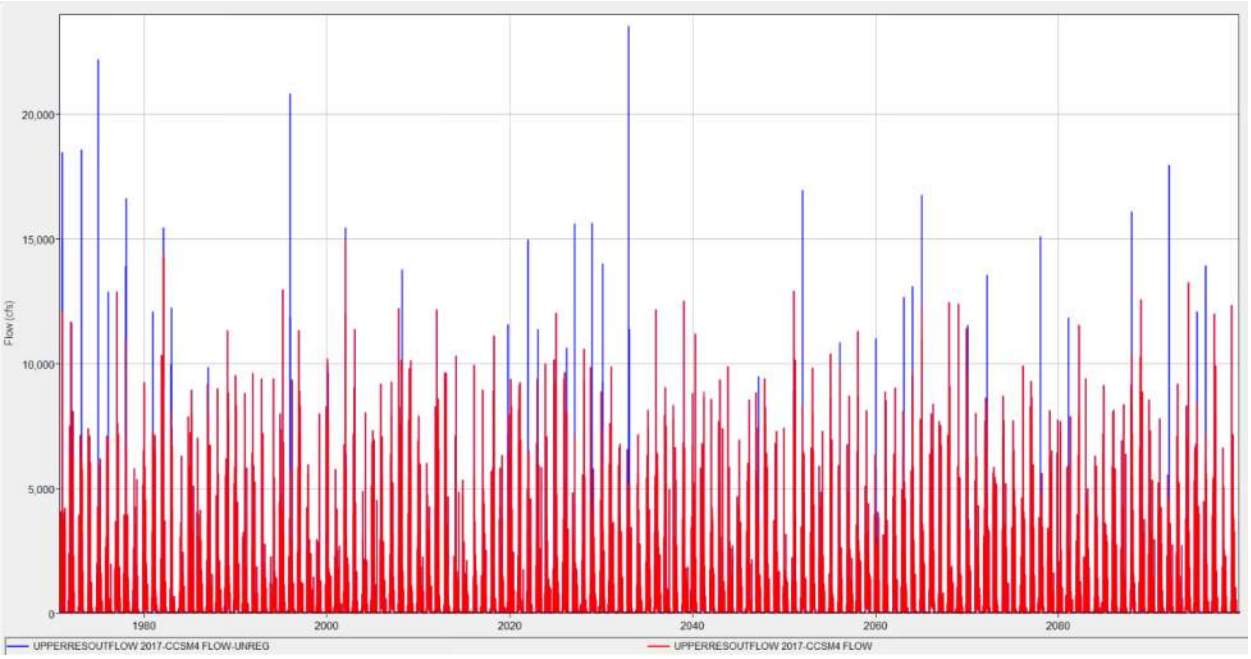


Figure 1-10. CCSM4 Regulated (2017 Operations) Reservoir Pool Elevation at the FRE Site

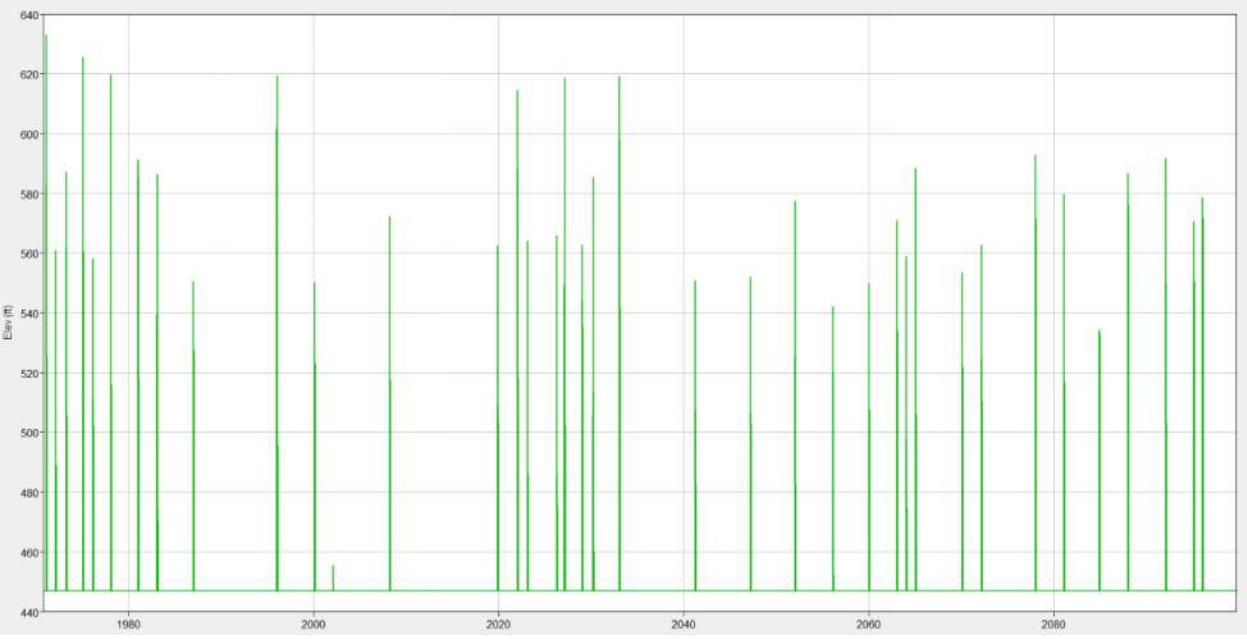


Figure 1-11. Csiro-mk3_6_0 Unregulated and Regulated (2017 Operations) Flows Through the Reservoir Site

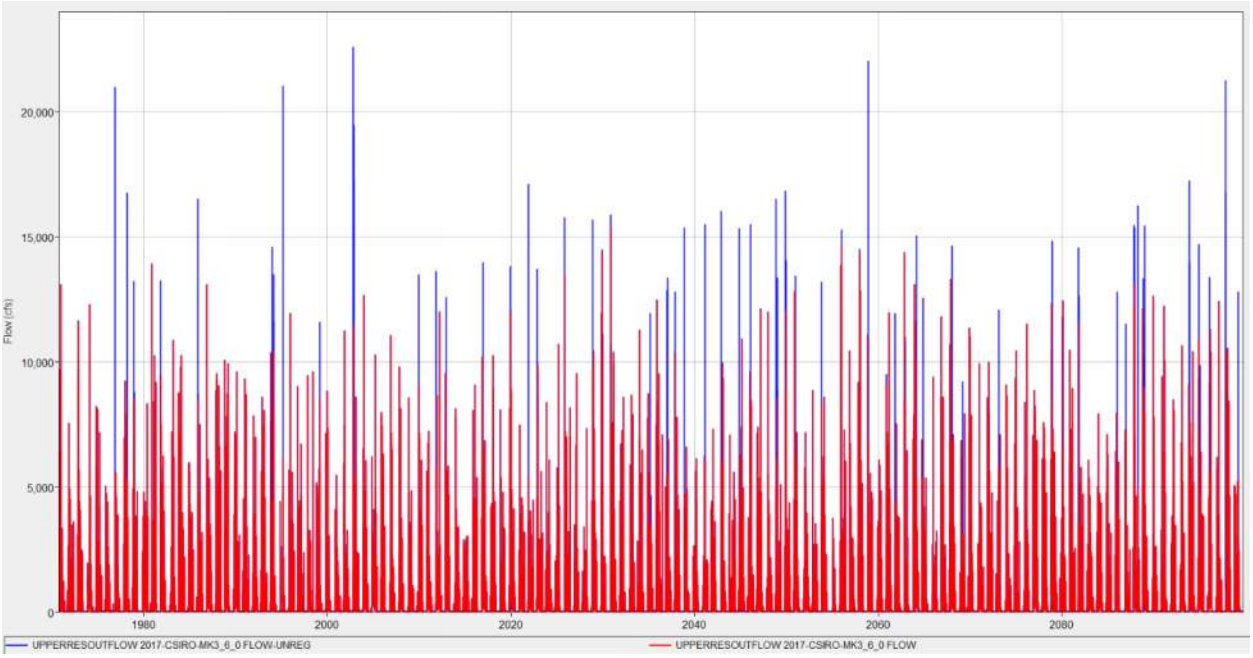


Figure 1-12. Csiro-mk3_6_0 CCSM4 Regulated (2017 Operations) Reservoir Pool Elevation at the FRE Site

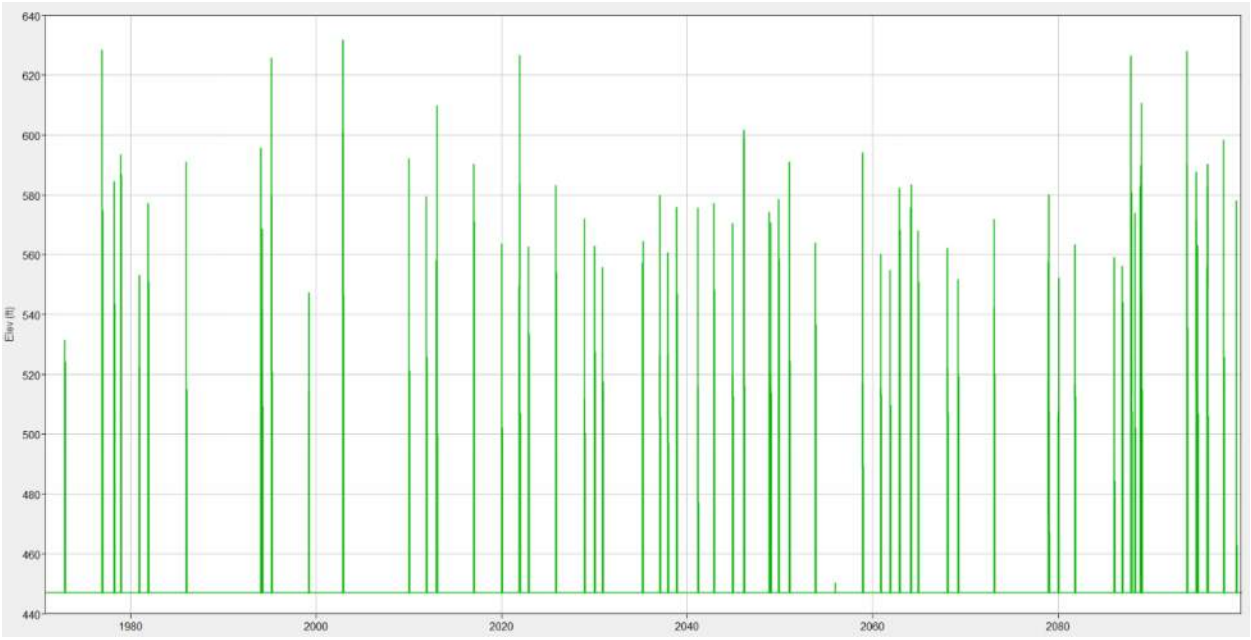


Figure 1-13. FGOALS-g2 Unregulated and Regulated (2017 Operations) Flows Through the Reservoir Site

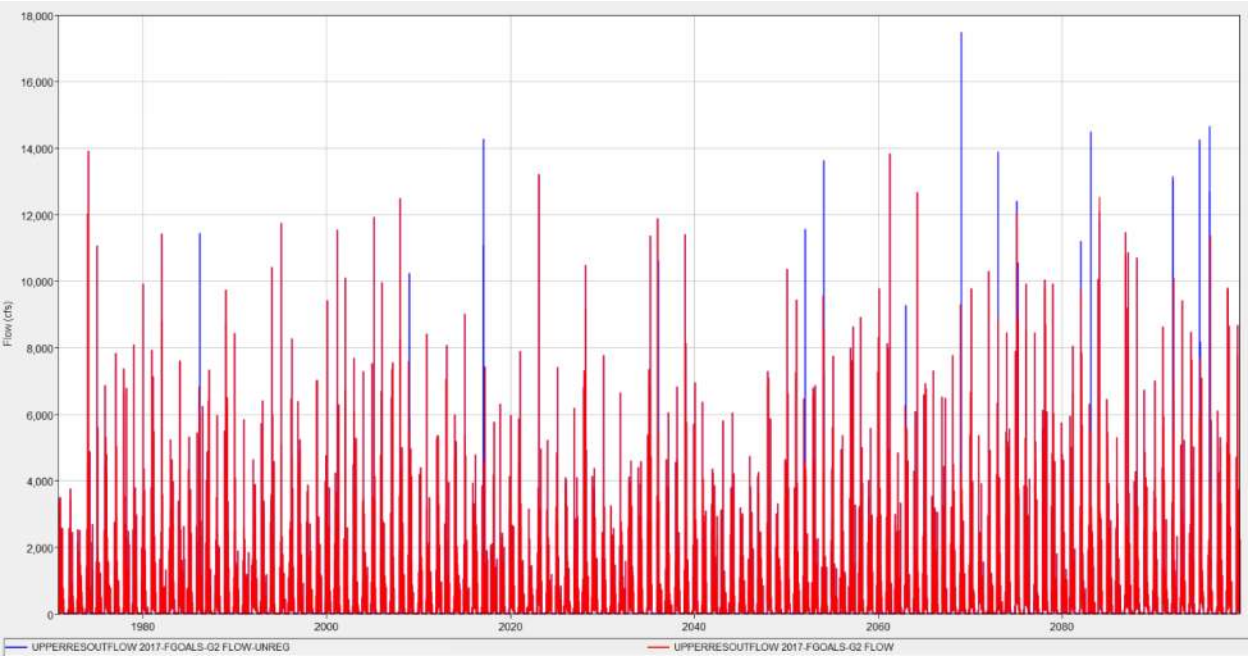


Figure 1-14. FGOALS-g2 Regulated (2017 Operations) Reservoir Pool Elevation at the FRE Site

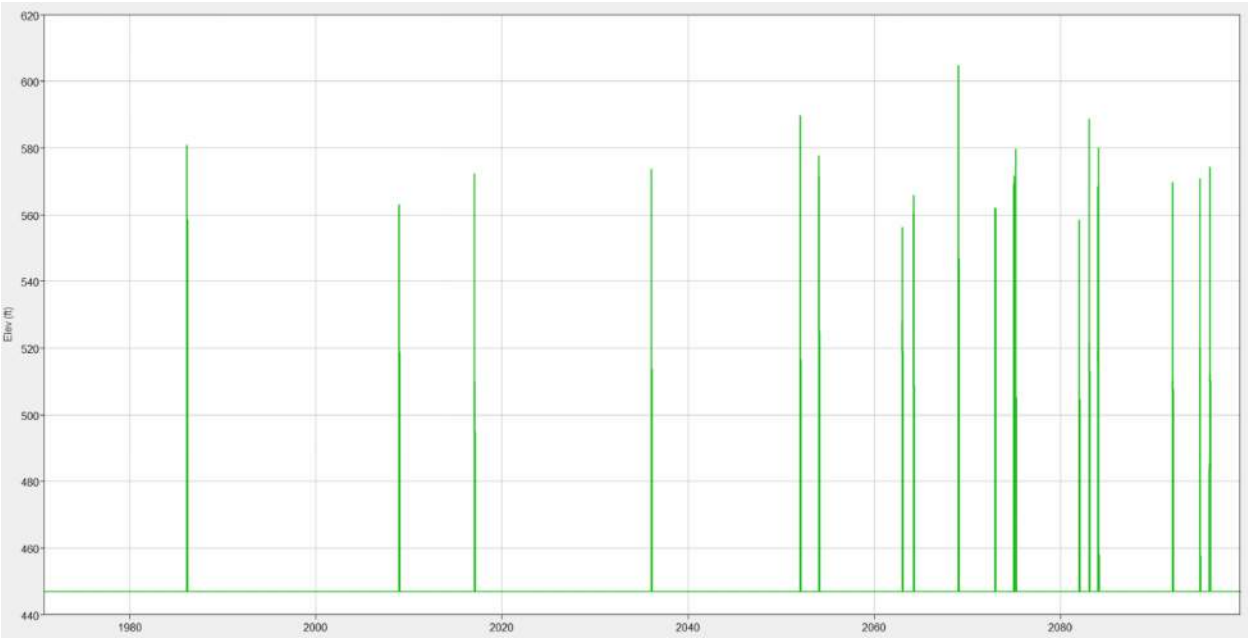


Figure 1-15. GFDL-CM3 Unregulated and Regulated (2017 Operations) Flows Through the Reservoir Site

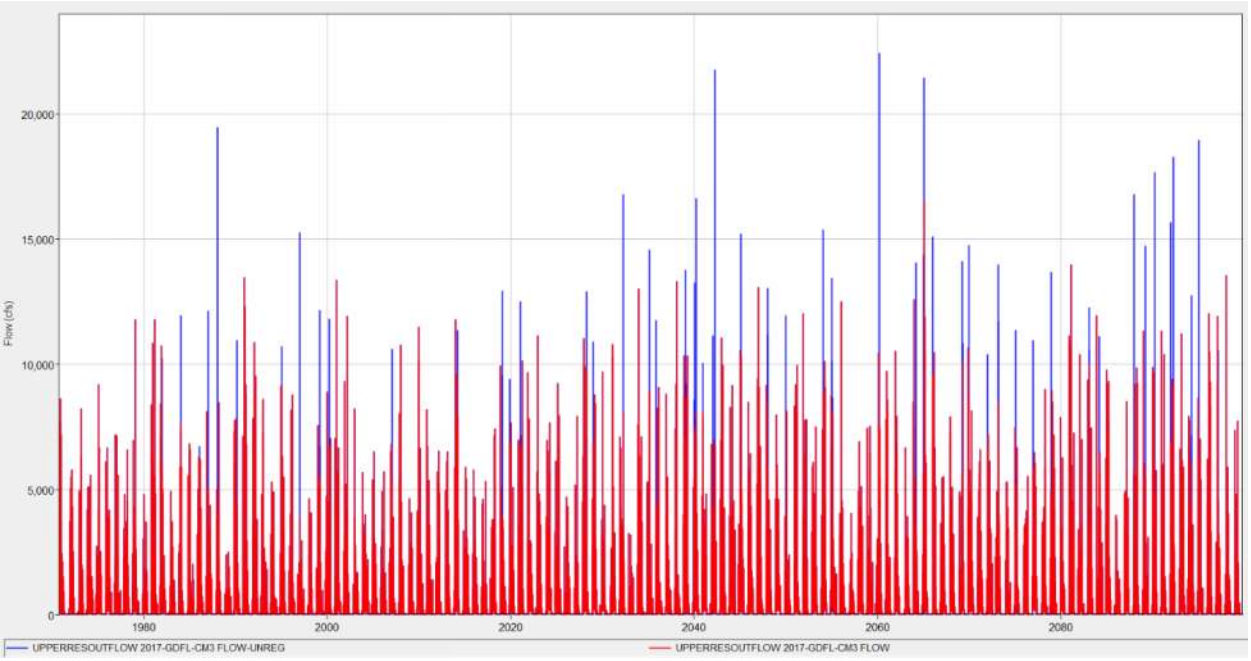


Figure 1-16. GFDL-CM3 Regulated (2017 Operations) Reservoir Pool Elevation at the FRE Site

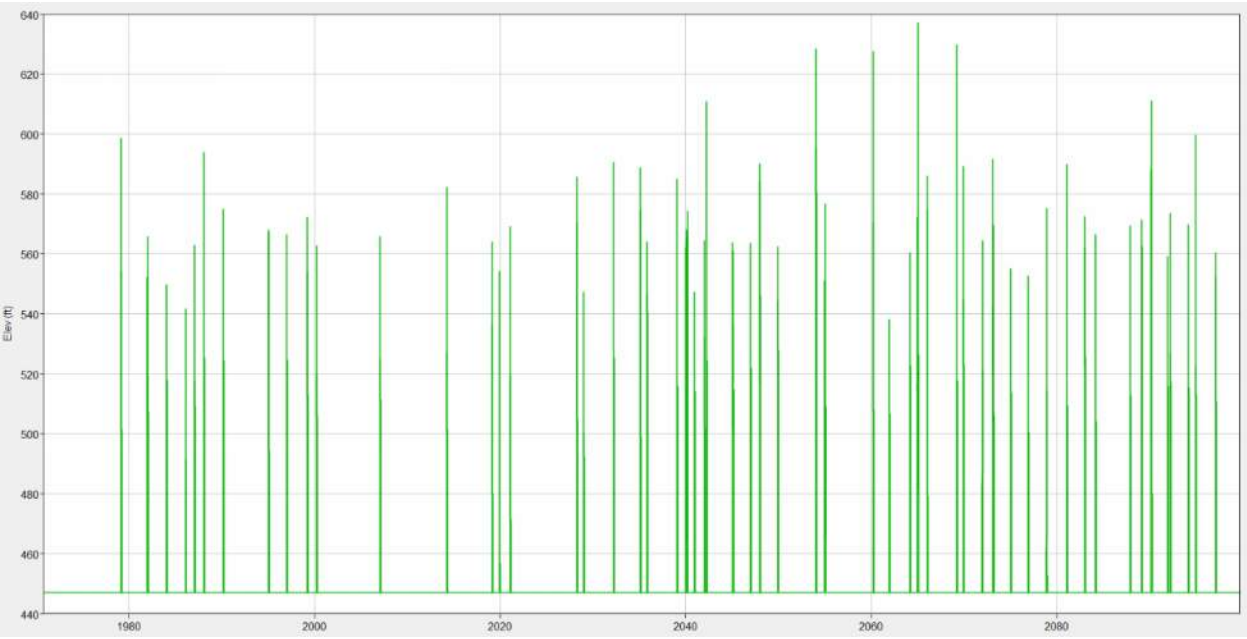


Figure 1-17. GISS-E2-H Unregulated and Regulated (2017 Operations) Flows Through the Reservoir Site

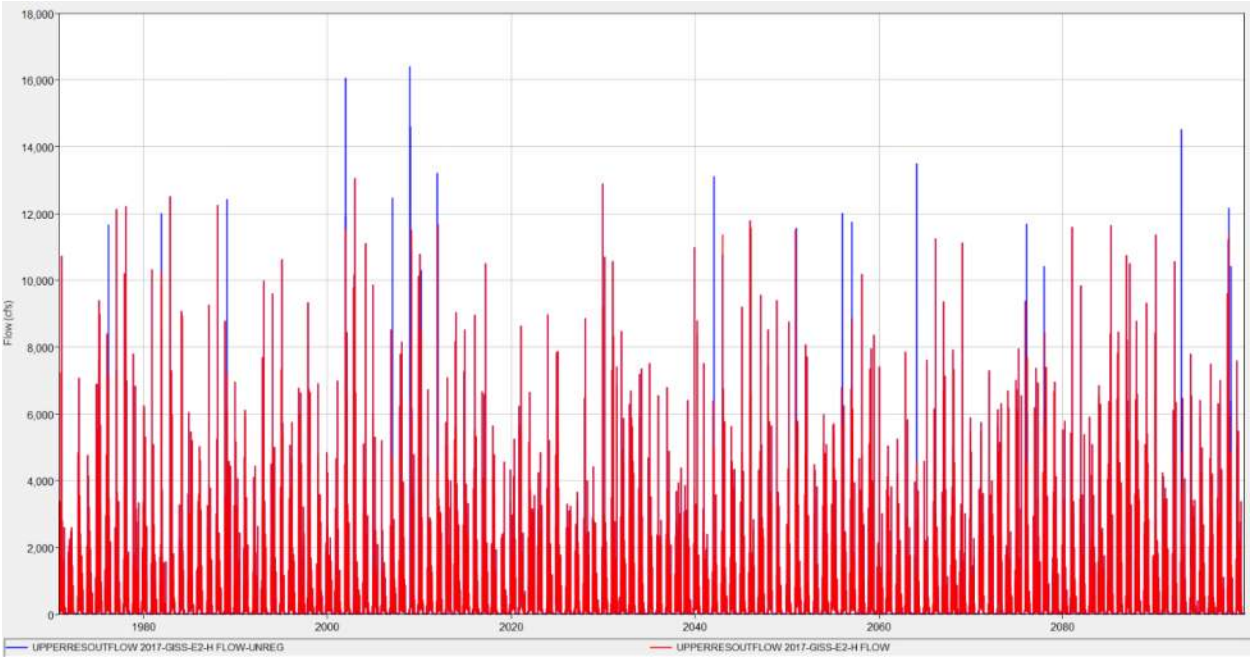


Figure 1-18. GISS-E2-H Regulated (2017 Operations) Reservoir Pool Elevation at the FRE Site

Figure 1-19. MIROC5 Unregulated and Regulated (2017 Operations) Flows Through the Reservoir Site

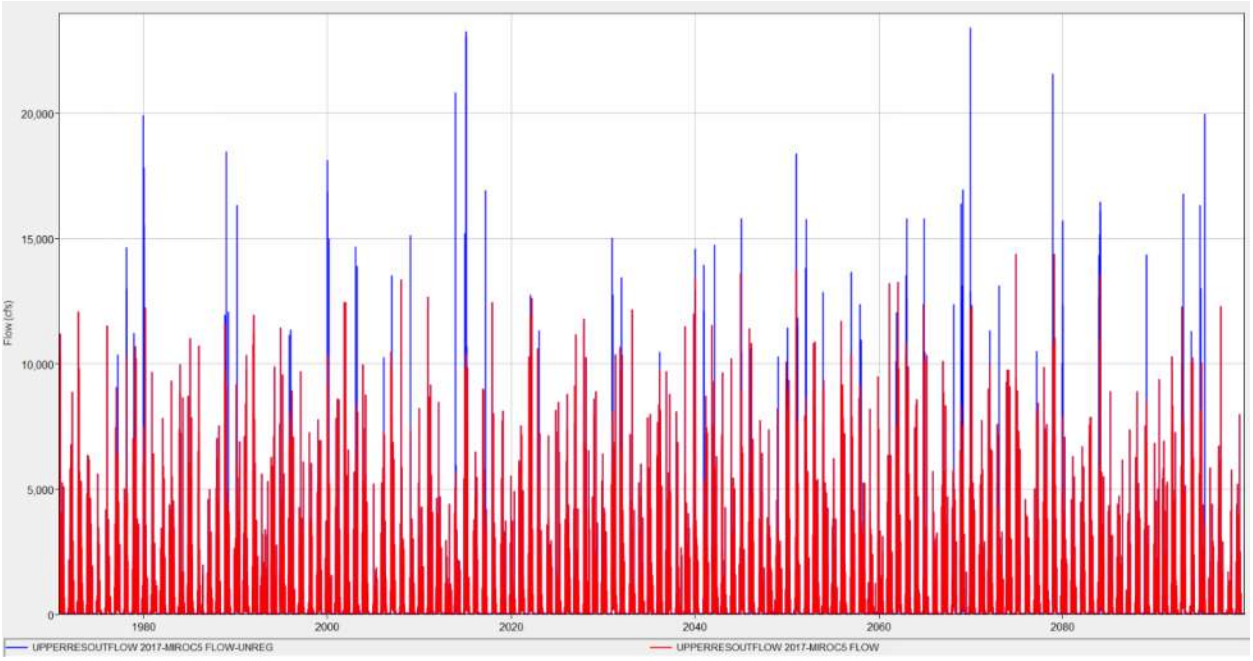


Figure 1-20. MIROC5 Regulated (2017 Operations) Reservoir Pool Elevation at the FRE Site

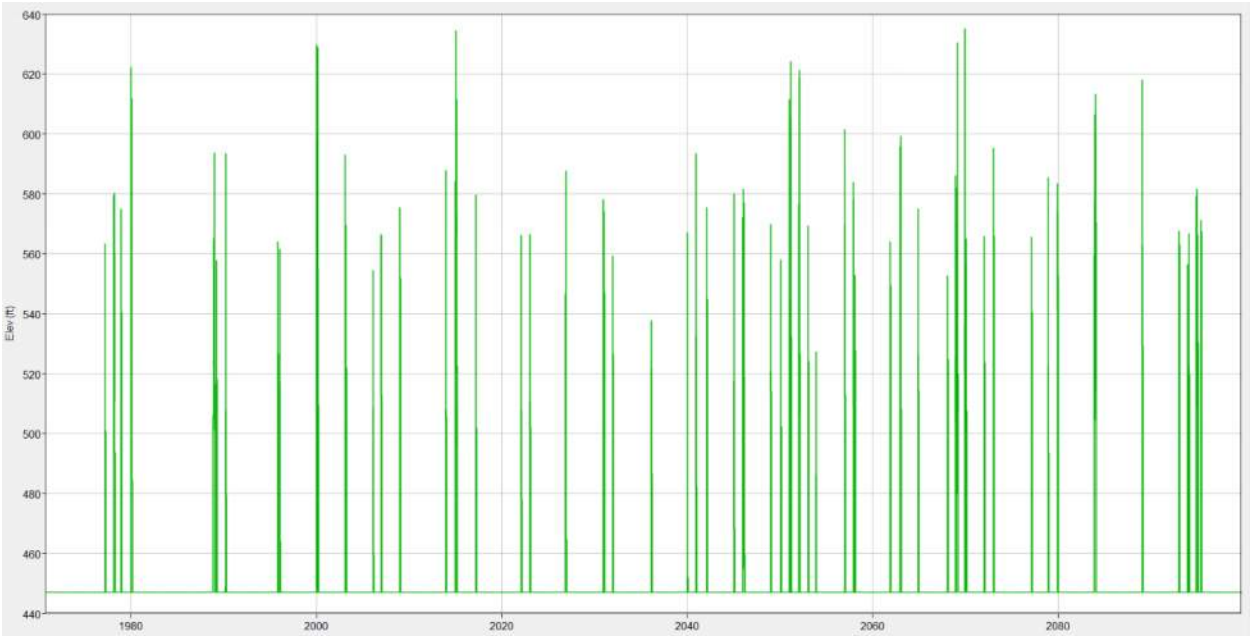


Figure 1-21. MRI-CGCM3 Unregulated and Regulated (2017 Operations) Flows Through the Reservoir Site

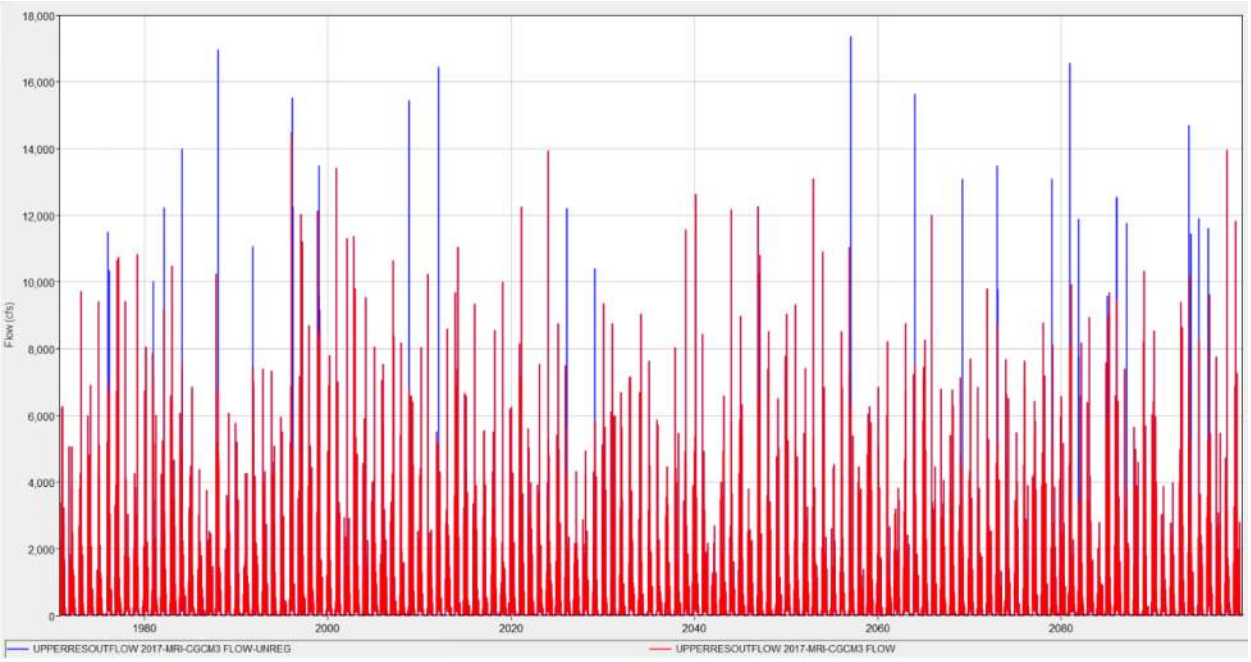


Figure 1-22. MRI-CGCM3 Regulated (2017 Operations) Reservoir Pool Elevation at the FRE Site

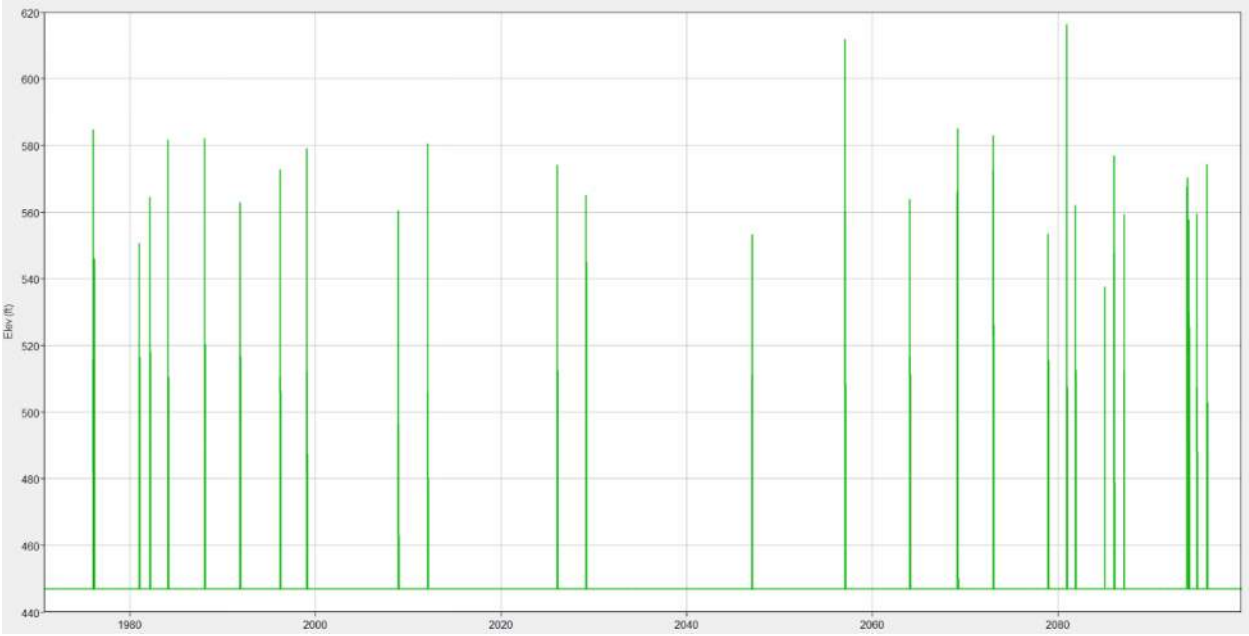


Figure 1-23. NorESM1-M Unregulated and Regulated (2017 Operations) Flows Through the Reservoir Site

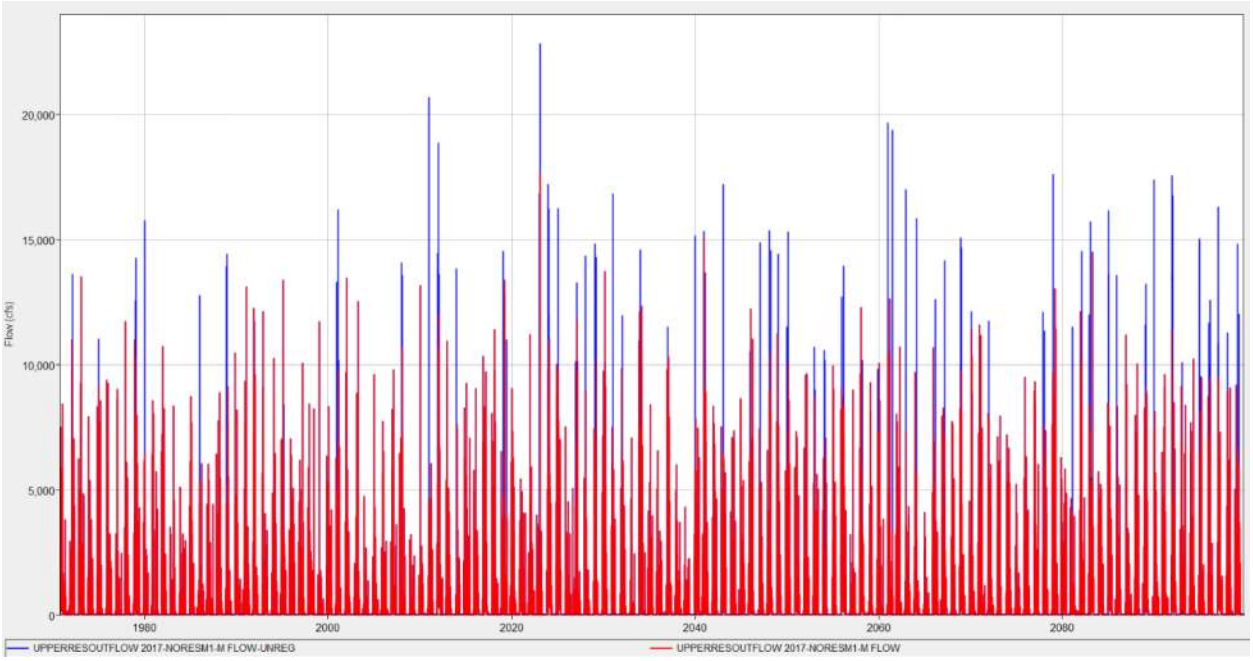
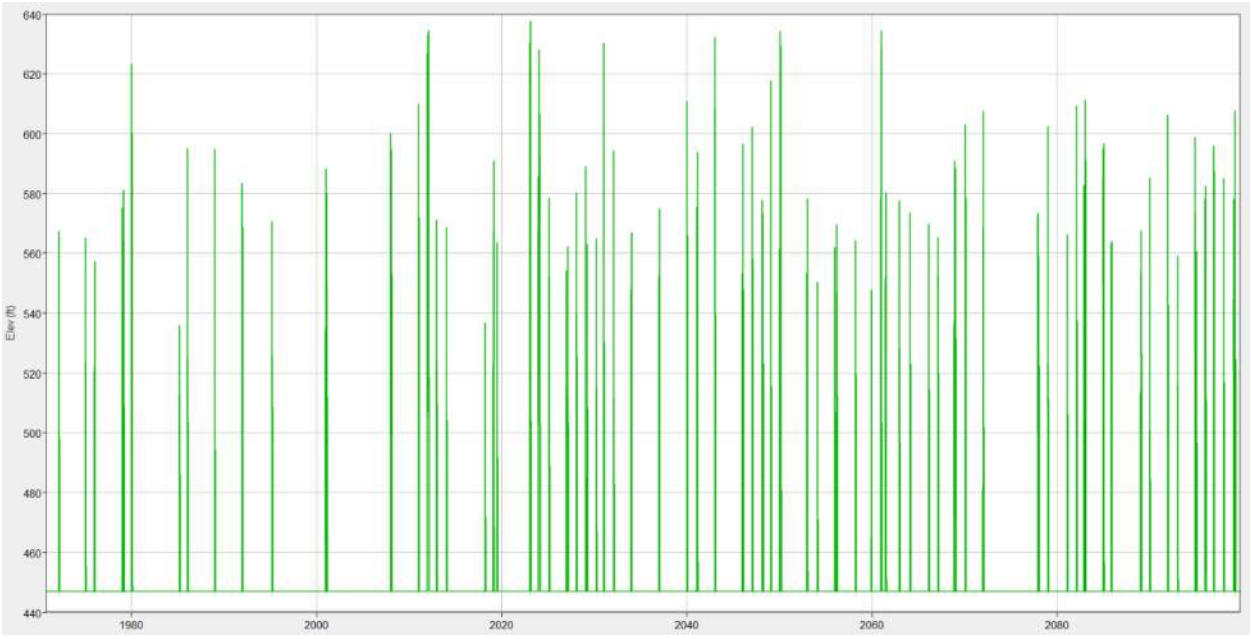


Figure 1-24. NorESM1-M Regulated (2017 Operations) Reservoir Pool Elevation at the FRE Site



Attachment 2. Grand Mound WSEL PTE – Detailed View (140–148 feet)

Figure 2-1. Access 1.0 Grand Mound WSEL PTE Detailed View of WSEL 140–148 feet

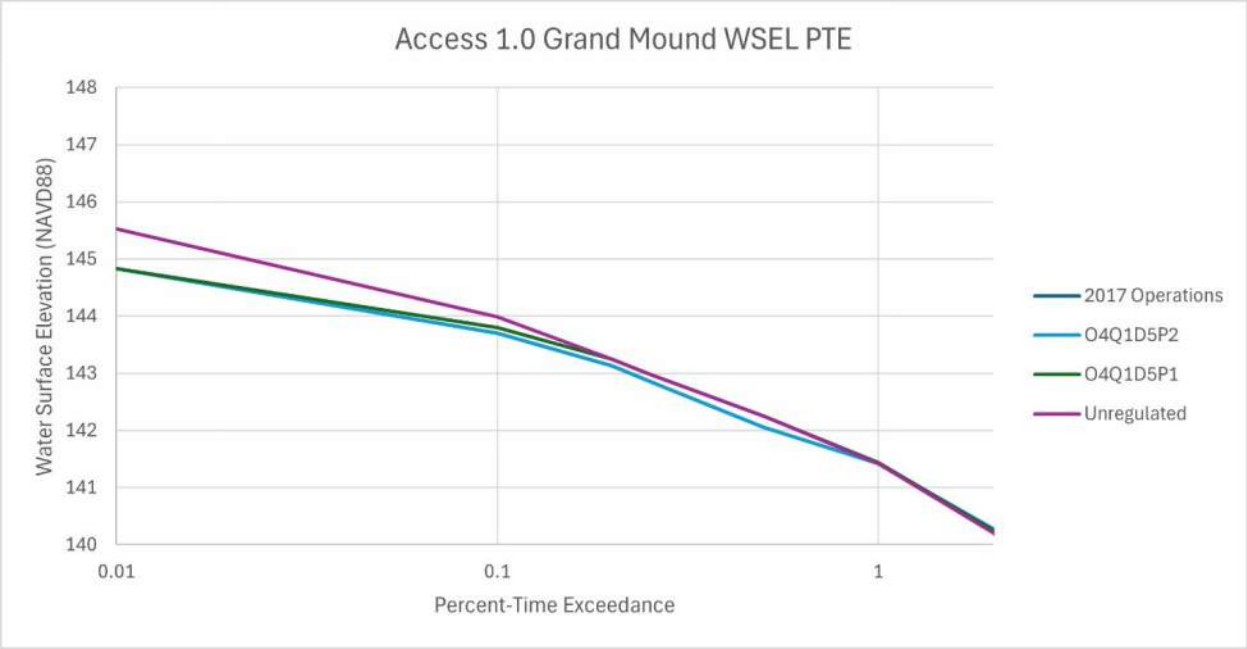


Figure 2-2. Access 1.3 Grand Mound WSEL PTE Detailed View of WSEL 140–148 feet

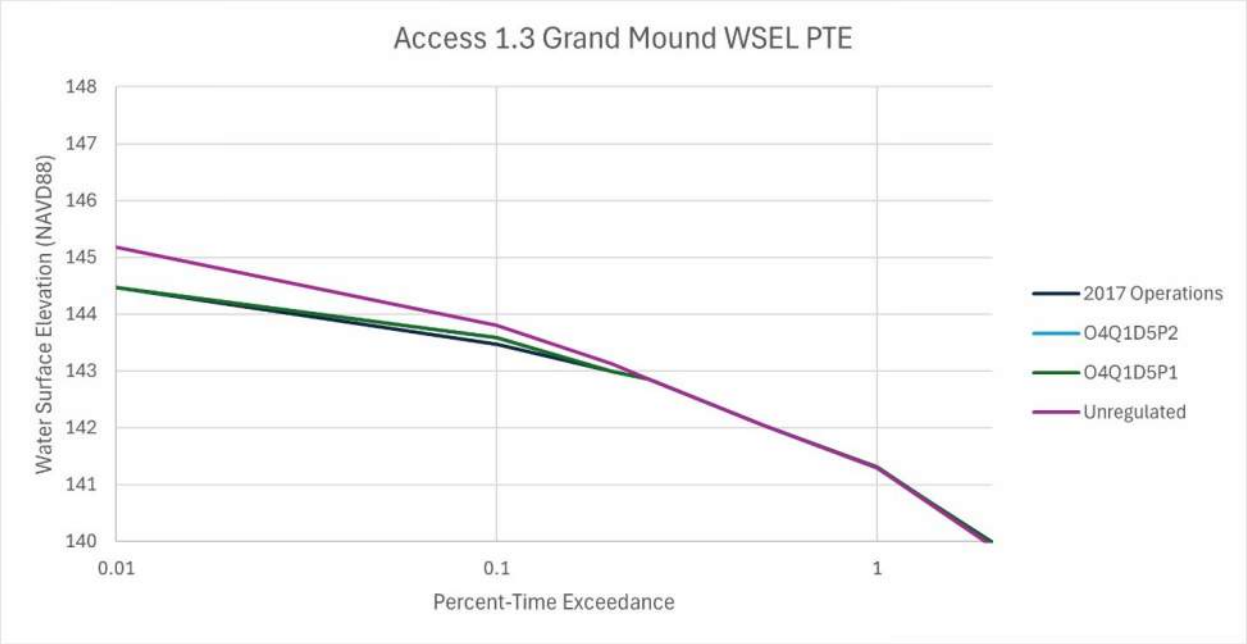


Figure 2-3. BCC_CSM 1.1 Grand Mound WSEL PTE Detailed View of WSEL 140–148 feet

Figure 2-4. canESM2 Grand Mound WSEL PTE Detailed View of WSEL 140–148 feet

Figure 2-5. CCSM4 Grand Mound WSEL PTE Detailed View of WSEL 140–148 feet

Figure 2-6. Csiro-mk3 6.0 Grand Mound WSEL PTE Detailed View of WSEL 140–148 feet

Figure 2-7. FGOALS-g2 Grand Mound WSEL PTE Detailed View of WSEL 140–148 feet

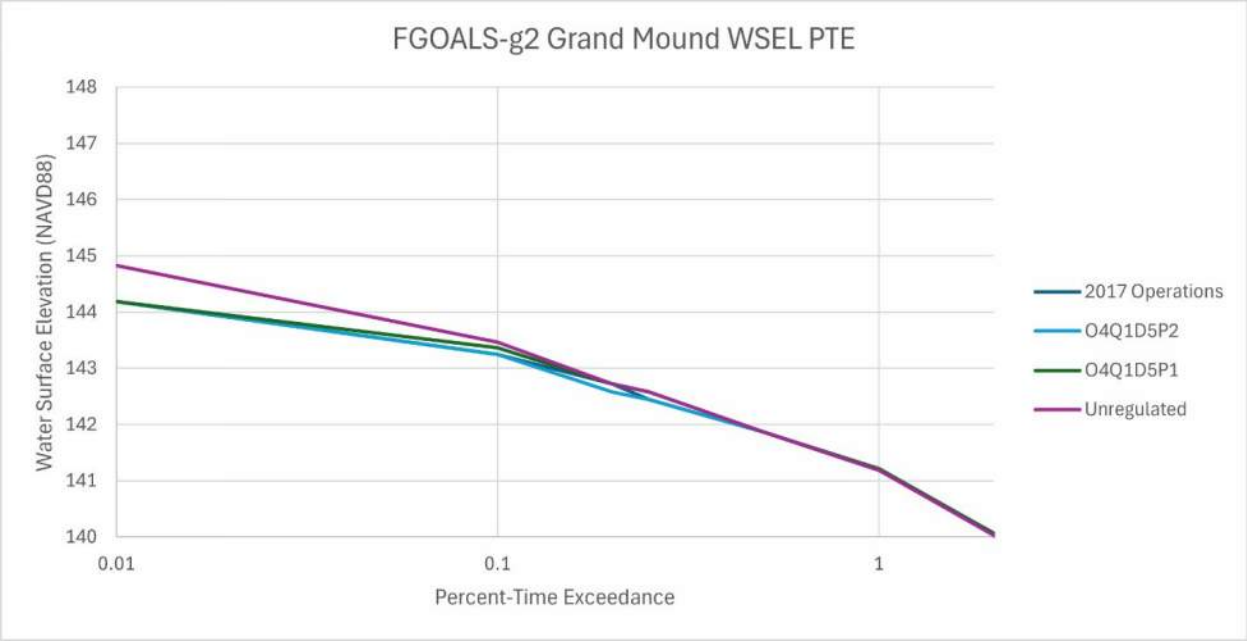


Figure 2-8. GFDL-CM3 Grand Mound WSEL PTE Detailed View of WSEL 140–148 feet

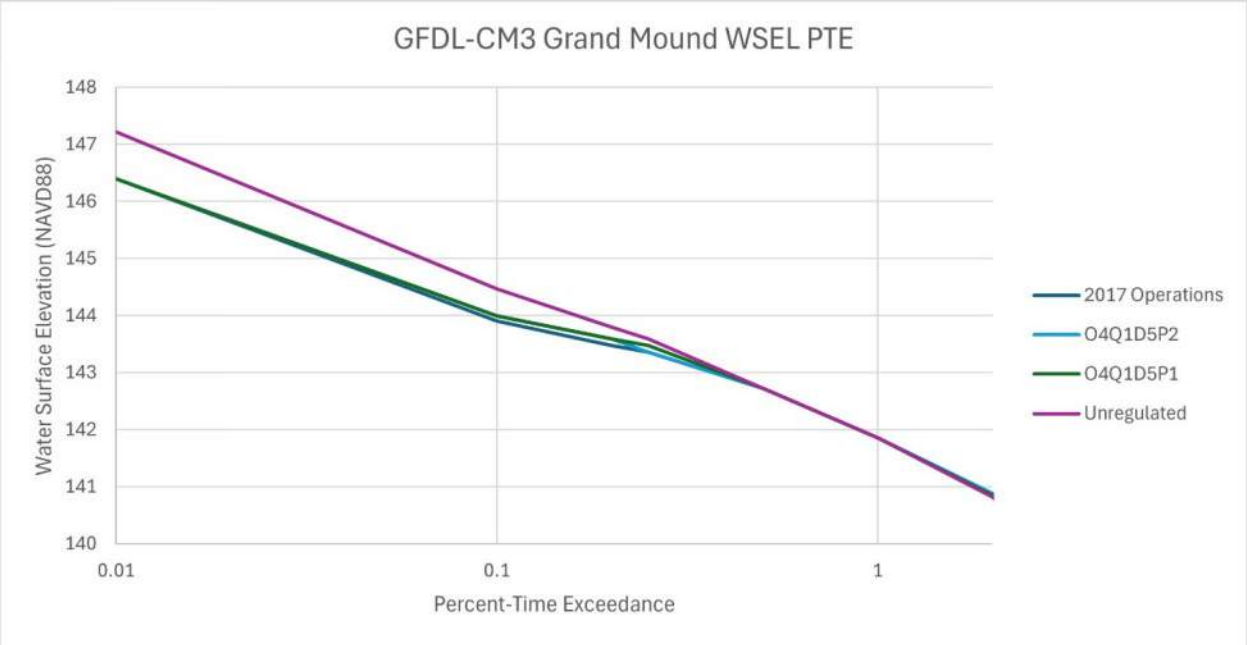


Figure 2-9. GISS-E2-H Grand Mound WSEL PTE Detailed View of WSEL 140–148 feet

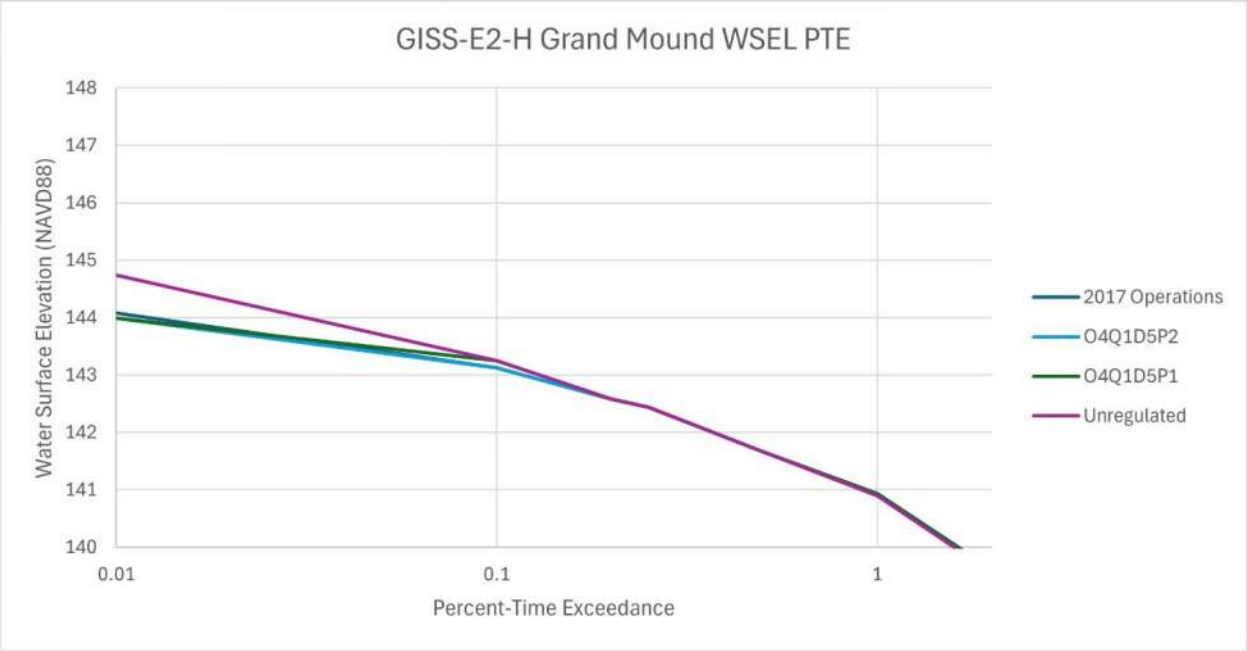
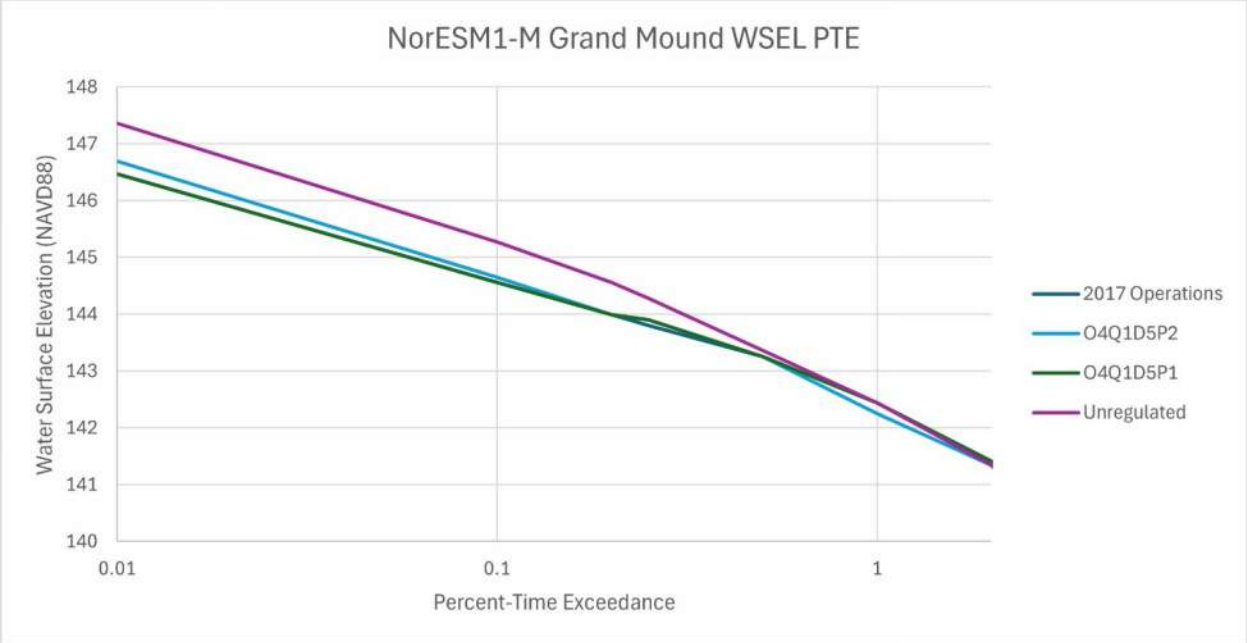


Figure 2-10. MIROC5 Grand Mound WSEL PTE Detailed View of WSEL 140–148 feet

Figure 2-11. MRI-CGCM3 Grand Mound WSEL PTE Detailed View of WSEL 140–148 feet

Figure 2-12. NorESM1-M Grand Mound WSEL PTE Detailed View of WSEL 140–148 feet



Attachment 3. Future Climate Fisk Falls Spawning Reach Inundation Days and PTE

Table 3-1. Days of Inundation at Fisk Falls Spawning Reach – 2017 Operations

Calendar Year	Access 1.0	Access 1.3	bcc-csm 1.1	canesm2	ccsm4	csiro-mk3.6	fgoals-g2	gfdl-cm3	giss-e2-h	MIROC5	mri-cgcm3	noresm1-m
2026	0.0	0.0	0.0	0.0	5.4	0.0	0.0	0.0	0.0	8.9	6.0	3.8
2027	0.0	0.0	0.0	0.0	13.2	0.0	0.0	0.0	0.0	0.0	0.0	5.2
2028	0.0	0.0	0.0	0.0	0.0	6.0	0.0	10.9	0.0	0.0	0.0	6.9
2029	5.4	0.0	0.0	3.0	4.6	0.0	0.0	0.0	0.0	0.0	5.1	13.3
2030	0.0	11.8	0.0	0.0	7.7	8.4	0.0	0.0	0.0	6.9	0.0	5.7
2031	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.6	0.0	13.6
2032	0.0	0.0	4.8	0.0	0.0	0.0	0.0	8.4	0.0	0.0	0.0	9.2
2033	0.0	0.0	11.6	0.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1
2034	0.0	0.0	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
2035	0.0	0.0	0.0	0.0	0.0	5.1	0.0	13.0	0.0	0.0	0.0	0.0
2036	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0	1.0	0.0	0.0
2037	0.0	0.0	0.0	0.0	0.0	10.8	0.0	0.0	0.0	0.0	0.0	6.5
2038	0.0	0.0	0.0	0.0	0.0	6.4	0.0	0.0	0.0	0.0	0.0	0.0
2039	3.8	0.0	0.0	0.0	0.0	0.0	0.0	7.8	0.0	5.5	0.0	0.0
2040	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.3	0.0	8.9	0.0	11.1
2041	0.0	4.5	0.0	0.0	3.0	6.5	0.0	2.5	5.0	0.0	0.0	8.8
2042	0.0	0.0	15.5	0.0	0.0	6.3	0.0	13.8	5.6	6.5	0.0	0.0
2043	10.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.3
2044	0.0	0.0	0.0	0.0	0.0	5.9	0.0	0.0	0.0	0.8	0.0	0.0
2045	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.4	0.0	7.2	0.0	3.6
2046	0.0	0.0	0.0	0.0	0.0	9.8	0.0	4.9	0.0	13.4	0.0	10.2
2047	0.0	0.0	11.9	0.0	3.3	0.0	0.0	8.0	0.0	0.0	3.3	10.0
2048	5.0	2.5	0.0	0.0	0.0	11.6	0.0	7.8	0.0	5.1	0.0	13.4
2049	6.4	0.0	8.4	7.6	0.0	7.4	0.0	5.0	0.0	0.8	0.0	17.3
2050	0.0	0.0	14.0	4.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	17.3
2051	0.0	6.0	0.0	0.0	6.0	8.9	0.0	0.0	4.2	24.8	0.0	0.0

Calendar Year	Access 1.0	Access 1.3	bcc-csm 1.1	canesm2	ccsm4	csiro-mk3.6	fgoals-g2	gfdl-cm3	giss-e2-h	MIROC5	mri-cgcm3	noresm1-m
2052	0.0	0.0	0.0	0.0	0.7	0.0	8.8	0.0	0.0	20.4	0.0	8.9
2053	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	5.5	0.0	0.0
2054	0.0	11.6	0.0	0.0	0.0	0.0	6.8	20.5	0.0	0.0	0.0	3.3
2055	11.1	0.0	7.9	0.0	0.0	0.0	0.0	6.8	0.0	0.0	0.0	4.6
2056	5.4	6.0	0.0	0.0	2.0	0.0	0.0	0.0	5.4	9.9	0.0	5.8
2057	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	11.7	11.0	0.0
2058	3.5	10.9	0.0	0.0	0.0	8.8	0.0	0.0	0.0	3.8	0.0	5.0
2059	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8
2060	0.0	0.0	5.6	3.0	1.0	4.5	0.0	13.0	0.0	0.0	0.0	13.3
2061	0.0	0.0	6.8	9.1	0.0	4.0	0.0	1.3	0.0	7.8	0.0	8.0
2062	0.0	8.8	0.0	0.0	0.0	7.5	0.0	0.0	0.0	17.1	0.0	6.7
2063	0.0	12.0	0.0	0.0	6.0	0.0	4.0	0.0	0.0	7.7	0.0	0.0
2064	0.0	0.0	4.1	0.0	4.3	12.8	5.5	10.4	8.5	6.5	5.0	6.3
2065	3.6	0.0	0.0	0.0	8.2	0.0	0.0	15.0	0.0	0.0	0.0	0.0
2066	0.0	0.0	10.3	0.0	0.0	0.0	0.0	8.0	0.0	0.0	0.0	5.8
2067	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1
2068	5.0	0.0	0.0	3.5	0.0	5.0	0.0	0.0	0.0	11.3	0.0	8.8
2069	15.6	4.5	7.7	4.8	0.0	3.5	10.6	23.1	0.0	47.0	7.8	8.3
2070	7.1	11.8	4.0	0.0	3.6	0.0	0.0	0.0	0.0	5.4	0.0	10.2
2071	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	0.0	8.6
2072	0.0	0.0	10.5	0.0	4.7	0.0	0.0	0.0	0.0	5.3	0.0	3.5
2073	0.0	0.0	0.0	8.1	0.0	6.0	4.8	14.3	0.0	9.4	13.8	0.0
2074	0.0	0.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2075	0.0	0.0	0.0	10.0	0.0	0.0	13.3	3.7	0.0	0.0	0.0	0.0
2076	0.0	5.0	0.0	0.0	0.0	0.0	0.0	3.5	4.4	0.0	0.0	0.0
2077	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	5.3	0.0	8.1
2078	15.2	0.0	0.0	0.0	9.0	11.1	0.0	6.5	0.0	7.8	3.3	13.1

Calendar Year	Access 1.0	Access 1.3	bcc-csm 1.1	canesm2	ccsm4	csiro-mk3.6	fgoals-g2	gfdl-cm3	giss-e2-h	MIROC5	mri-cgcm3	noresm1-m
2079	9.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.2	0.0	0.0
2080	3.7	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0	12.3	0.0
2081	7.0	5.0	0.0	0.0	7.6	4.8	1.0	8.5	0.0	0.0	4.7	5.0
2082	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0	20.0
2083	2.6	0.0	0.0	0.0	0.0	0.0	8.3	10.8	0.0	17.1	0.0	11.4
2084	0.0	0.0	3.8	0.0	0.5	0.0	12.8	5.4	0.0	18.5	0.0	10.4
2085	7.7	5.5	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	10.5
2086	0.0	4.4	4.0	0.0	0.0	8.2	0.0	0.0	0.0	0.0	6.9	0.0
2087	0.0	0.0	0.0	0.0	0.0	21.3	0.0	5.7	0.0	0.0	4.2	0.0
2088	0.0	0.0	0.0	3.9	8.0	27.5	0.0	0.0	0.0	0.0	0.0	0.0
2089	0.0	0.0	0.0	0.0	0.0	1.8	0.0	6.0	0.0	12.5	0.0	18.7
2090	7.2	7.3	6.1	0.0	0.0	0.0	0.0	11.5	0.0	0.0	0.0	0.0
2091	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0	0.0	10.5
2092	19.4	16.8	0.0	0.0	8.5	0.0	5.5	6.3	5.8	0.0	0.0	4.4
2093	0.0	0.0	0.0	0.0	0.0	18.5	0.0	0.0	0.0	9.6	11.0	0.0
2094	6.5	6.0	8.6	0.0	0.0	8.2	5.8	15.7	0.0	19.7	8.5	9.8
2095	3.6	0.0	4.4	0.0	5.9	4.9	0.0	0.0	0.0	11.0	0.0	11.3
2096	0.0	0.0	5.5	0.0	6.9	15.1	12.0	0.0	0.0	0.0	6.3	17.0
2097	5.5	1.3	4.2	11.5	0.0	9.2	0.0	4.4	4.2	0.0	0.0	7.8
2098	0.0	9.1	0.0	2.7	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.3
2099	0.0	0.0	0.0	0.0	0.0	6.8	0.0	0.0	0.0	0.0	0.0	18.3

Table 3-2. Days of Inundation at Fisk Falls Spawning Reach – O4Q1D5P1 Operations

Calendar Year	Access 1.0	Access 1.3	bcc-csm 1.1	canesm2	ccsm4	csiro-mk3.6	fgoals-g2	gfdl-cm3	giss-e2-h	MIROC5	mri-cgcm3	noresm1-m
2026	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	5.1	0.0	0.0
2027	0.0	0.0	0.0	0.0	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2028	0.0	0.0	0.0	0.0	0.0	4.3	0.0	10.6	0.0	0.0	0.0	5.0
2029	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	9.8
2030	0.0	7.5	0.0	0.0	7.8	0.0	0.0	0.0	0.0	6.8	0.0	1.1
2031	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.8
2032	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.6	0.0	0.0	0.0	8.1
2033	0.0	0.0	9.7	0.0	11.1	0.0	0.0	0.0	0.0	0.0	0.0	4.4
2034	0.0	0.0	7.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2035	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	0.0	0.0	0.0	0.0
2036	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0
2037	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2
2038	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0
2039	0.2	0.0	0.0	0.0	0.0	0.0	0.0	6.8	0.0	1.8	0.0	0.0
2040	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	0.0	7.6	0.0	9.5
2041	0.0	0.0	0.0	0.0	0.0	6.5	0.0	2.7	4.9	0.0	0.0	7.5
2042	0.0	0.0	14.3	0.0	0.0	0.0	0.0	13.0	0.3	3.1	0.0	0.0
2043	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.6
2044	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.8	0.0	0.0
2045	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	6.3	0.0	0.0
2046	0.0	0.0	0.0	0.0	0.0	8.5	0.0	0.6	0.0	7.6	0.0	1.5
2047	0.0	0.0	11.7	0.0	0.0	0.0	0.0	5.5	0.0	0.0	0.0	8.2
2048	7.0	0.0	0.0	0.0	0.0	8.8	0.0	4.7	0.0	4.3	0.0	14.2
2049	0.5	0.0	7.1	3.7	0.0	3.0	0.0	3.6	0.0	0.0	0.0	11.1
2050	0.0	0.0	17.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.4
2051	0.0	0.3	0.0	0.0	6.5	8.7	0.0	0.0	0.0	23.2	0.0	0.0
2052	0.0	0.0	0.0	0.0	0.8	0.0	4.9	0.0	0.0	15.3	0.0	0.0

Calendar Year	Access 1.0	Access 1.3	bcc-csm 1.1	canesm2	ccsm4	csiro-mk3.6	fgoals-g2	gfdl-cm3	giss-e2-h	MIROC5	mri-cgcm3	noresm1-m
2053	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
2054	0.0	6.7	0.0	0.0	0.0	0.0	2.2	17.1	0.0	0.0	0.0	0.7
2055	8.7	0.0	8.5	0.0	0.0	0.0	0.0	5.5	0.0	0.0	0.0	0.0
2056	7.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	8.3	0.0	4.5
2057	0.0	4.1	0.0	0.0	0.0	0.0	0.0	0.0	5.9	3.8	7.3	0.0
2058	0.0	4.4	0.0	0.0	0.0	10.6	0.0	0.0	0.0	2.8	0.0	0.4
2059	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2060	0.0	0.0	3.8	0.0	0.0	0.0	0.0	12.1	0.0	0.0	0.0	13.6
2061	0.0	0.0	6.3	5.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	6.1
2062	0.0	5.6	0.0	0.0	0.0	6.0	0.0	0.0	0.0	16.4	0.0	5.3
2063	0.0	6.4	0.0	0.0	0.3	0.0	0.0	0.0	0.0	7.2	0.0	0.0
2064	0.0	0.0	3.2	0.0	0.0	1.7	4.3	4.7	7.5	5.4	0.0	5.0
2065	0.0	0.0	0.0	0.0	10.9	0.0	0.0	14.1	0.0	0.0	0.0	0.0
2066	0.0	0.0	10.0	0.0	0.0	0.0	0.0	6.5	0.0	0.0	0.0	1.8
2067	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7
2068	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	6.6	0.0	7.6
2069	14.7	4.5	0.5	0.0	0.0	0.0	9.4	18.9	0.0	35.9	6.0	7.0
2070	6.0	12.6	4.4	0.0	0.0	0.0	0.0	0.0	0.0	4.7	0.0	8.5
2071	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9
2072	0.0	0.0	9.5	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	3.2
2073	0.0	0.0	0.0	6.1	0.0	5.8	0.0	14.8	0.0	8.4	5.9	0.0
2074	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2075	0.0	0.0	0.0	8.7	0.0	0.0	6.2	0.0	0.0	0.0	0.0	0.0
2076	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2077	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	5.3	0.0	7.4
2078	11.5	0.0	0.0	0.0	8.2	6.3	0.0	5.1	0.0	6.3	0.0	12.4
2079	7.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.9	0.0	0.0

Calendar Year	Access 1.0	Access 1.3	bcc-csm 1.1	canesm2	ccsm4	csiro-mk3.6	fgoals-g2	gfdl-cm3	giss-e2-h	MIROC5	mri-cgcm3	noresm1-m
2080	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.2	0.0
2081	3.3	3.5	0.0	0.0	6.3	0.0	0.0	5.0	0.0	0.0	0.0	0.0
2082	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.1
2083	0.0	0.0	0.0	0.0	0.0	0.0	7.1	0.8	0.0	10.5	0.0	10.8
2084	0.0	0.0	0.0	0.0	0.0	0.0	9.1	6.3	0.0	14.0	0.0	10.5
2085	6.3	4.1	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3
2086	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8	0.0
2087	0.0	0.0	0.0	0.0	0.0	13.5	0.0	4.0	0.0	0.0	0.0	0.0
2088	0.0	0.0	0.0	0.5	6.6	20.9	0.0	0.0	0.0	0.0	0.0	0.0
2089	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	0.0	10.9	0.0	10.4
2090	6.0	3.3	6.7	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0
2091	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.5
2092	7.2	6.5	0.0	0.0	7.0	0.0	0.0	5.2	3.2	0.0	0.0	0.0
2093	0.0	0.0	0.0	0.0	0.0	17.4	0.0	0.0	0.0	4.7	4.2	0.0
2094	4.9	4.7	21.9	0.0	0.0	7.3	2.4	9.9	0.0	15.3	0.0	9.0
2095	0.0	0.0	4.5	0.0	3.8	0.7	0.0	0.0	0.0	4.2	0.0	6.3
2096	0.0	0.0	4.5	0.0	3.5	12.1	6.4	0.0	0.0	0.0	2.4	15.5
2097	4.8	0.5	3.0	4.8	0.0	7.9	0.0	0.0	0.0	0.0	0.0	8.4
2098	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.6
2099	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	0.0	0.0	18.2

Table 3-3. Days of Inundation at Fisk Falls Spawning Reach – O4Q1D5P2 Operations

Calendar Year	Access 1.0	Access 1.3	bcc-csm 1.1	canesm2	ccsm4	csiro-mk3.6	fgoals-g2	gfdl-cm3	giss-e2-h	MIROC5	mri-cgcm3	noresm1-m
2026	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	10.1	0.0	0.0
2027	0.0	0.0	0.0	0.0	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2028	0.0	0.0	0.0	0.0	0.0	9.4	0.0	10.9	0.0	0.0	0.0	5.4
2029	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	11.7
2030	0.0	12.0	0.0	0.0	7.8	0.0	0.0	0.0	0.0	7.1	0.0	1.1
2031	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	0.0	12.9
2032	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.3	0.0	0.0	0.0	8.1
2033	0.0	0.0	0.7	0.0	11.1	0.0	0.0	0.0	0.0	0.0	0.0	4.4
2034	0.0	0.0	7.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
2035	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	0.0	0.0	0.0	0.0
2036	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	0.0	0.0	0.0
2037	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.2
2038	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	0.0	0.0	0.0	0.0
2039	2.6	0.0	0.0	0.0	0.0	0.0	0.0	6.8	0.0	11.2	0.0	0.0
2040	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.1	0.0	15.1	0.0	11.3
2041	0.0	2.3	0.0	0.0	0.0	6.5	0.0	2.7	3.0	0.0	0.0	10.8
2042	0.0	0.0	10.6	0.0	0.0	0.0	0.0	13.0	0.0	5.6	0.0	0.0
2043	10.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.8
2044	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.8	0.0	0.0
2045	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	13.9	0.0	0.0
2046	0.0	0.0	0.0	0.0	0.0	11.8	0.0	4.0	0.0	9.9	0.0	9.1
2047	0.0	0.0	10.1	0.0	0.0	0.0	0.0	6.6	0.0	0.0	0.0	8.3
2048	7.0	0.0	0.0	0.0	0.0	9.1	0.0	5.7	0.0	4.3	0.0	32.3
2049	4.0	0.0	7.0	4.4	0.0	21.8	0.0	3.6	0.0	0.0	0.0	11.9
2050	0.0	0.0	12.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7
2051	0.0	0.0	0.0	0.0	6.5	12.1	0.0	0.0	0.0	23.3	0.0	0.0
2052	0.0	0.0	0.0	0.0	0.8	0.0	8.0	0.0	0.0	19.5	0.0	0.0

Calendar Year	Access 1.0	Access 1.3	bcc-csm 1.1	canesm2	ccsm4	csiro-mk3.6	fgoals-g2	gfdl-cm3	giss-e2-h	MIROC5	mri-cgcm3	noresm1-m
2053	0.0	0.0	0.0	0.0	0.0	6.8	0.0	0.0	0.0	9.1	0.0	0.0
2054	0.0	9.3	0.0	0.0	0.0	0.0	10.8	17.2	0.0	0.0	0.0	2.4
2055	11.7	0.0	0.0	0.0	0.0	0.0	0.0	5.5	0.0	0.0	0.0	0.0
2056	7.4	0.0	0.0	0.0	6.8	0.0	0.0	0.0	3.0	13.6	0.0	4.5
2057	0.0	4.1	0.0	0.0	0.0	0.0	0.0	0.0	2.4	8.0	8.8	0.0
2058	0.0	4.4	0.0	0.0	0.0	18.3	0.0	0.0	0.0	2.8	0.0	3.4
2059	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2060	0.0	0.0	3.8	0.0	0.0	0.0	0.0	16.3	0.0	0.0	0.0	13.6
2061	0.0	0.0	5.3	5.1	0.0	2.4	0.0	0.0	0.0	0.0	0.0	6.3
2062	0.0	11.9	0.0	0.0	0.0	6.6	0.0	0.0	0.0	18.3	0.0	10.7
2063	0.0	6.5	0.0	0.0	4.0	0.0	0.0	0.0	0.0	18.8	0.0	0.0
2064	0.0	0.0	0.8	0.0	0.0	8.5	5.0	4.7	7.5	5.4	0.0	5.1
2065	0.0	0.0	0.0	0.0	16.7	0.0	0.0	24.9	0.0	0.0	0.0	0.0
2066	0.0	0.0	5.8	0.0	0.0	0.0	0.0	18.3	0.0	0.0	0.0	4.7
2067	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7
2068	0.0	0.0	0.0	0.0	0.0	9.5	0.0	0.0	0.0	12.2	0.0	7.8
2069	14.8	4.5	0.5	0.0	0.0	2.7	9.4	26.1	0.0	40.5	6.3	7.3
2070	15.6	17.3	4.1	0.0	0.0	0.0	0.0	0.0	0.0	19.8	0.0	11.5
2071	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9
2072	0.0	0.0	9.2	0.0	4.3	0.0	0.0	0.0	0.0	5.6	0.0	3.2
2073	0.0	0.0	0.0	17.3	0.0	5.8	1.2	19.3	0.0	8.4	13.2	0.0
2074	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2075	0.0	0.0	0.0	8.8	0.0	0.0	15.8	0.0	0.0	0.0	0.0	0.0
2076	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2077	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	5.3	0.0	22.3
2078	14.0	0.0	0.0	0.0	8.2	6.3	0.0	5.7	0.0	9.6	0.0	13.3
2079	11.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.7	0.0	14.1

Calendar Year	Access 1.0	Access 1.3	bcc-csm 1.1	canesm2	ccsm4	csiro-mk3.6	fgoals-g2	gfdl-cm3	giss-e2-h	MIROC5	mri-cgcm3	noresm1-m
2080	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.7	0.0
2081	5.3	3.6	0.0	0.0	7.1	0.0	0.0	15.5	0.0	0.0	0.0	0.0
2082	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.7
2083	0.0	0.0	0.0	0.0	0.0	0.0	7.2	6.4	0.0	10.7	0.0	10.9
2084	0.0	0.0	0.0	0.0	0.0	0.0	26.5	6.8	0.0	28.0	0.0	10.5
2085	6.3	4.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5
2086	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8	0.0
2087	0.0	0.0	0.0	0.0	0.0	32.9	0.0	4.0	0.0	0.0	0.0	0.0
2088	0.0	0.0	0.0	3.0	8.5	31.7	0.0	0.0	0.0	0.0	0.0	0.0
2089	0.0	0.0	0.0	0.0	0.0	4.0	0.0	5.5	0.0	13.6	0.0	34.7
2090	8.4	3.3	5.0	0.0	0.0	0.0	0.0	10.1	0.0	0.0	0.0	1.5
2091	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	9.5
2092	22.6	12.0	0.0	0.0	7.3	0.0	0.0	5.3	0.4	0.0	0.0	0.0
2093	0.0	0.0	0.0	0.0	0.0	17.4	0.0	0.0	0.0	8.0	11.5	0.0
2094	5.5	4.7	0.9	0.0	0.0	17.8	11.7	13.6	0.0	22.3	0.0	9.0
2095	0.0	0.0	4.5	0.0	4.1	1.4	6.1	0.0	0.0	12.5	0.0	11.0
2096	0.0	0.0	4.5	0.0	11.8	16.3	13.3	0.0	0.0	0.0	5.5	36.8
2097	12.8	3.3	3.0	10.5	0.0	24.5	0.0	0.0	0.0	0.0	0.0	8.4
2098	0.0	26.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
2099	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	0.0	0.0	0.0	19.1

Figure 3-1. Access1_0 Days of Fisk Falls Inundation PTE

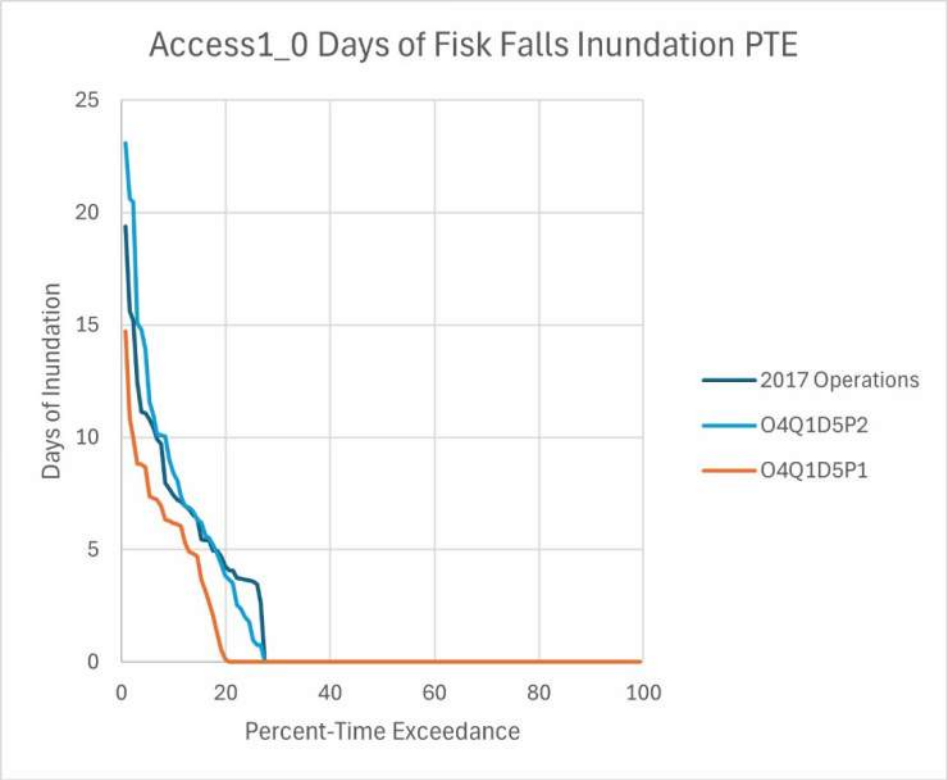


Figure 3-2. Access1_3 Days of Fisk Falls Inundation PTE

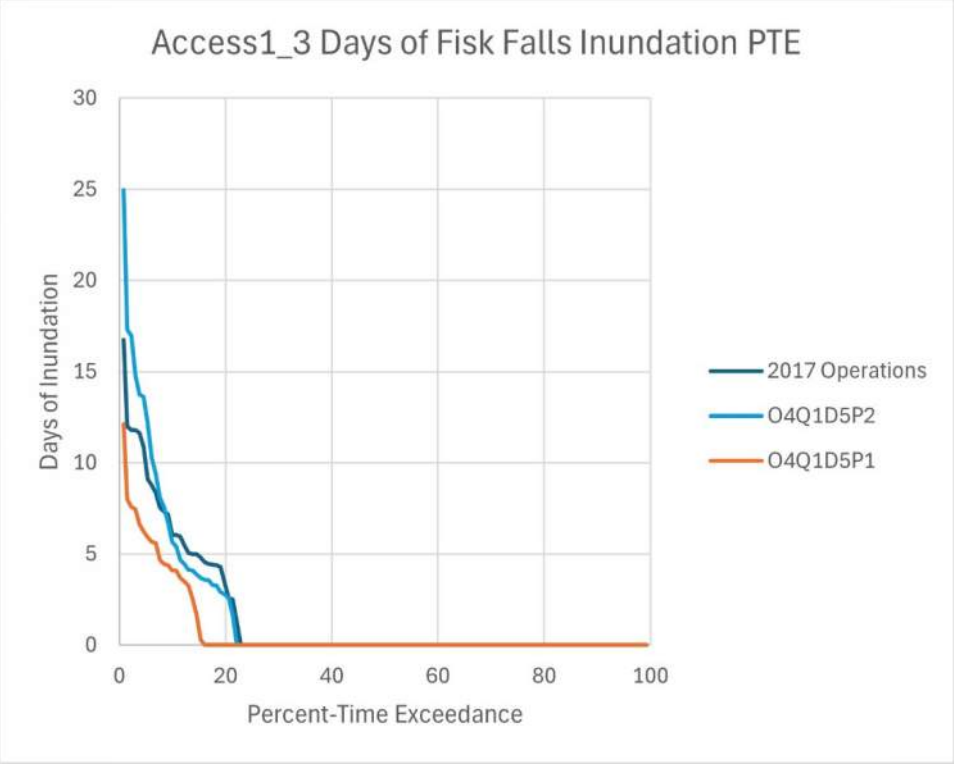


Figure 3-3. Bcc_csm1-1 Days of Fisk Falls Inundation PTE

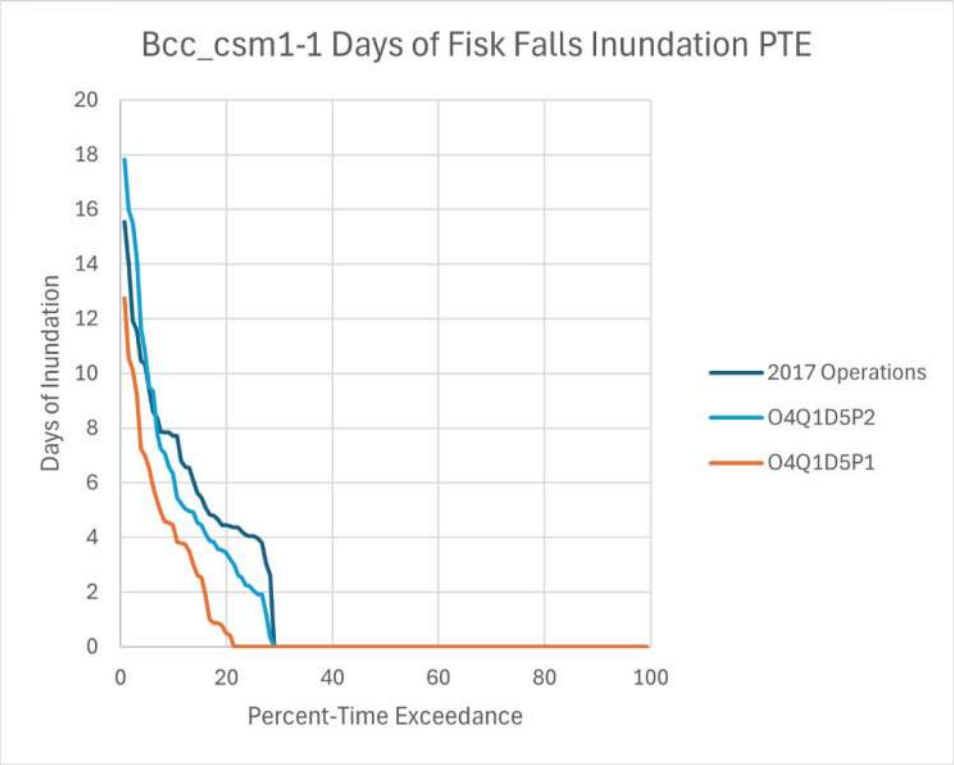


Figure 3-4. canESM2 Days of Fisk Falls Inundation PTE

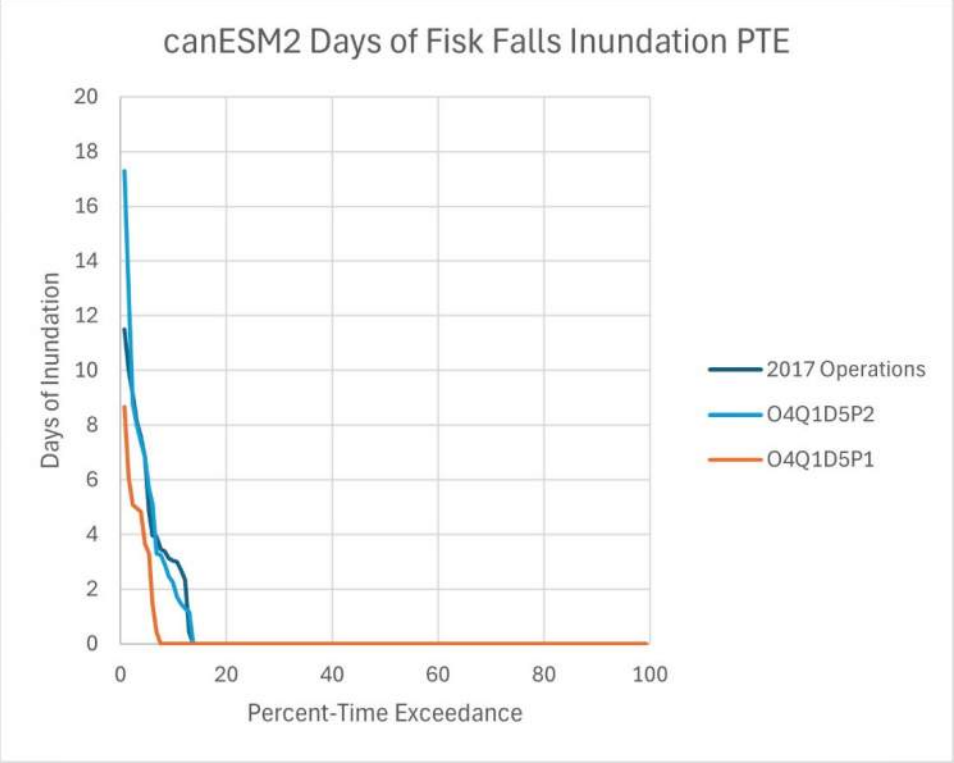


Figure 3-5. CCSM4 Days of Fisk Falls Inundation PTE

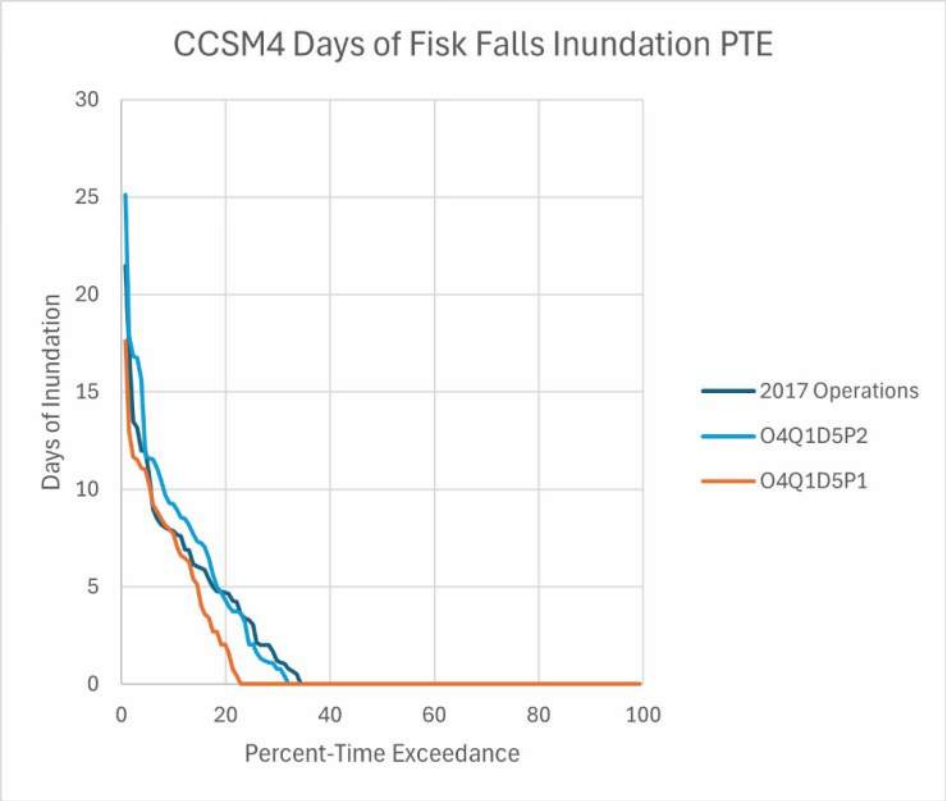


Figure 3-6. CSIRO-Mk3-6-0 Days of Fisk Falls Inundation PTE

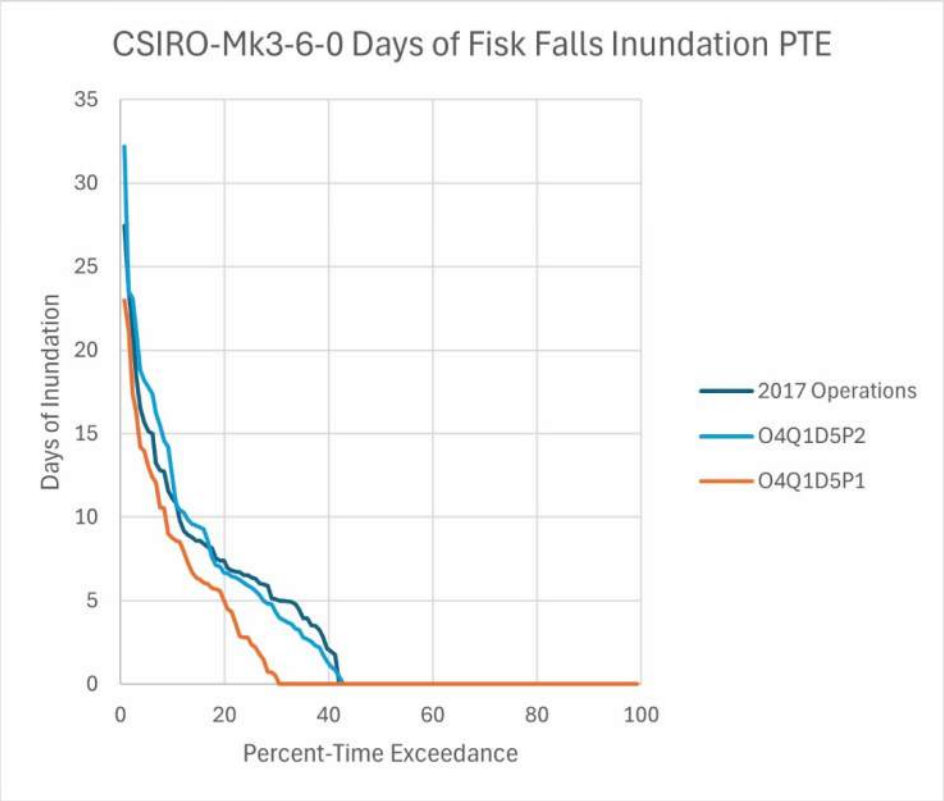


Figure 3-7. FGOALS-g2 Days of Fisk Falls Inundation PTE

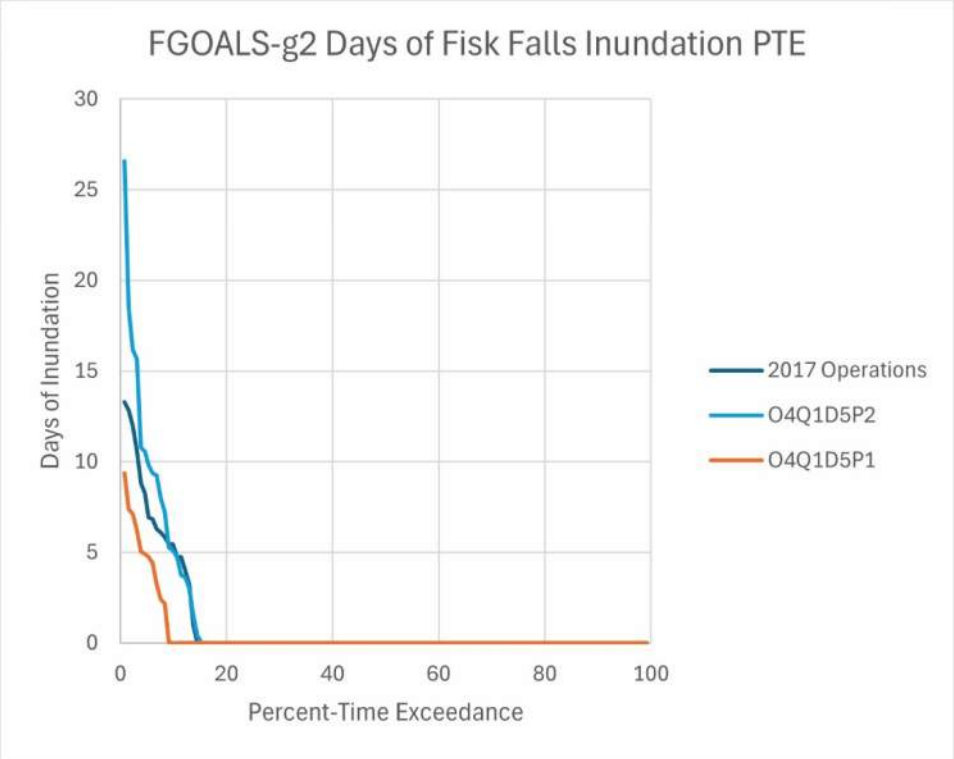


Figure 3-8. GFDL-CM3 Days of Fisk Falls Inundation PTE

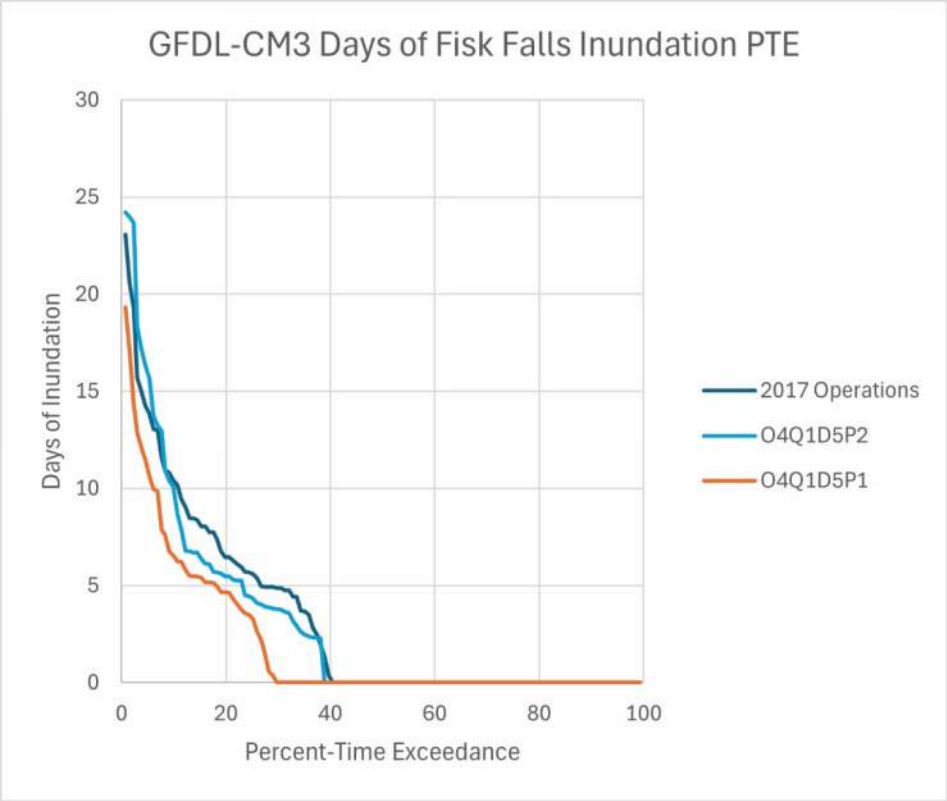


Figure 3-9. GISS-E2-H Days of Fisk Falls Inundation PTE

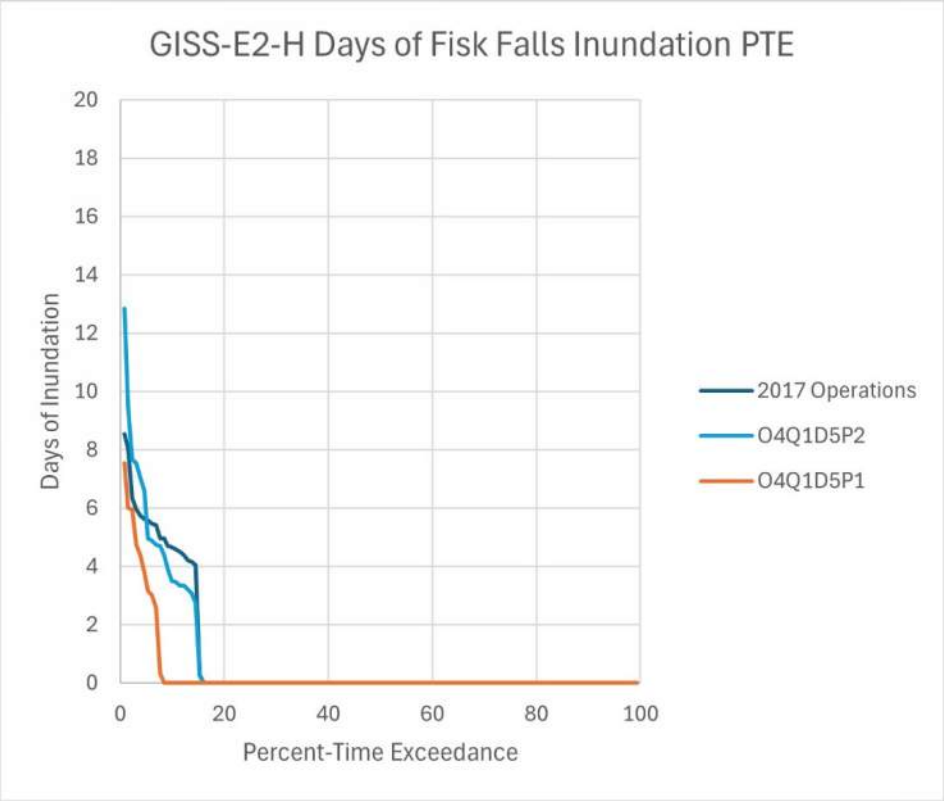


Figure 3-10. MIROC5 Days of Fisk Falls Inundation PTE

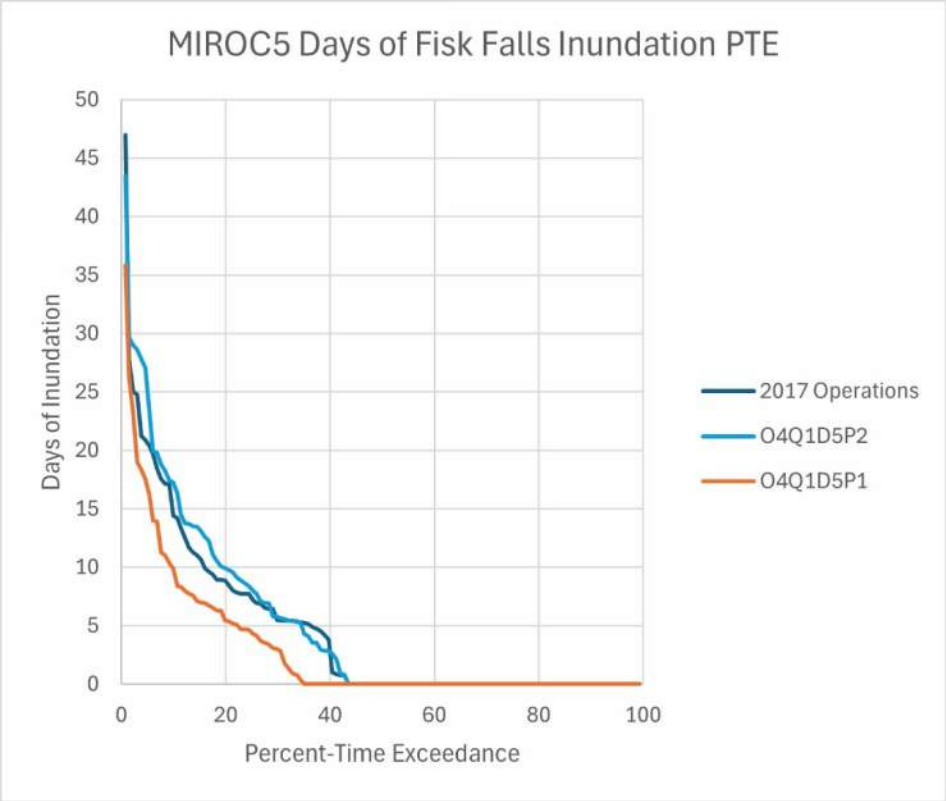


Figure 3-11. MRI-CGCM3 Days of Fisk Falls Inundation PTE

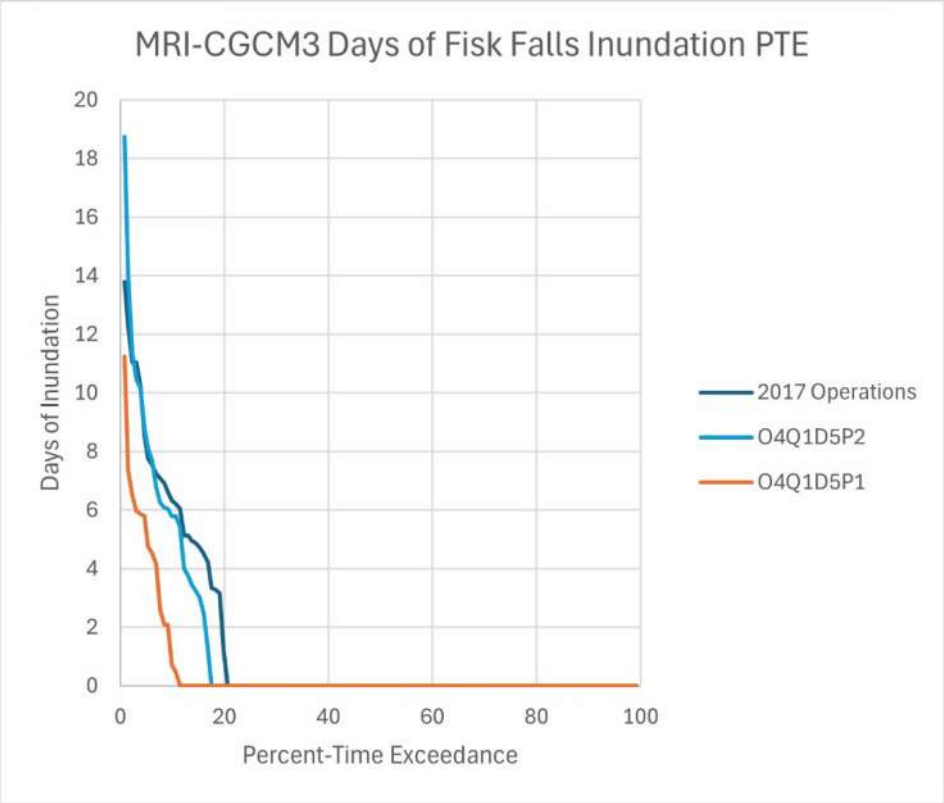
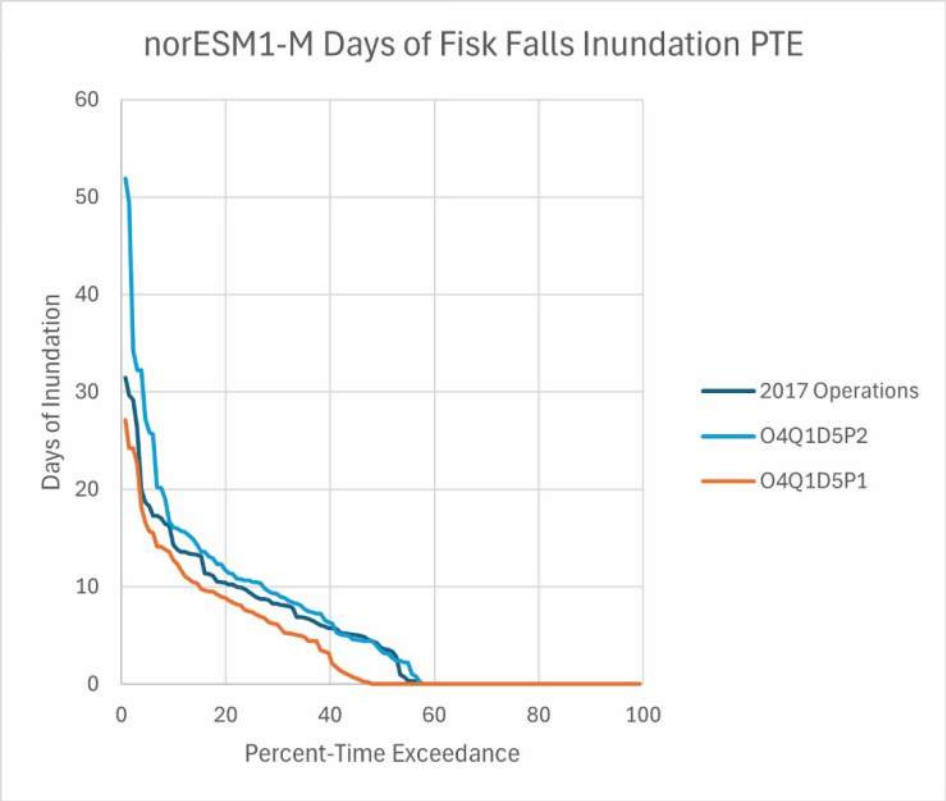


Figure 3-12. norESM1-M Days of Fisk Falls Inundation PTE



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Attachment 3 – Inundation Technical Memorandum

February 4, 2026

TECHNICAL MEMORANDUM

Date: February 2, 2026
To: Kathy Burnaham, Chehalis River Basin Flood Control Zone District
From: MaryLouise Keefe, PhD, Jason Romine Ph.D., and Kai Steimle Kleinschmidt Associates
Cc: Jason Kent, PE, PMP, Kleinschmidt Associates
Re: Inundation Analysis with 2024 Project Design and 2025 (O4P2) Operational Scenario

Introduction

The Chehalis River Basin Flood Control Zone District (District) is proposing to construct a Flood Retention Expandable (FRE) facility to reduce the risk of flood damage along the mainstem Chehalis River. The primary purpose of the FRE facility is to reduce flooding coming from the Willapa Hills by storing floodwaters in the temporary pool during major or greater floods. Thus, the FRE facility will include a temporary pool that is only inundated during infrequent flood operations.

State and Federal environmental reviews of the FRE facility (Ecology 2020, 2025; Corps 2020) have determined that by temporarily storing peak flows during major flood events, operating the FRE facility would inundate fish redds and riparian vegetation, resulting in the mortality of both. For redds, the 2025 Draft Environmental Impact Statements (DEISs) assumed that 100 percent redd mortality would occur within the temporary pool. The DEISs also assumed a loss of trees that would result in a loss of riparian shade and, in turn, was hypothesized to negatively impact water temperatures. The water temperature impact was predicted based on results from a water quality model that was updated in 2025 (PSU 2025) based on the 2024 Chehalis River Basin Flood Damage Reduction Project (Project) design. The DEIS predicted water temperature impacts of up to 1.5 °C immediately downstream of the FRE facility and 0.3 °C or greater downstream to approximately river mile (RM) 94.9 (downstream of Dryad, Washington).

In 2024, the FRE facility was relocated to avoid cultural impacts, which resulted in design revisions. A refined 2024 Project design incorporated two changes relevant to inundation. First, the FRE was moved upstream to approximately RM 108.7, thereby eliminating inundation impacts in the approximate 0.25-mile reach between the 2017 and 2024 FRE locations. Second, under a 2025 Project operations model (O4P2), operations would result in both inundation of a slightly smaller temporary pool and a reduced duration of inundation. This technical memorandum describes the analyses done by Kleinschmidt Associates (Kleinschmidt) to evaluate how changes in the FRE location and operation will affect redd and tree mortality within the temporary pool as summarized in the main body of this document.

Methods

Inundation

As described in the main body of this technical memorandum, the 2025 (O4P2) operations modeled nine different flood events that would trigger operation of the FRE facility based on historic flows (Table 1). Data on depth and duration of the temporary pool that formed during several of these events were used in this inundation analysis. In evaluating the potential effects of temporary inundation on redds, data from flood events representing a catastrophic flood (1996) and major floods (2019 and 2022) were used. For vegetation, to be consistent with a previous vegetation analysis completed for the District's Revised Mitigation Plan (Kleinschmidt 2024), the representative catastrophic flood event used was based on hydrology from 2007 and the major flood was based on 2015. Both analyses used hourly depth data modeled by HDR under the O4P2 operations model. Hourly data were then filtered for FRE operational events listed above and identified by year (Table 1).[1]

Table 1
FRE operations by flood event and year with start and stop times for the O4P2 operational scenario.

OPERATIONAL EVENT	START TIME	END TIME	YEAR
1	1990-01-07 11:00	1990-01-23 17:00	1990
2	1996-02-06 10:00	1996-02-25 22:00	1996
3	2006-11-05 11:00	2006-11-23 14:00	2006
4	2007-12-02 04:00	2007-12-21 15:00	2007
5	2009-01-05 15:00	2009-01-24 14:00	2009
6	2015-01-05 00:00	2015-01-18 13:00	2015
7	2017-02-09 02:00	2017-02-23 17:00	2017
8	2019-12-20 01:00	2020-01-04 08:00	2019
9	2022-01-05 20:00	2022-01-26 10:00	2022

The hourly depth data from HDR demonstrated how the 2025 and 2017 operations, respectively, would fill and drain the temporary inundation pool in a flood event comparable to the catastrophic 1996 flood. In general, both operations sets begin filling the temporary inundation pool when major or catastrophic flooding is forecasted; eventually, each fills the pool to a maximum extent and then begins to drain. The portion of the pool that drains first is labeled the "Initial Evacuation Zone." Each operation set then slows drainage of the pool while debris is collected; the area inundated during this time is called the "Debris Management Zone." Drainage resumes until the pool is completely evacuated. The extent of the

[1] Historically, the Grand Mound gage did not reach 38,800 cubic feet per second (cfs) in either 2015 or 2019, and so flood operations would not have been triggered. The HDR hydrology overestimates flows somewhat, however, making these modeled floods exceed that threshold. The overestimate in 2015 was slight; Ground Mound reached 37,700 cfs that year. The 2019 overestimate was more pronounced, but the redd analysis using that flood also considers 1996 and 2022, both of which exceeded the 38,800 cfs trigger at Grand Mound historically. In the context of this analysis, the 2015 and 2019 modeled floods are suitable candidates for the types of major floods in which flood operations may occur in the future, and so can inform the analysis.

pool during this time is called the "Final Evacuation Zone." For both operations sets, the Initial Evacuation Zone is inundated for the least time and the Final Evacuation Zone is inundated for the most time. For a flood comparable to 1996, the 2025 operations set does not inundate quite as much area as the 2017 operations set, so there is a portion of the 2017 Initial Evacuation Zone that the 2025 operations set does not inundate. Moreover, the 2025 operations set drains faster than the 2017 operations set, and so the sizes of the Initial Evacuation, Debris Management, and Final Evacuation zones are not the same.

Redds

Data from annual redd surveys conducted by Washington Department of Fish and Wildlife (WDFW) in the middle and upper Chehalis Basin was obtained from WDFW. Data reviewed for this analysis included data from surveys conducted for spring- and fall-run Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), and steelhead (*O. mykiss*) upstream of the proposed FRE site from 2013 through 2020. In the 2017 and 2018 survey seasons, redd surveys were also conducted downstream of the FRE facility (Ronne et al. 2020). Given the new upstream location of the FRE facility, a small number of redds that were classified as being upstream of the FRE during those survey years are now downstream of the FRE under the refined alignment.

WDFW redd data consisted of species and locations (latitude and longitude) for individual redds from 2014 through 2020. Data were imported to R (R Core Team 2025) and spatially filtered to remove redds with incorrect location information (n=3). A digital elevation model was developed in ArcPro (ESRI) from available light detection and ranging data. The digital elevation model was brought into R and was used to interpolate redd elevation using the extract function in the terra package. All analyses were conducted in the North American Vertical Datum of 1988 (NAVD 88).

For the purposes of this analysis, the Chehalis River from the confluence with the Newaukum River upstream to the forks was divided into seven different river zones (Table 2). Based on their elevation, each redd was classified into one of the river zones. The extent of these zones differed between the 2025 and 2017 operations. The change in FRE facility location (upstream and at a higher elevation) combined with operational changes in debris management resulted in shifts to the upper extent of the Rainbow Falls to FRE zone and changes to the size and extent of the evacuation zones within the inundation pool (Table 2). Two of the more notable changes were a decrease in the extent of the Debris Management Zone, an increase in the Initial Evacuation Zone, and a lower extent of the maximum inundation pool for the modeled 1996 flood event.

Table 2
Analyses zones for redd inundation and elevation range of each zone for 1996 modeled flood under 2017 and 2025 (O4P2) operations.

RIVER ZONE	ELEVATION BAND IN FEET (NAVD 88) 2025 (O4P2) OPERATIONS	2017 OPERATIONS	RELATIVE LOCATION
Newaukum River to Rainbow Falls	<265	<265	Downstream of FRE
Rainbow Falls to FRE	265 – 447	265 – 425	Downstream of FRE
Final Evacuation[1]	447 – 477	425 – 500	Within Max Inundation Pool
Debris Management[1]	477 – 487	500 – 528	Within Max Inundation Pool
Initial Evacuation – 2025 Operations[1]	487 – 587	528 – 587	Within Max Inundation Pool
Initial Evacuation – 2017 Operations	587 – 627	587 – 627	Upstream of Max Pool
Mainstem and Tributaries Upstream	>627	>627	Upstream of Max Pool

[1] The 2025 and 2017 operations sets have different elevation bands for these three rows because the pool evacuates at different speeds under the two operations sets. The 2025 operations evacuate to a lower elevation faster.

After redds were assigned elevations, the FRE operational data were analyzed to calculate the depth and duration of redd inundation for three flood scenarios (1996, 2019, 2022; catastrophic flood, minor flood, median flood, respectively). Based on known depths of fall-run Chinook salmon redds in the Columbia River and the presumed presence of water flow over the substrate associates with infilling and outflow, Kleinschmidt assumed that redds that experienced a depth of 30 feet or more for three consecutive days would suffer complete mortality. This level of mortality is likely overestimated, as the nature of flows at depth within the temporary pool are unknown at this time, but it provides a basis to understand how variability in floods and refined Project operations could impact redds in the temporary inundation area. Given these criteria, Kleinschmidt assigned a nonviable or viable condition to each redd for each FRE scenario for all species. For consistency and comparison purposes Kleinschmidt used 2017 and 2018 redd survey data to examine the "population" level impact of the FRE to compare impacts to salmon redds upstream of Newaukum.

Run year classification for Chinook salmon (spring- and fall-run) and coho salmon differed from the run year classification for steelhead in WDFW data. Chinook salmon arriving and spawning in fall of 2018 were classified as run year 2018, whereas steelhead spawning in December 2018 were classified as run year 2019. To maintain consistency across species for impacts, run year for steelhead was aligned with Chinook arriving in the same season (September – April). For example, steelhead spawning in the spring of 2019, were re-classified as run year 2018 for analysis purposes.

To identify any potential changes to FRE-related impacts, Kleinschmidt also examined the conditions created by the first proposed 2017 alignment and operations as compared to the refined 2024 alignment and 2025 (O4P2) operations. Redds observed in 2018 were used in these comparisons.

Vegetation

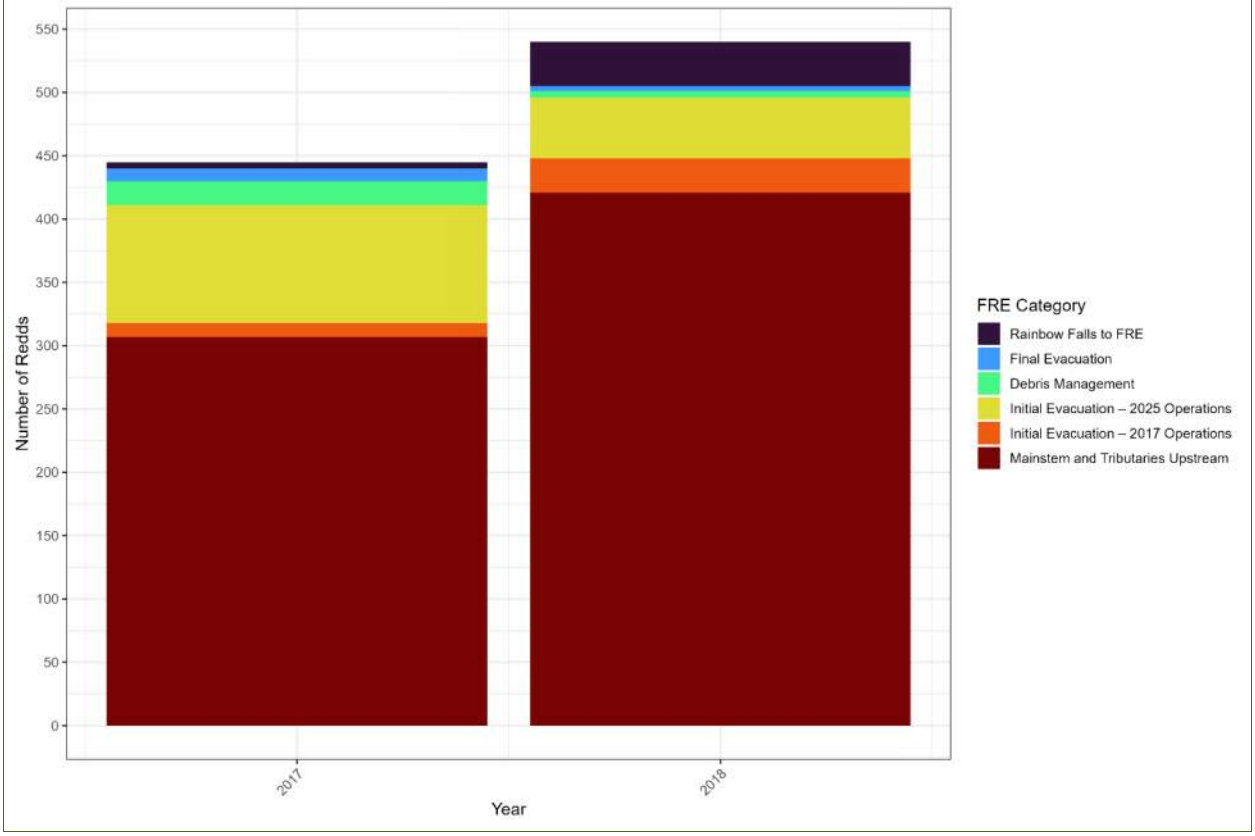
Analysis of riparian vegetation mortality due to temporary inundation was based on survival estimates included in the Vegetation Management Plan (Appendix D of the 2024 Revised Mitigation Plan, Kleinschmidt 2024). Vegetation inundated for more than a week was not expected to survive, based on observations at Mud Mountain Dam. Vegetation survival was predicted to be selective when inundation duration was less than 7 days. Because the tree species that are tolerant of inundation mature at shorter heights than evergreens, for example, that canopy height was reduced to 50 feet. Vegetation survival was assessed for both representative catastrophic flood (2007) and major flood (2015) events.

Results and Discussion

Redd Distribution under 2025 (O4P2) Operations

The numbers of observed redds within river zone classifications under 2025 operations are presented by species in Figures 1 through 4, Table 3 for coho salmon and steelhead, and Table 4 for spring- and fall-run Chinook salmon. Tables 3 and 4 also show the number of observed redds within river zone classifications under 2017 operations, as well as the differences between the 2025 and 2017 operations. During both survey years, the majority of coho salmon and steelhead redds were located upstream of the inundation zone. In contrast, the majority of spring-run Chinook and fall-run Chinook salmon redds were observed downstream of the FRE facility to the Newaukum. For all species, the proportion of the redds observed in FRE inundation zones, including the portion of the Initial Evacuation Zone that would not be inundated based on the 2025 operations set, was less than one-fourth of the total redd count. For spring-run Chinook salmon, the redd count within all FRE inundation zones was less than 3%.

Figure 1
2017 and 2018 redd distribution for coho salmon in the mainstem Chehalis River upstream of the Newaukum[1] to the East and West forks. FRE evacuation zones reflect 2024 alignment and 2025 (O4P2) operations; 447 feet elevation is below the FRE.



[1] Zero redds observed between the confluence of the Newaukum and Rainbow Falls.

Figure 2
2017 and 2018 redd distribution for fall-run Chinook salmon in the mainstem Chehalis River upstream of the Newaukum to the East and West forks. FRE evacuation zones reflect 2024 alignment and 2025 (O4P2) operations; 447 feet elevation is below the FRE.

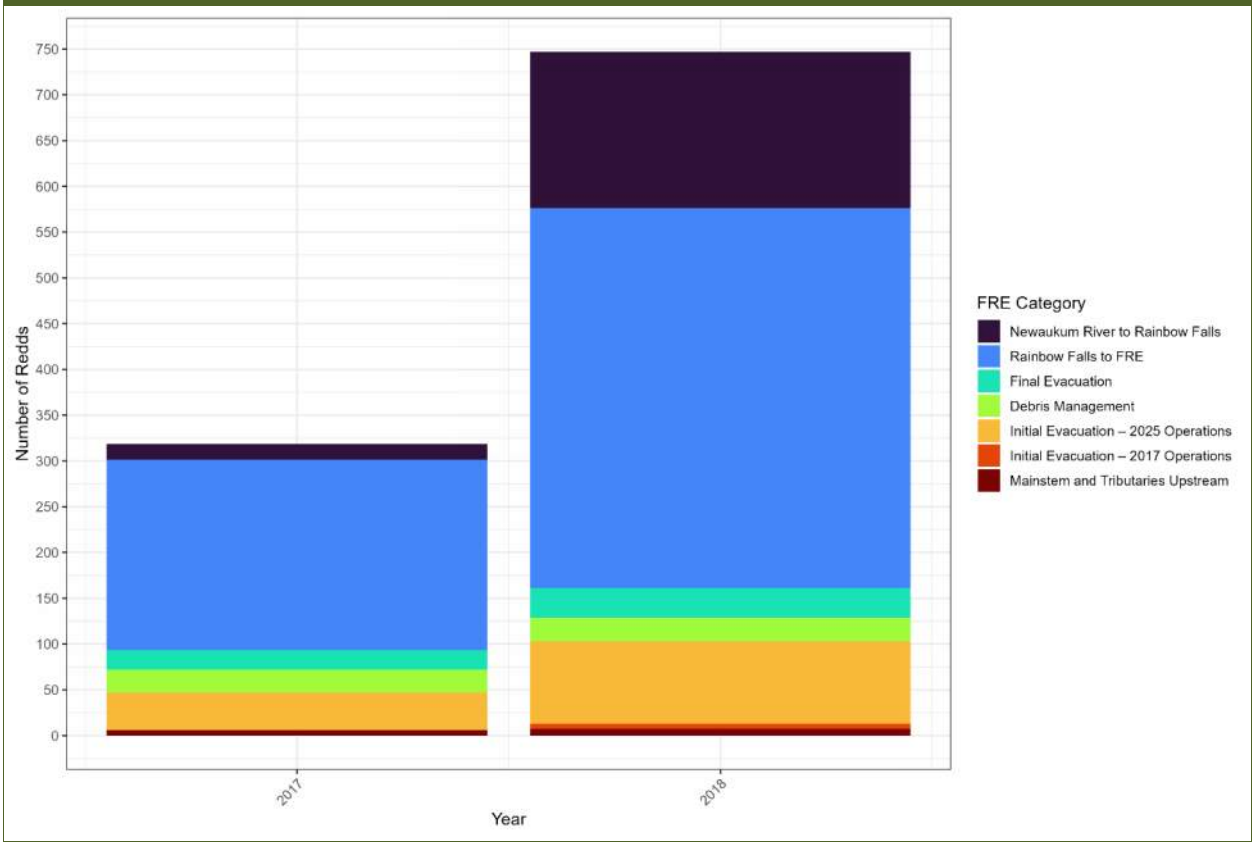


Figure 3
2017 and 2018 redd distribution for spring-run Chinook salmon in the mainstem Chehalis River upstream of the Newaukum to the East and West forks. FRE evacuation zones reflect 2024 alignment and 2025 (O4P2) operations; 447 feet elevation is below the FRE.

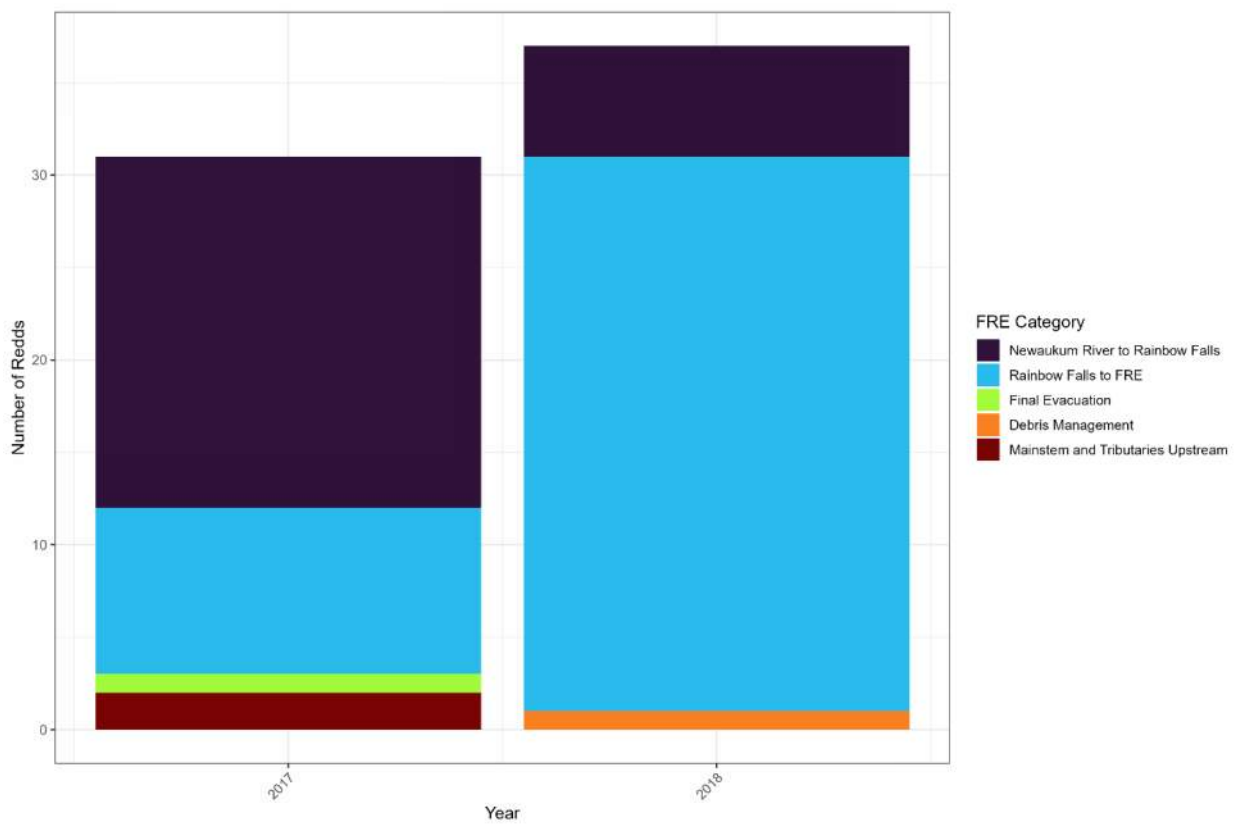


Figure 4
2017 and 2018 redd distribution for steelhead in the mainstem Chehalis River upstream of the Newaukum to the East and West forks. FRE evacuation zones reflect 2024 alignment and 2025 (O4P2) operations; 447 feet elevation is below the FRE.

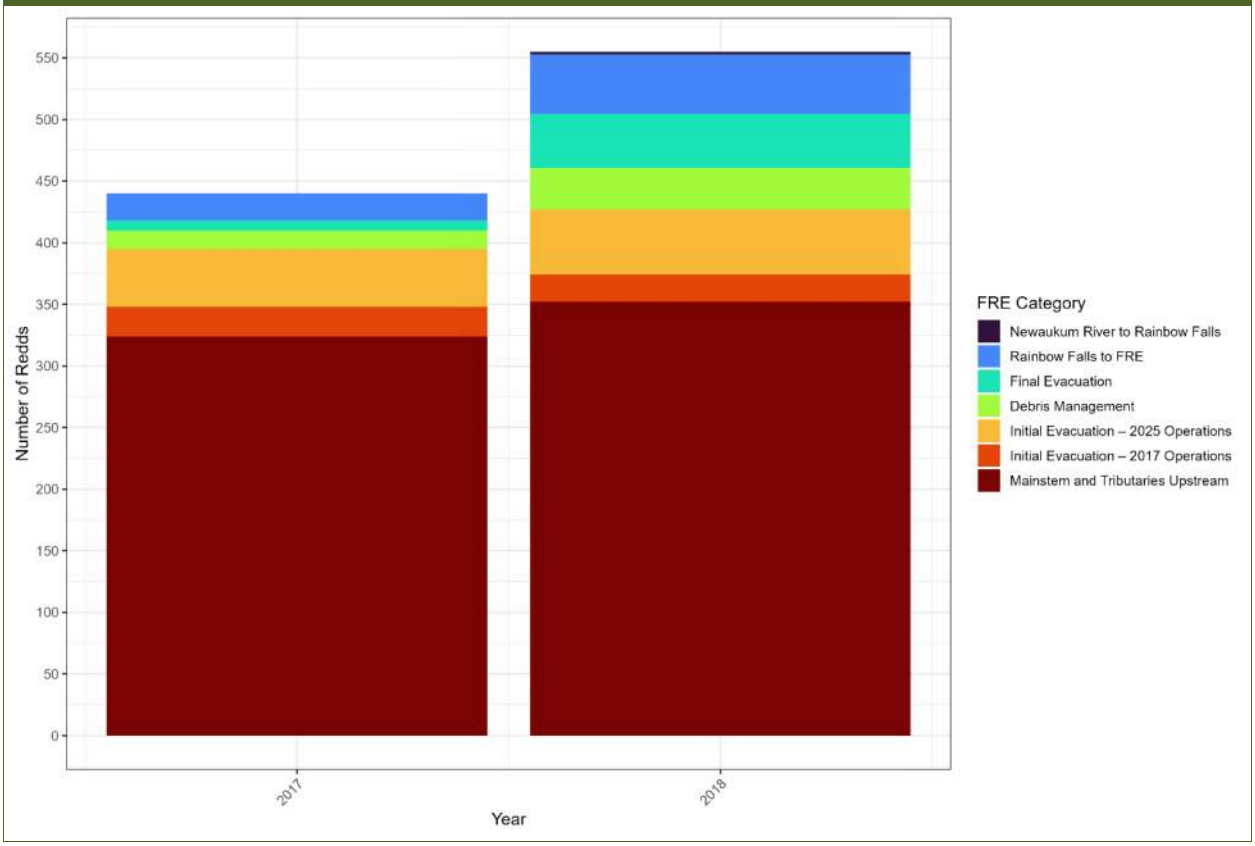


Table 3
Changes to coho salmon and steelhead redd distribution by species under 2017 operations and 2024 FRE design and 2025 (O4P2) operations.

	NUMBER OF REDDS OBSERVED IN 2018					
	COHO SALMON			STEELHEAD		
RIVER ZONE	O4P2	2017	DIFFERENCE	O4P2	2017	DIFFERENCE
Newaukum River to Rainbow Falls	0	0	0	2	2	0
Rainbow Falls to FRE	37	35	2	49	48	1
Final Evacuation[1]	1	4	-3	20	44	-24
Debris Management[1]	1	5	-4	16	34	-18
Initial Evacuation – 2025 Operations[1]	53	48	5	94	53	41
Initial Evacuation – 2017 Operations	27	27	0	22	22	0
Mainstem and Tributaries Upstream	421	421	0	352	352	0

[1] The 2025 and 2017 operations sets have different elevation bands for these three rows because the pool evacuates at different speeds under the two operations sets. The 2025 operations evacuate to a lower elevation faster.

Table 4

Changes to spring- and fall-run Chinook salmon redd distribution under 2017 operations and 2024 FRE design and 2025 (O4P2) operations.

	NUMBER OF REDDS OBSERVED IN 201					
	SPRING-RUN CHINOOK SALMON			FALL-RUN CHINOOK SALMON		
RIVER ZONE	O4P2	2017	DIFFERENCE	O4P2	2017	DIFFERENCE
Newaukum River to Rainbow Falls	6	6	0	171	171	0
Rainbow Falls to FRE	30	30	0	428	415	13
Final Evacuation[1]	0	0	0	12	32	-24
Debris Management[1]	0	1	-1	5	26	-21
Initial Evacuation – 2025 Operations[1]	1	0	1	118	90	28
Initial Evacuation – 2017 Operations	0	0	0	6	6	0
Mainstem and Tributaries Upstream	0	0	0	7	7	0

[1] The 2025 and 2017 operations sets have different elevation bands for these three rows because the pool evacuates at different speeds under the two operations sets. The 2025 operations evacuate to a lower elevation faster.

Because the FRE was moved upstream from the originally proposed location, the assignment of the redds to the river zones shifted between 2017 and 2025 operations, resulting in differences in numbers within each zone (Tables 3 and 4). While these numbers are small for some categories, there are notable differences. First, the increase in numbers in the Rainbow Falls to FRE zone shows that 16 redds (across three species) that previously would have been inundated under the 2017 operations would not be inundated under 2025 operations. In addition, even with a catastrophic flood event under 2025 operations, the upper extent of the temporary pool is predicted to be downstream of the 2017 operations Initial Evacuation Zone. Thus, it is highly unlikely that any of the redds within this zone would experience inundation under 2025 operations. Finally, the 2025 operations with faster drainage of the temporary inundation pool results in a reduction in the number of redds in the Debris Management and Final Evacuation zones; these redds are instead in the Initial Evacuation Zone, where the upper extent of the temporary inundation pool varies with flood level. This zone is where understanding the variability in the extent of the inundation pool will help to understand potential impacts.

Under 2017 operations, 78.5% of fall-run Chinook salmon redds were located downstream of the FRE facility and 21.5% were located upstream of the FRE facility (Table 6). Under 2025 (O4P2) operations, 80.2% of fall-run Chinook redds were located downstream of the FRE facility and 19.8% were located upstream of the FRE facility (Table 5). Distribution of coho salmon and steelhead redds between the two alignments did not vary much given that these species generally do not spawn in the mainstem, but in tributaries upstream of the inundation zone (Tables 5 and 6). For all species/runs the proportion of redds within the FRE zones that would be inundated by a catastrophic flood represents less than one fourth of the total redd count; for spring-run Chinook salmon, it is less than 3%.

Table 5

Percentage of total 2018 redds by FRE zone and species under the 2025 (O4P2) operations.

RIVER ZONE	COHO SALMON (N = 540)	FALL-RUN CHINOOK SALMON (N = 747)	SPRING-RUN CHINOOK SALMON (N = 37)	STEELHEAD (N = 440)
Newaukum River to Rainbow Falls	0.0%	22.9%	16.2%	0.4%
Rainbow Falls to FRE	6.9%	57.3%	81.1%	8.8%
Final Evacuation[1]	0.2%	1.6%	0.0%	3.6%
Debris Management[1]	0.2%	0.7%	0.0%	2.9%
Initial Evacuation – 2025 Operations[1]	9.8%	15.8%	2.7%	16.9%
Initial Evacuation – 2017 Operations	5.0%	0.8%	0.0%	4.0%
Mainstem and Tributaries Upstream	78.0%	0.9%	0.0%	63.4%

Table 6

Percentage of total 2018 redds by FRE zone and species under the 2017 (O4P2) operations.

RIVER ZONE	COHO SALMON (N = 540)	FALL-RUN CHINOOK SALMON (N = 747)	SPRING-RUN CHINOOK SALMON (N = 37)	STEELHEAD (N = 440)
Newaukum River to Rainbow Falls	0.0%	22.9%	16.2%	0.4%
Rainbow Falls to FRE	6.5%	55.6%	81.1%	8.6%
Final Evacuation[1]	0.7%	4.3%	0.0%	7.9%
Debris Management[1]	0.9%	3.5%	2.7%	6.1%
Initial Evacuation – 2025 Operations[1]	8.9%	12.0%	0.0%	9.5%
Initial Evacuation – 2017 Operations	5.0%	0.8%	0.0%	4.0%
Mainstem and Tributaries Upstream	78.0%	0.9%	0.0%	63.4%

[1] The 2025 and 2017 operations sets have different elevation bands for these three rows because the pool evacuates at different speeds under the two operations sets. The 2025 operations evacuate to a lower elevation faster.

Redd Viability Across All Modeled Flood Events

Under both alignments, the percentage of redds predicted to be nonviable (inundated at a depth greater than 30 feet and for longer than 3 days) within the maximum pool varied across operational scenarios and across river zones within the pool. By zone, both the broadest range and the largest estimated percent of redds that may suffer inundation mortality occurred in the Initial Evacuation 2017 Operations Zone (Tables 7 and 8). In general, there was no variation in inundation impact to redds across operational years for the Final Evacuation Zone and the Debris Management Zone.

Table 7

Estimated impacts to 2018 redds by species from 2025 (O4P2) operations across all operational years. Percentages represent percent of total observed redds. Number in parentheses represent the total number of redds observed in 2018 for that run or species.

RIVER ZONE	COHO SALMON (N = 540)	FALL-RUN CHINOOK SALMON (N = 747)	SPRING-RUN CHINOOK SALMON (N = 37)	STEELHEAD (N = 440)
Newaukum River to Rainbow Falls	No Risk	No Risk	No Risk	No Risk
Rainbow Falls to FRE	No Risk	No Risk	No Risk	No Risk
Final Evacuation[1]	0.2-0.2%	1.6-1.6%	0.0-0.0%	0.9-0.9%
Debris Management[1]	0.2-0.2%	0.7-0.7%	0.0-0.0%	0.5-0.5%
Initial Evacuation – 2025 Operations[1]	0.0-1.5%	0.0-5.5%	0.0-2.7%	0.0-6.6%
Initial Evacuation – 2017 Operations	0.0-0.0%	0.0-0.0%	0.0-0.0%	0.0-0.0%
Mainstem and Tributaries Upstream	No Risk	No Risk	No Risk	No Risk

[1] The 2025 and 2017 operations sets have different elevation bands for these three rows because the pool evacuates at different speeds under the two operations sets. The 2025 operations evacuate to a lower elevation faster.

Table 8

Range of estimated impacts to 2018 redds by species from 2017 operations across all operational years. Percentages represent minimum and maximum percent of total observed redds. Number in parentheses represent the total number of redds observed in 2018 for that run or species.

RIVER ZONE	COHO SALMON (N = 540)	FALL-RUN CHINOOK SALMON (N = 747)	SPRING-RUN CHINOOK SALMON (N = 37)	STEELHEAD (N = 440)
Newaukum River to Rainbow Falls	No Risk	No Risk	No Risk	No Risk
Rainbow Falls to FRE	No Risk	No Risk	No Risk	No Risk
Final Evacuation[1]	0.4-0.4%	2.5-2.5%	0.0-0.0%	1.6-1.6%
Debris Management[1]	0.0-0.9%	0.1-3.5%	0.0-2.7%	0.2-3.4%
Initial Evacuation – 2025 Operations[1]	0.0-1.3%	0.0-5.6%	0.0-0.0%	0.0-4.3%
Initial Evacuation – 2017 Operations	0.0-0.0%	0.0-0.0%	0.0-0.0%	0.0-0.0%
Mainstem and Tributaries Upstream	No Risk	No Risk	No Risk	No Risk

[1] The 2025 and 2017 operations sets have different elevation bands for these three rows because the pool evacuates at different speeds under the two operations sets. The 2025 operations evacuate to a lower elevation faster.

Redd Viability with a Catastrophic Flood Event

During a catastrophic flood event (e.g., 1996) under 2017 operations, Kleinschmidt estimated that 11.6% of 2018 fall-run Chinook salmon redds would not be viable if the inundation event occurred prior to emergence. This percentage was reduced under 2025 operations to 7.8% (Table 9). The percentage of nonviable redds would also be reduced from 2.9% to 1.9% for coho salmon and from 9.3% to 7.8% for steelhead (Table 9). However, HDR's modeling of future floods across a 56-year period of record predicted that FRE facility operation would occur, on average, less than 1 day in March and less than 4 hours in April. Thus, it would be expected that the vast majority of Project operations would occur prior

to steelhead spawning in the upper basin and inundation of steelhead redds would likely be closer to 0%.

Table 9
Catastrophic flood event (e.g., 1996) impacts to 2018 redds under 2025 (O4P2) operations. Percentages represent percent of total observed redds.

RIVER ZONE	COHO SALMON (N = 540)	FALL-RUN CHINOOK SALMON (N = 747)	SPRING-RUN CHINOOK SALMON (N = 37)	STEELHEAD (N = 440)
Newaukum River to Rainbow Falls	No Risk	No Risk	No Risk	No Risk
Rainbow Falls to FRE	No Risk	No Risk	No Risk	No Risk
Final Evacuation[1]	0.2%	1.6%	0.0%	0.9%
Debris Management[1]	0.2%	0.7%	0.0%	0.5%
Initial Evacuation – 2025 Operations[1]	1.5%	5.5%	2.7%	6.4%
Initial Evacuation – 2017 Operations	0.0-0.0%	0.0-0.0%	0.0-0.0%	0.0-0.0%
Mainstem and Tributaries Upstream	No Risk	No Risk	No Risk	No Risk

[1] The 2025 and 2017 operations sets have different elevation bands for these three rows because the pool evacuates at different speeds under the two operations sets. The 2025 operations evacuate to a lower elevation faster.

Redd Viability with a Major Flood Event[2]

Under 2025 (O4P2) operations the redd viability impact from the two major floods analyzed was much less than estimated for the catastrophic flood. The percentage of nonviable redds from a flood operation similar to 2019 was estimated at 3.2% of fall-run Chinook salmon, 0.4% of coho salmon, and 1.9% of steelhead (Table 10). Zero spring-run Chinook salmon redds were estimated to be nonviable. Operation during a flood similar to 2022 was estimated to result in 6% of fall-run Chinook salmon redds, 1.3% of coho salmon redds, 2.7% of spring-run Chinook salmon redds, and 5% of steelhead redds becoming nonviable (Table 11). Once again, the steelhead estimate is likely further reduced by the very small likelihood of FRE operation after the onset of steelhead spawning.

The differences in redd inundation presented are a function of differences in the maximum extent and depths of the temporary pool between the 1996 catastrophic and major floods (2019 or 2022) events. Figures 6 through 21 provided at the end of this technical memorandum depict how changes in area of the maximum temporary pool and the nonviable redd area would change under the Maximum, Median, and Minimum modeled flood levels, and provide a visualization of variation in redd inundation given the viability criteria developed for this analysis. For coho salmon, fall-run Chinook salmon, and steelhead, these map figures are presented in the same sequence beginning with the 2018 redd distribution followed by redds under the Maximum, Median, and Minimum modeled flood events. Only a 2018 redd

[2] This section discusses results only under 2025 (O4P2) operations, rather than comparing 2025 operations to 2017 operations, because the 2017 operations do not address specific flood years; they instead address floods at different recurrence intervals. A direct comparison of the two sets is possible only for the catastrophic flood, since the 1996 flood was almost exactly equal to a 100-year recurrence flood under current conditions.

distribution map was included for spring-run Chinook salmon as only one redd was observed upstream of Crim Creek in 2018.

Table 10

Impacts to redds with major, 2019-type, flood under 2025 (O4P2) operations. Percentages represent percent of total observed redds.

RIVER ZONE	COHO SALMON (N = 540)	FALL-RUN CHINOOK SALMON (N = 747)	SPRING-RUN CHINOOK SALMON (N = 37)	STEELHEAD (N = 440)
Newaukum River to Rainbow Falls	No Risk	No Risk	No Risk	No Risk
Rainbow Falls to FRE	No Risk	No Risk	No Risk	No Risk
Final Evacuation[1]	0.2%	1.6%	0.0%	0.9%
Debris Management[1]	0.2%	0.7%	0.0%	0.5%
Initial Evacuation – 2025 Operations[1]	0.0%	0.9%	0.0%	0.5%
Initial Evacuation – 2017 Operations	0.0-0.0%	0.0-0.0%	0.0-0.0%	0.0-0.0%
Mainstem and Tributaries Upstream	No Risk	No Risk	No Risk	No Risk

[1] The 2025 and 2017 operations sets have different elevation bands for these three rows because the pool evacuates at different speeds under the two operations sets. The 2025 operations evacuate to a lower elevation faster.

Table 11

Impacts to redds with a major, 2022 type, flood, under 2025 (O4P2) operations. Percentages represent percent of total observed redds.

RIVER ZONE	COHO SALMON (N = 540)	FALL-RUN CHINOOK SALMON (N = 747)	SPRING-RUN CHINOOK SALMON (N = 37)	STEELHEAD (N = 440)
Newaukum River to Rainbow Falls	No Risk	No Risk	No Risk	No Risk
Rainbow Falls to FRE	No Risk	No Risk	No Risk	No Risk
Final Evacuation[1]	0.2%	1.6%	0.0%	0.9%
Debris Management[1]	0.2%	0.7%	0.0%	0.5%
Initial Evacuation – 2025 Operations[1]	0.9%	3.7%	2.7%	3.6%
Initial Evacuation – 2017 Operations	0.0-0.0%	0.0-0.0%	0.0-0.0%	0.0-0.0%
Mainstem and Tributaries Upstream	No Risk	No Risk	No Risk	No Risk

[1] The 2025 and 2017 operations sets have different elevation bands for these three rows because the pool evacuates at different speeds under the two operations sets. The 2025 operations evacuate to a lower elevation faster.

Vegetation

Under the 2017 operational scenario, vegetation impacts were modeled for a catastrophic flood condition similar to the 2007 flood event. This flood event would have inundated 3.9 RMs for longer than 7 days, causing riparian vegetation mortality (Table 12). During a major flood event similar to 2015, inundation longer than 7 days would have occurred over 2.8 RMs. The 2024 Project design and 2025 (O4P2) operations model have reduced the extent of this inundation. Under the 2025 operations, a catastrophic flood (2007) would inundate 3.5 RMs for longer than 7 days, a reduction of 0.4 RMs. During

a major flood (2015), inundation longer than 7 days would be limited to 1.8 miles (Table 12, Figure 5), a reduction of 1.0 RM. These results indicate an additional 0.4 to 2.1 miles of riparian forest that will remain viable, producing shade and exhibiting additional growth as compared to the 2017 design and operations. The riparian forest range exceeds the RM range because the trees grow on both sides of the pool (Figure 5).

Table 12
Extent of the vegetation mortality under 2007- and 2015-type flood event under 2025 (O4P2) and 2017 operations.

OPERATIONS MODEL	YEAR	CHANCE OF BEING FLOODED IN A YEAR (%)	MIN DURATION OF INUNDATION AT UPSTREAM EXTENT (DAYS)	WATER SURFACE ELEVATION (FEET)	AREA (ACRES)	RIVER LENGTH (MILES)
2017	NA[1]	10	7 days	521	218.1	2.8
	2007	<1	7 days	543	336.5	3.9
O4P2	2015	10	7 days	487	85.3	1.8
	2007	<1	7 days	532	275.7	3.5

[1] The 2017 operations modeled the 10-year flood, based on recurrence interval, not a flood event associated with a specific year; however, the 2007 was identified as a catastrophic flood.

This increased tree viability and the associated reduction of potential loss of shade have important implications for evaluating the shade-related temperature impacts of the refined Project design and operations. The result of this analysis were used to estimate changes to canopy height along the affected reaches of the inundation pool. These data were input into a water temperature model of the refined project that is presented as a separate attachment to the main body of this document. Beyond these temperature effects, the additional acreage that remains viable under 2025 (O4P2) operations will reduce wildlife habitat impacts due to vegetation mortality and reduce erosion and landslide potential.

Conclusion

HDR produced a 2025 (O4P2) operations rule set that would inundate less area than the original 2017 operations and would drain the temporary inundation pool faster. This operational refinement reduces impacts to redds and minimizes vegetation mortality, thus reducing shade impacts.

When the most comprehensive redd survey data available (2018) was analyzed with respect to 2025 operations, it was evident that less than a quarter of each species' redds was located within the temporary inundation pool. The 2025 operations improved upon the 2017 operations in two ways. First, the 2025 operations would not inundate a portion of the redds that would have been inundated under 2017 operations. Second, for those redds that would still be inundated, more would be in the Initial Evacuation Zone that drains faster, making those redds less likely to be inundated at harmful levels.

The reduction in inundation area and duration would also reduce vegetation mortality. The area inundated for longer than 7 days was reduced by 0.4 RMs in a catastrophic flood (about 10%) and about 1.0 RM in a major flood (about 64%). This corresponds to between 0.4 and 2.1 miles of riparian forest that will remain viable, which under 2017 operations would not have survived. This increased tree viability will result in a taller canopy and increased shade, the temperature effects of which are modeled in a separate accompanying technical memorandum, and will reduce wildlife habitat impacts and erosion and landslide risk.

Figure 5
Extent of inundation upstream of the FRE under 2025 (O4P2) operations.

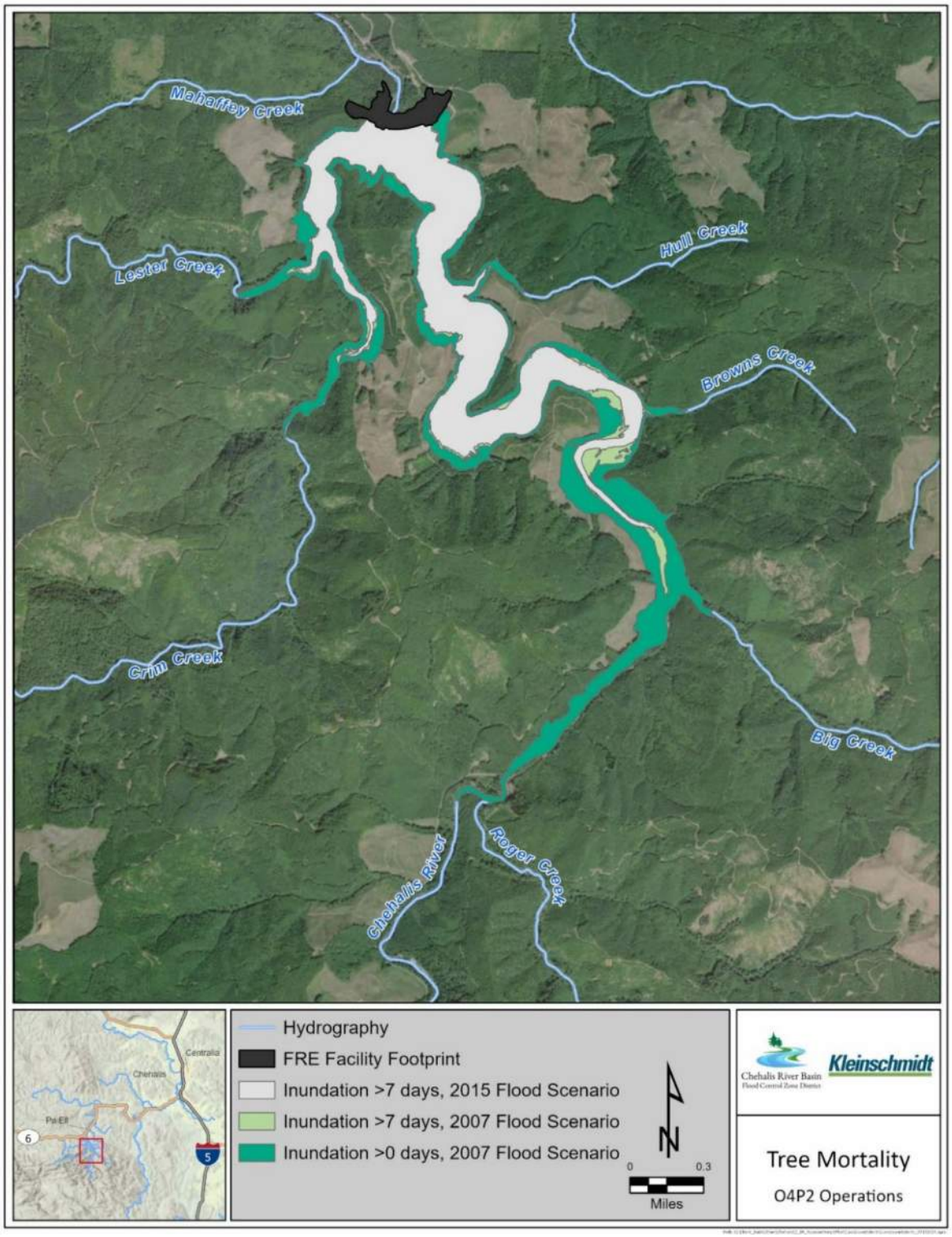


Figure 6
Distribution of 2018 coho salmon redds in the mainstem Chehalis River from the confluence of the Newaukum River upstream to the Forks and including tributaries upstream of Crim Creek.

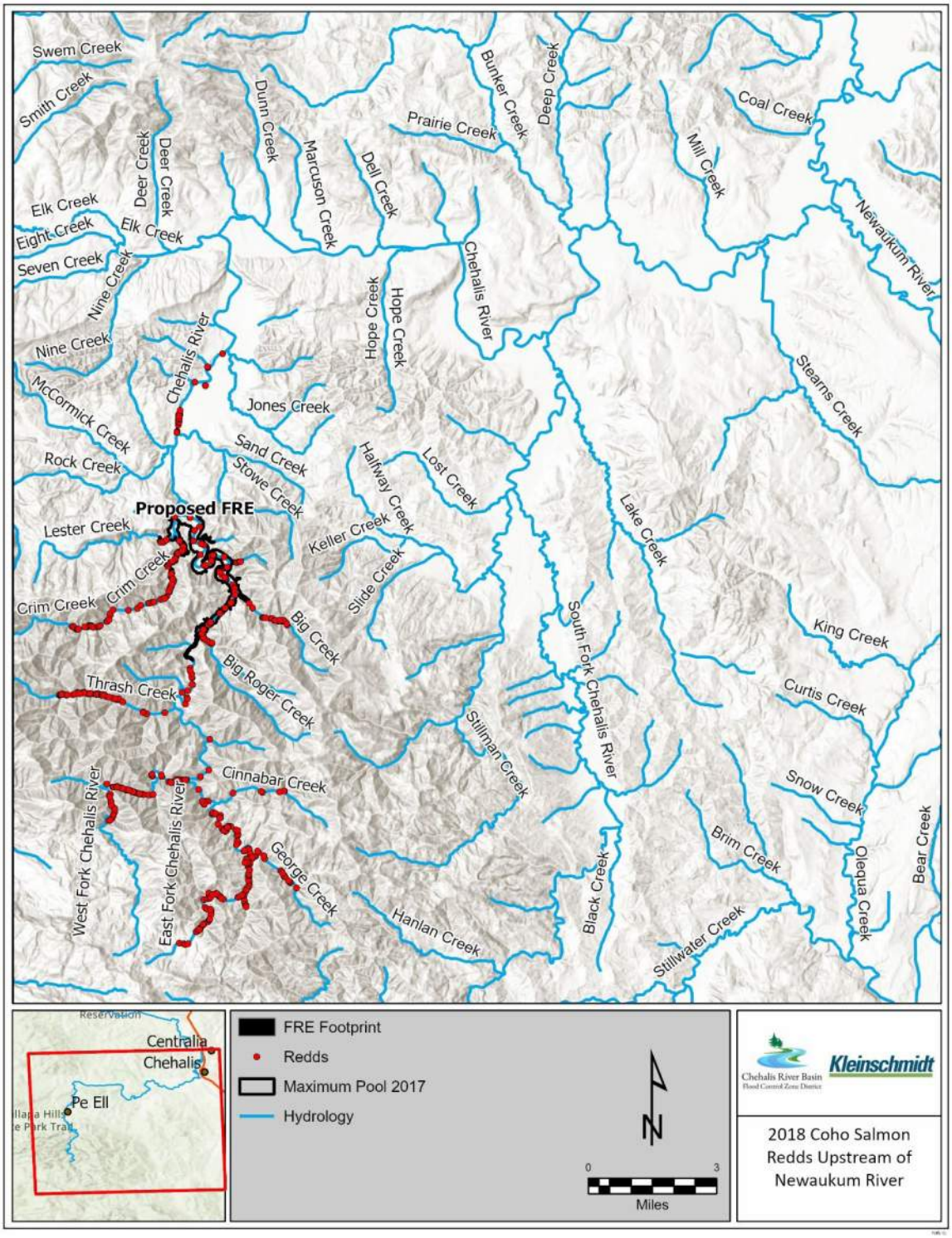


Figure 7
2018 coho salmon redd distribution upstream and immediately downstream of the FRE facility location.

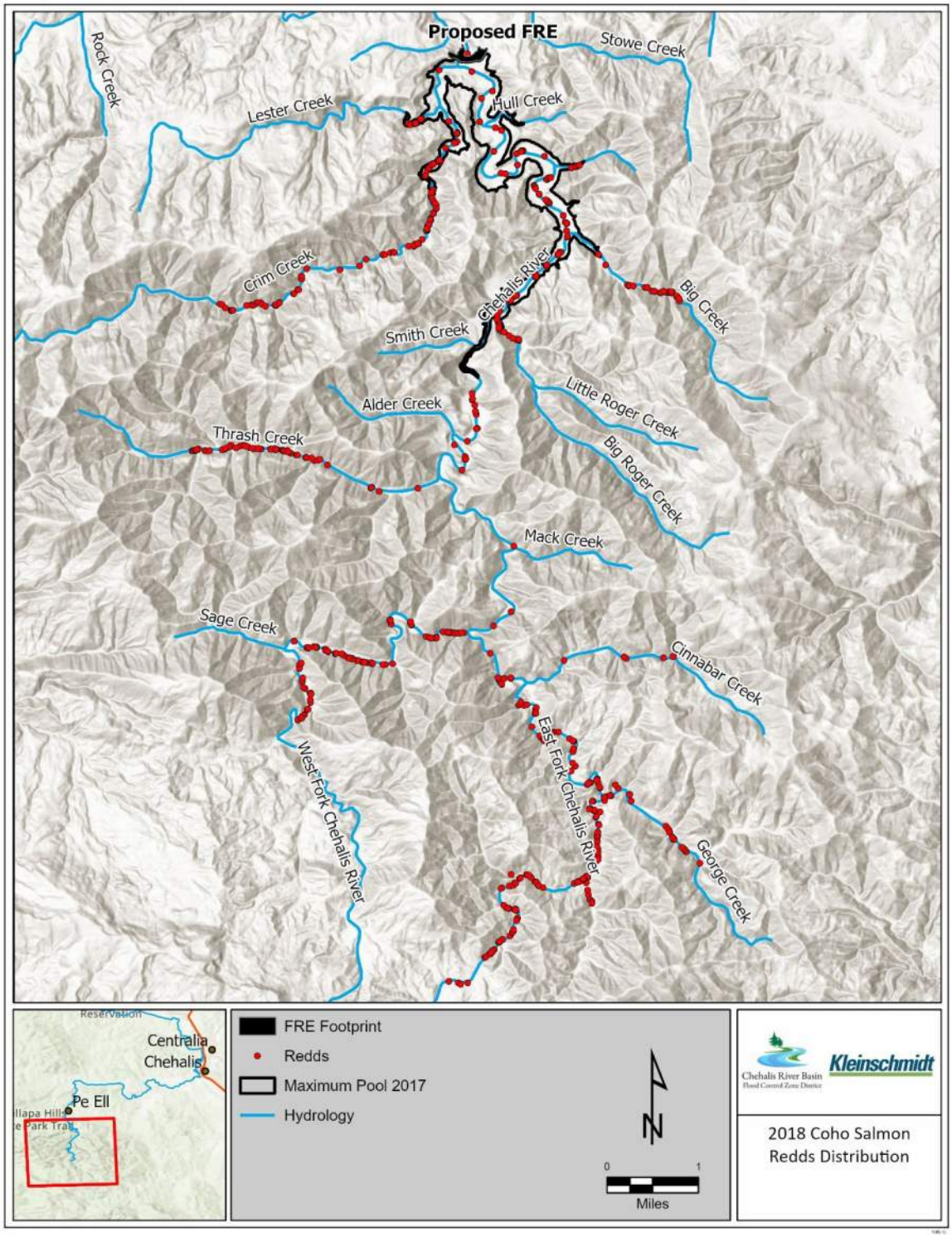


Figure 8
2018 coho salmon redds across portions of the temporary pool less than or greater than 30 feet deep for 3 days with a maximum flood event.

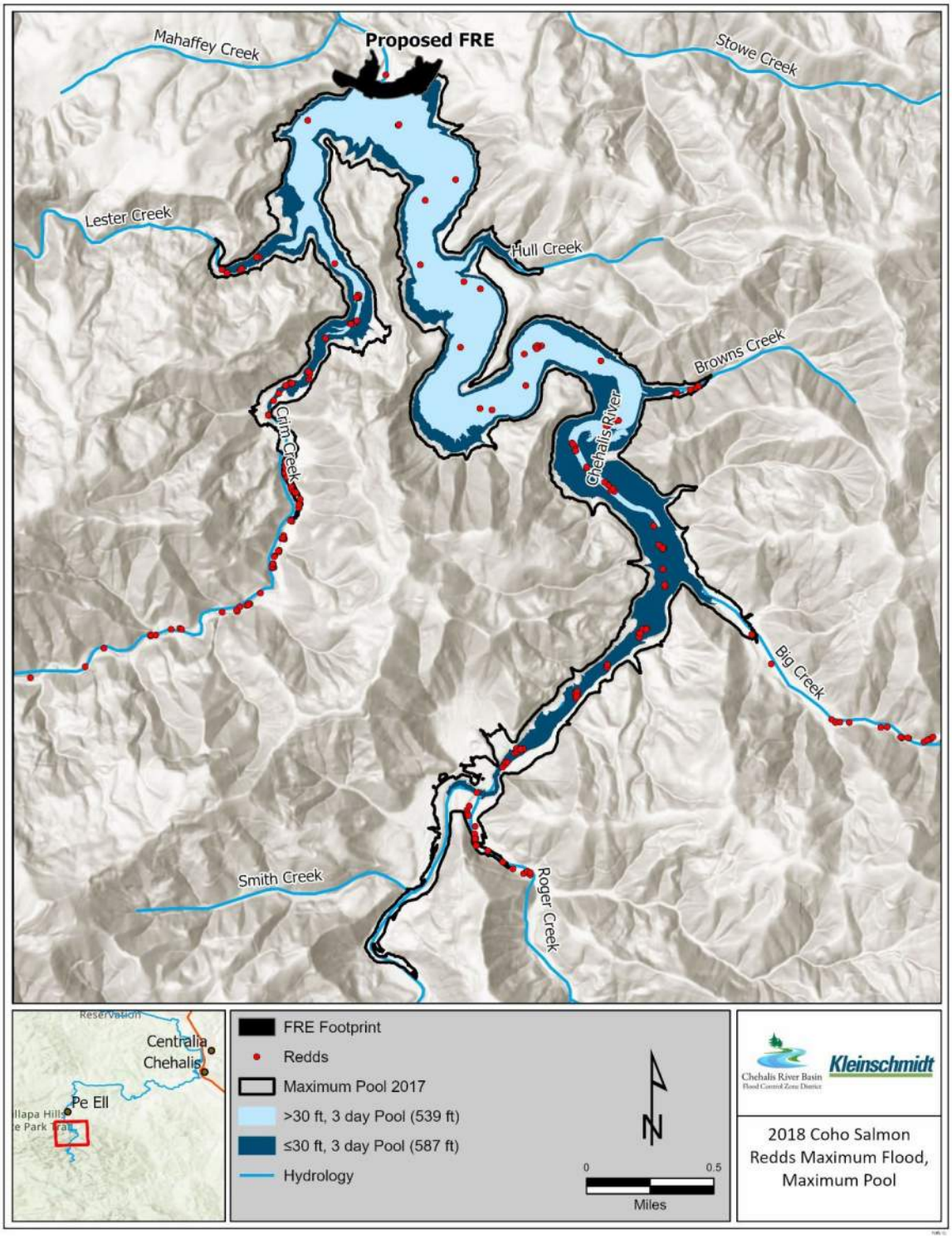


Figure 9
2018 coho salmon redds across portions of the temporary less than or greater than 30 feet deep for 3 days with a median flood event.

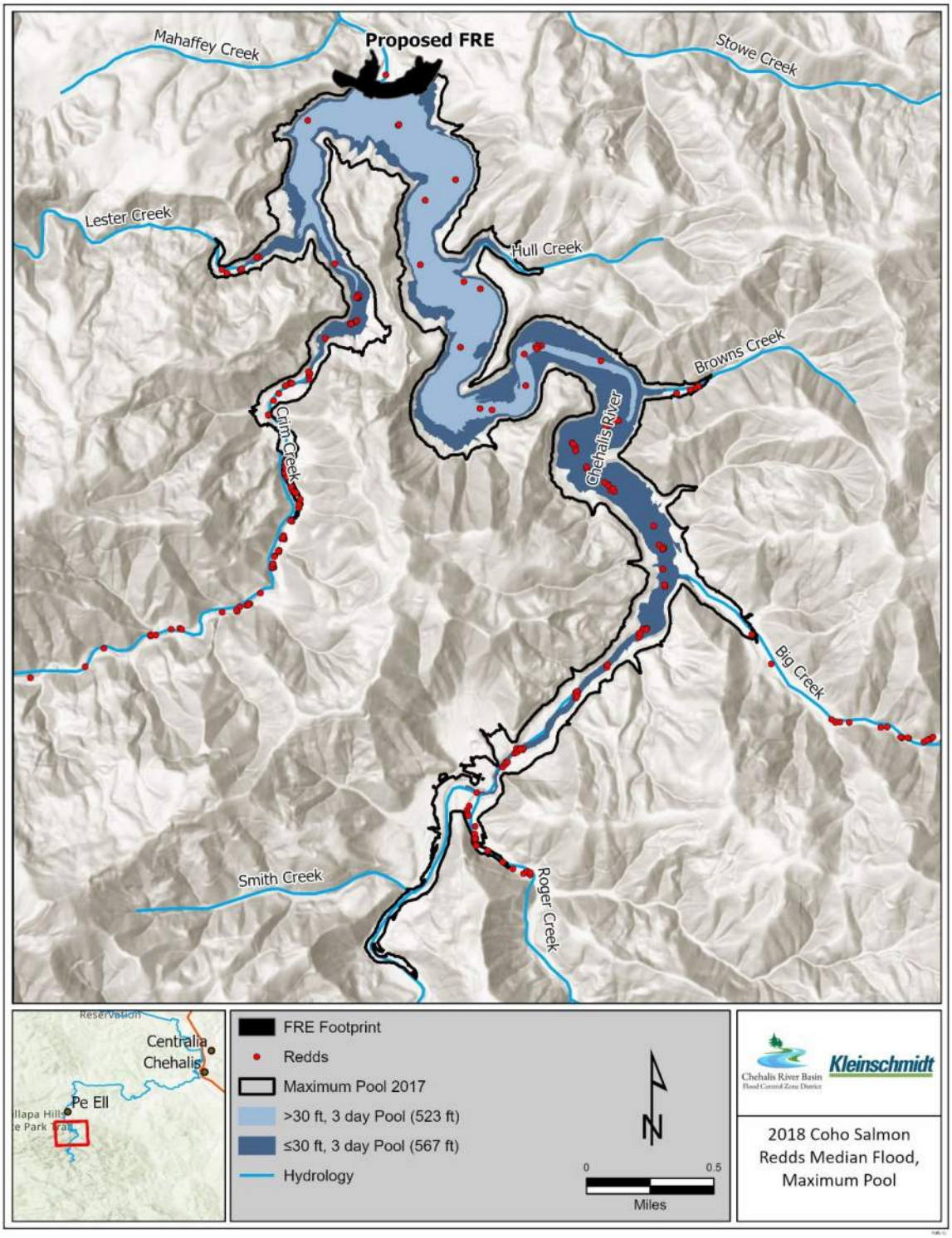


Figure 10
2018 coho salmon redds across portions of the temporary pool less than or greater than 30 feet deep for 3 days with a minimum flood event.

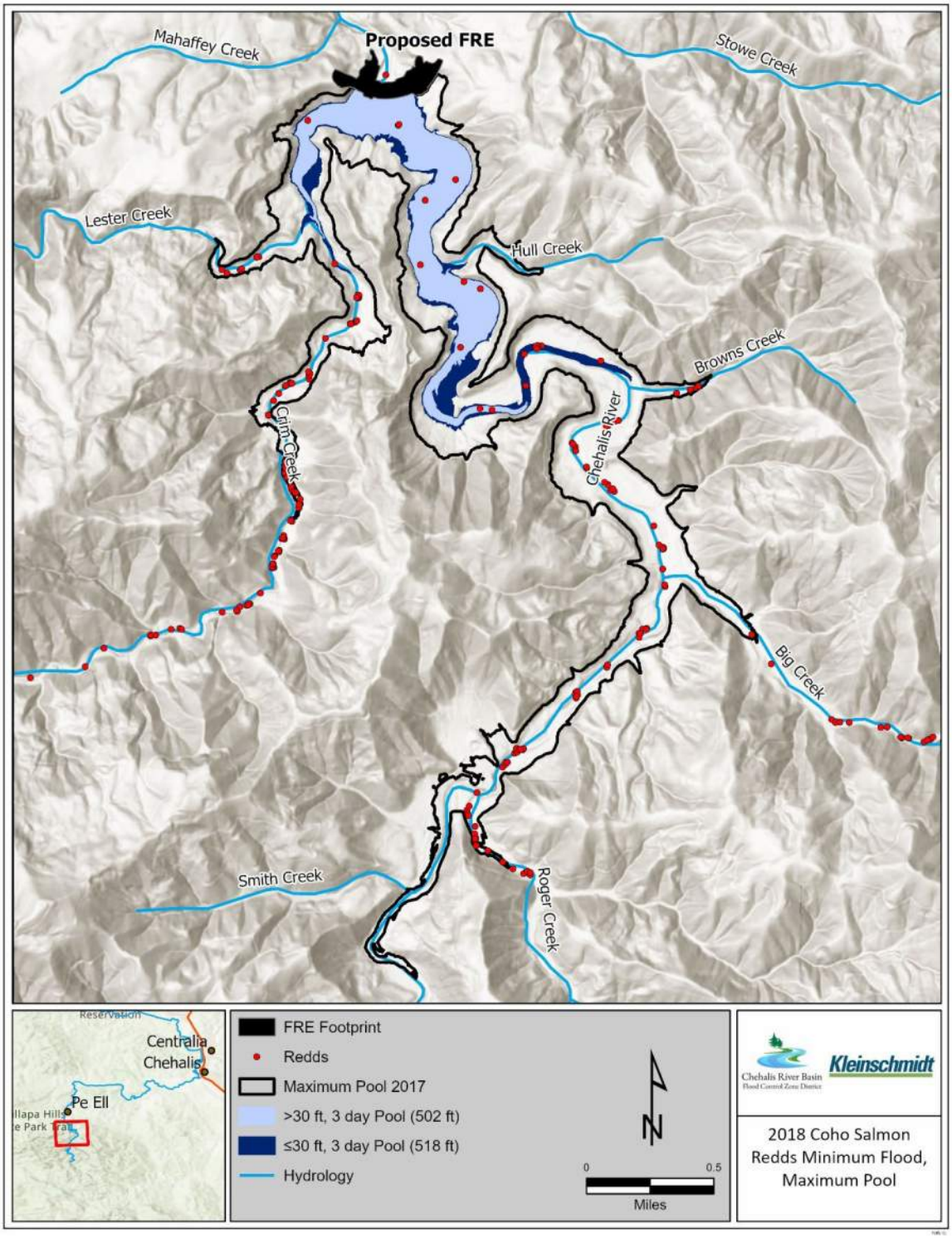


Figure 11
Distribution of 2018 fall-run Chinook salmon redds in the mainstem Chehalis River from the confluence of the Newaukum River upstream to the Forks and including tributaries upstream of Crim Creek.

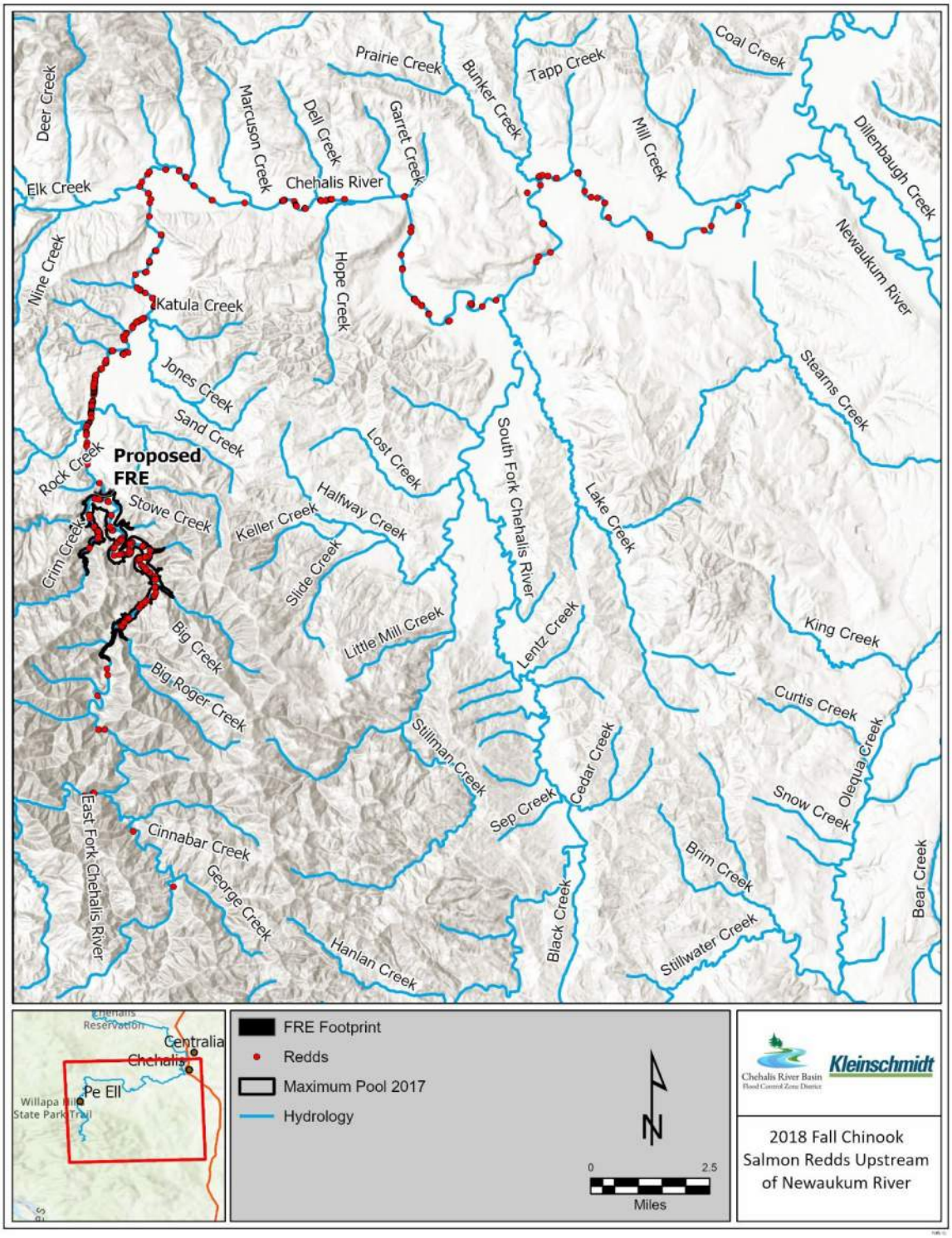


Figure 12
2018 fall-run Chinook salmon redd distribution upstream and immediately downstream of the FRE facility location.

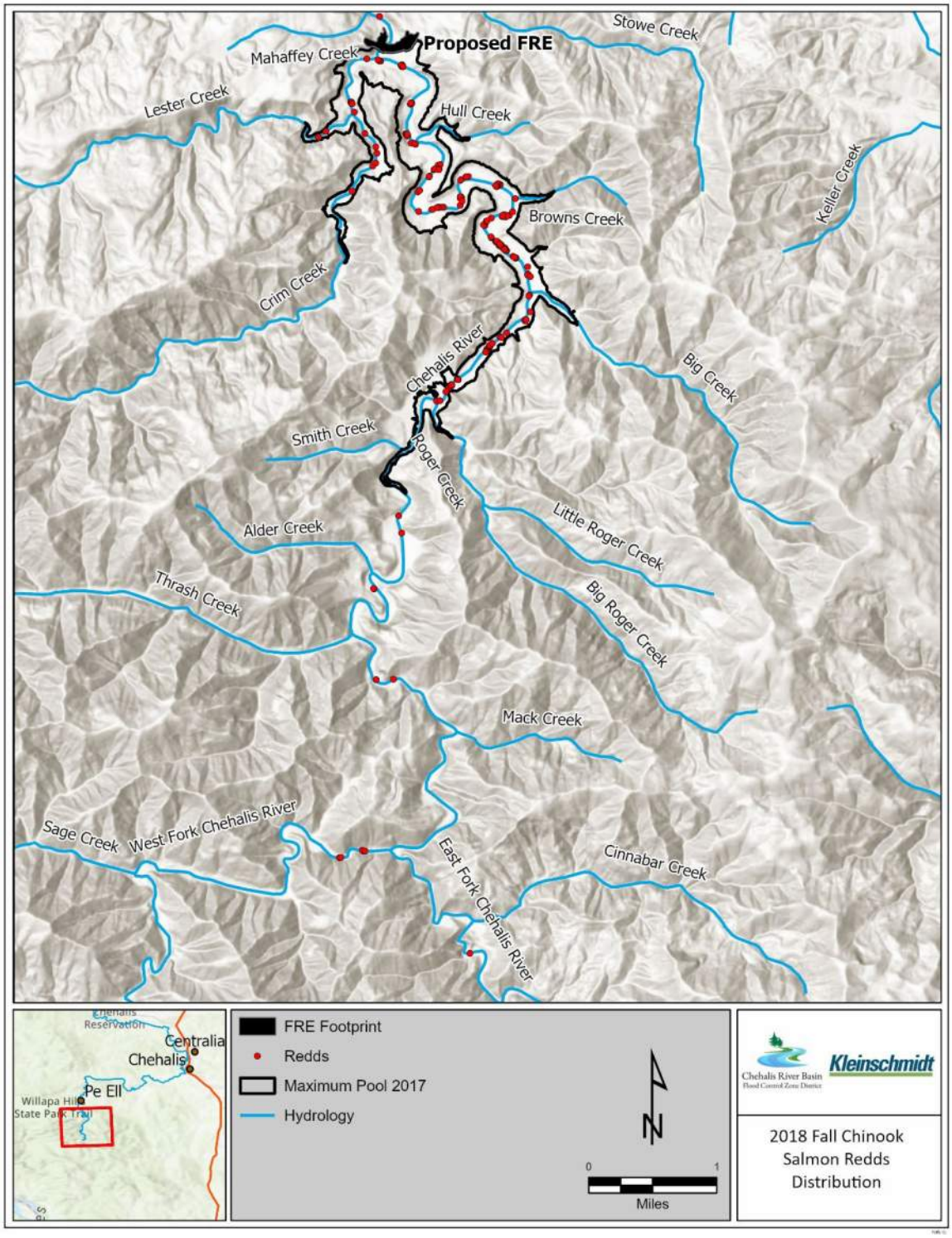


Figure 13
2018 fall-run Chinook salmon redds across portions of the temporary pool less than or greater than 30 feet deep for 3 days with a maximum flood event.

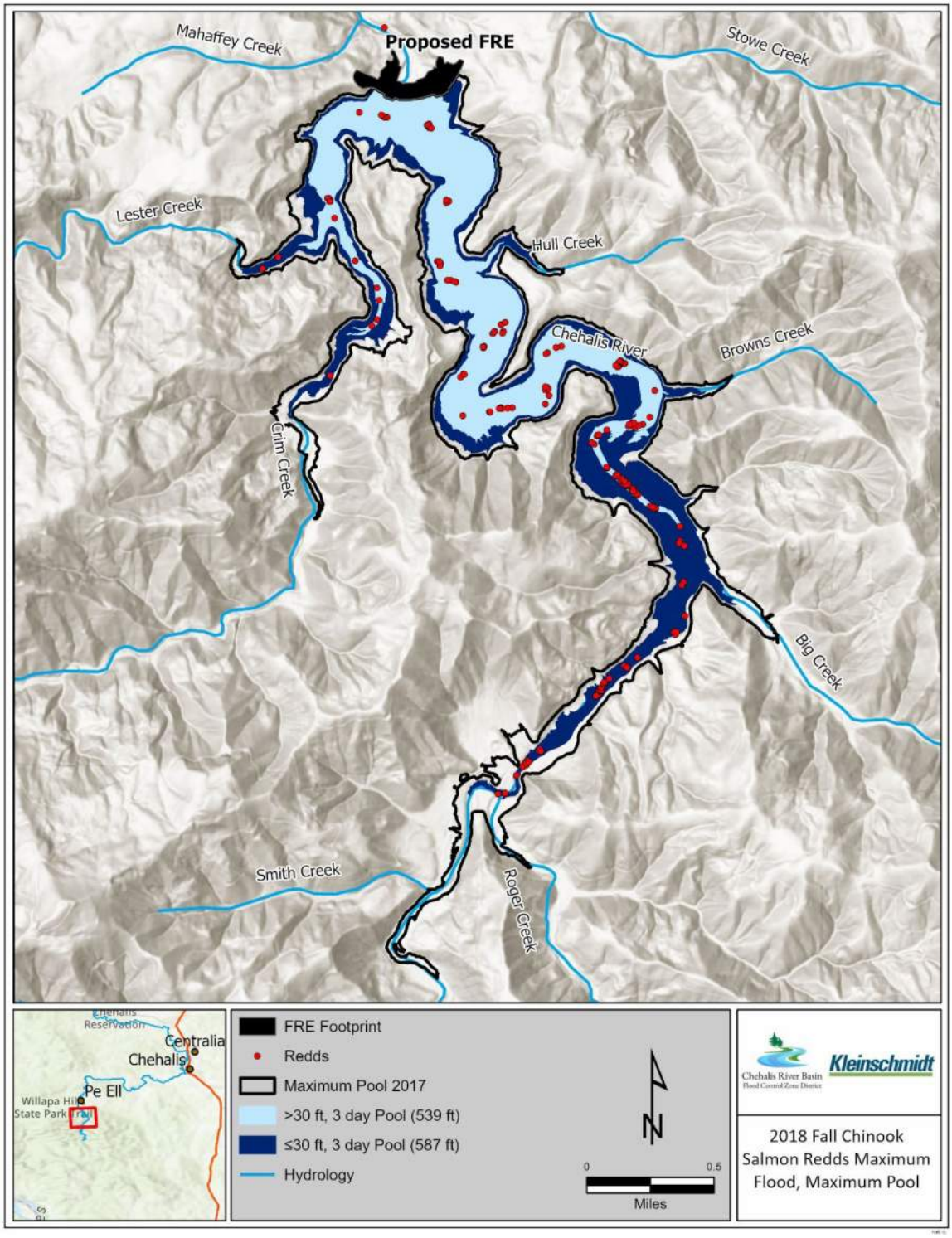


Figure 14
2018 fall-run Chinook salmon redds across portions of the temporary pool less than or greater than 30 feet deep for 3 days with a median flood event.

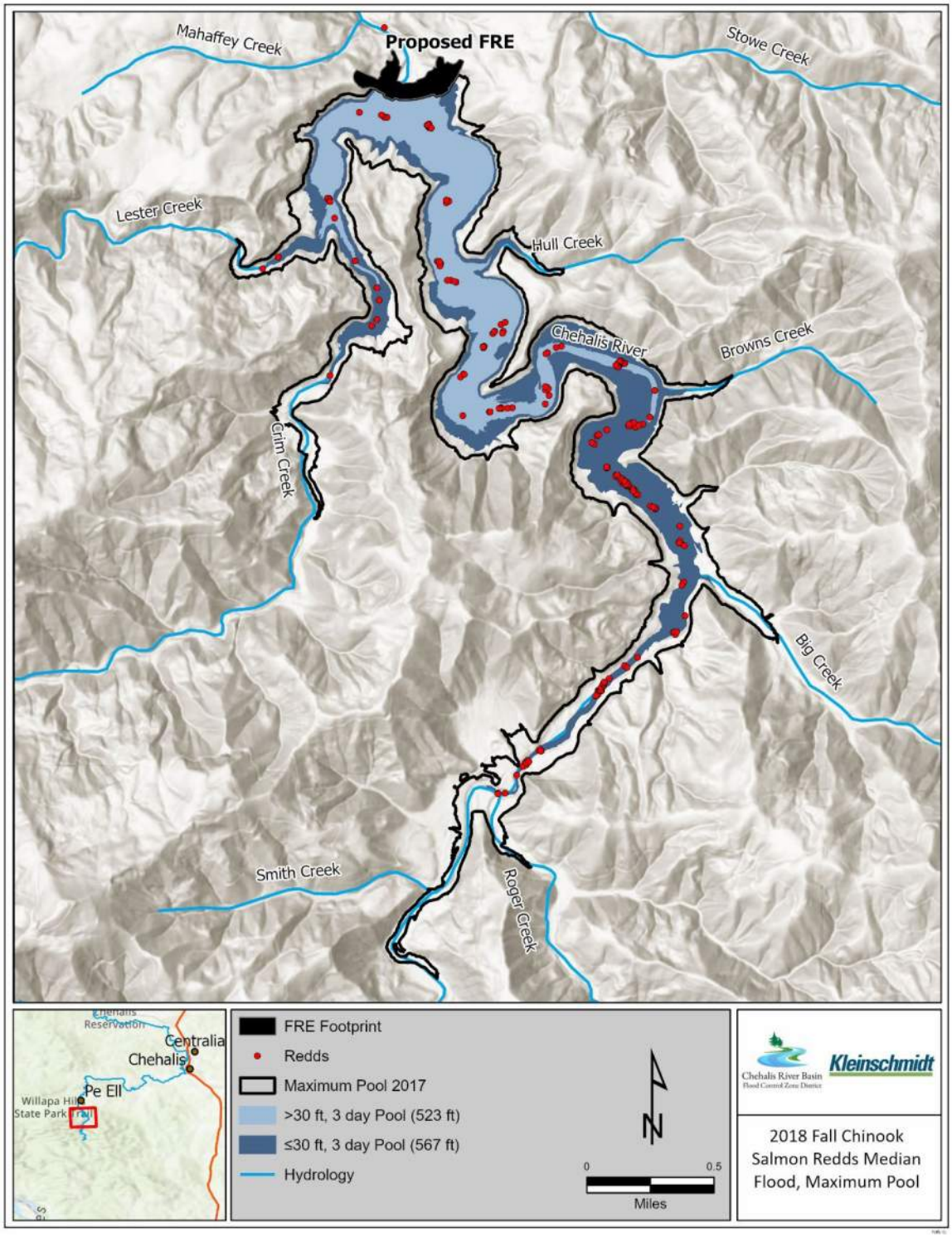


Figure 15
2018 fall-run Chinook salmon redds across portions of the temporary pool less than or greater than 30 feet deep for 3 days with a minimum flood event.

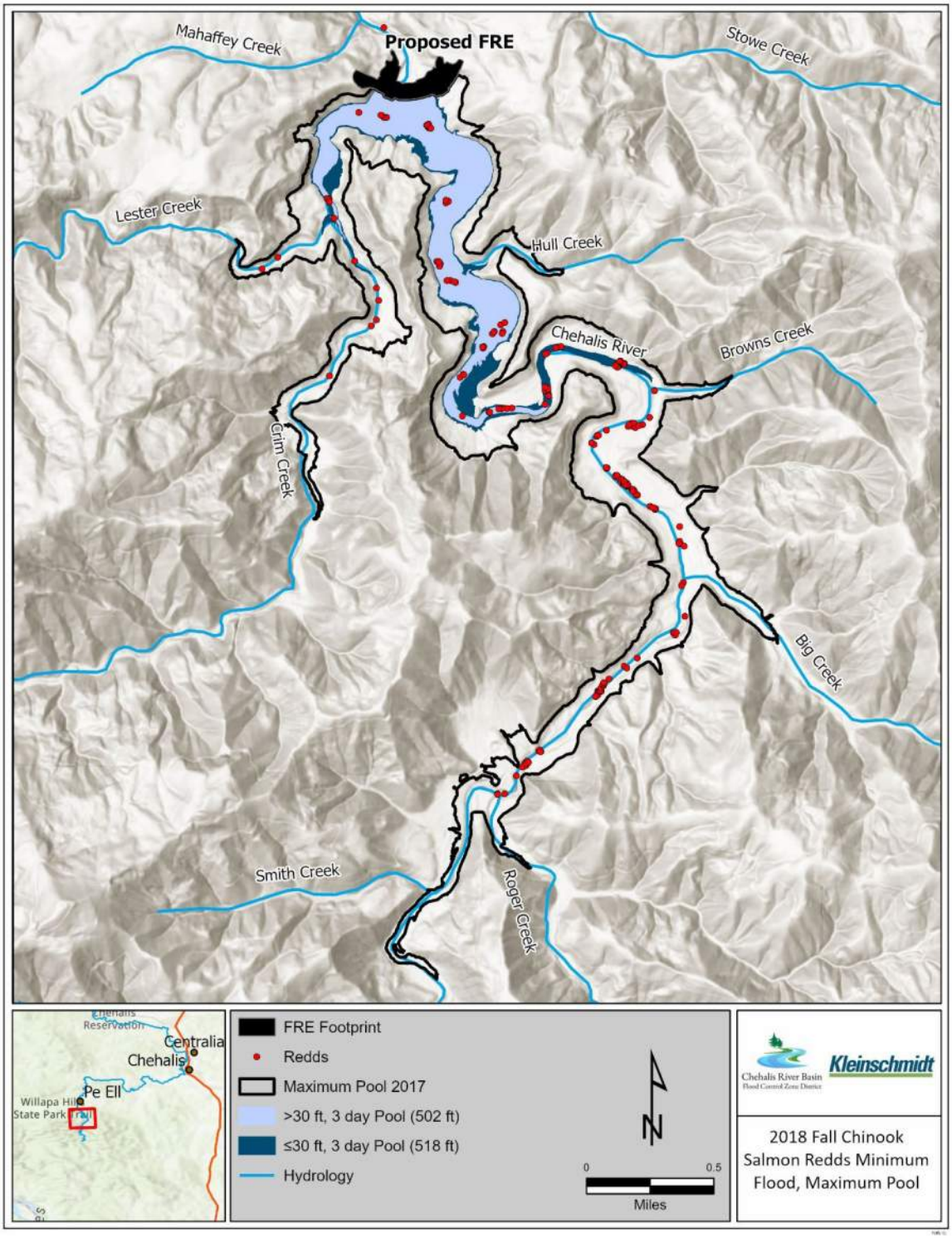


Figure 16
Distribution of 2019 steelhead redds in the mainstem Chehalis River from the confluence of the Newaukum River upstream to the Forks and including tributaries upstream of Crim Creek.

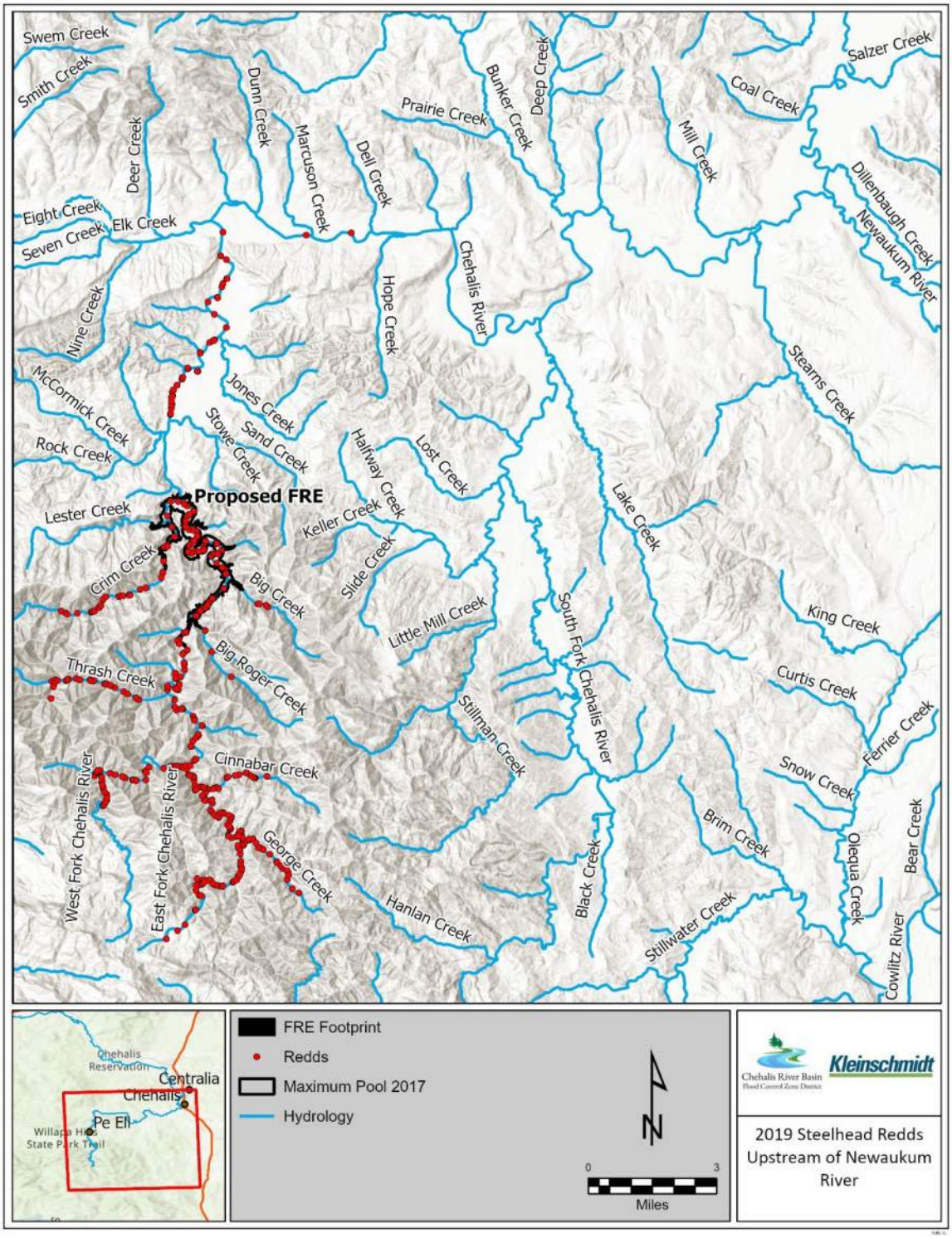


Figure 17
2019 steelhead redd distribution upstream of the FRE facility location.

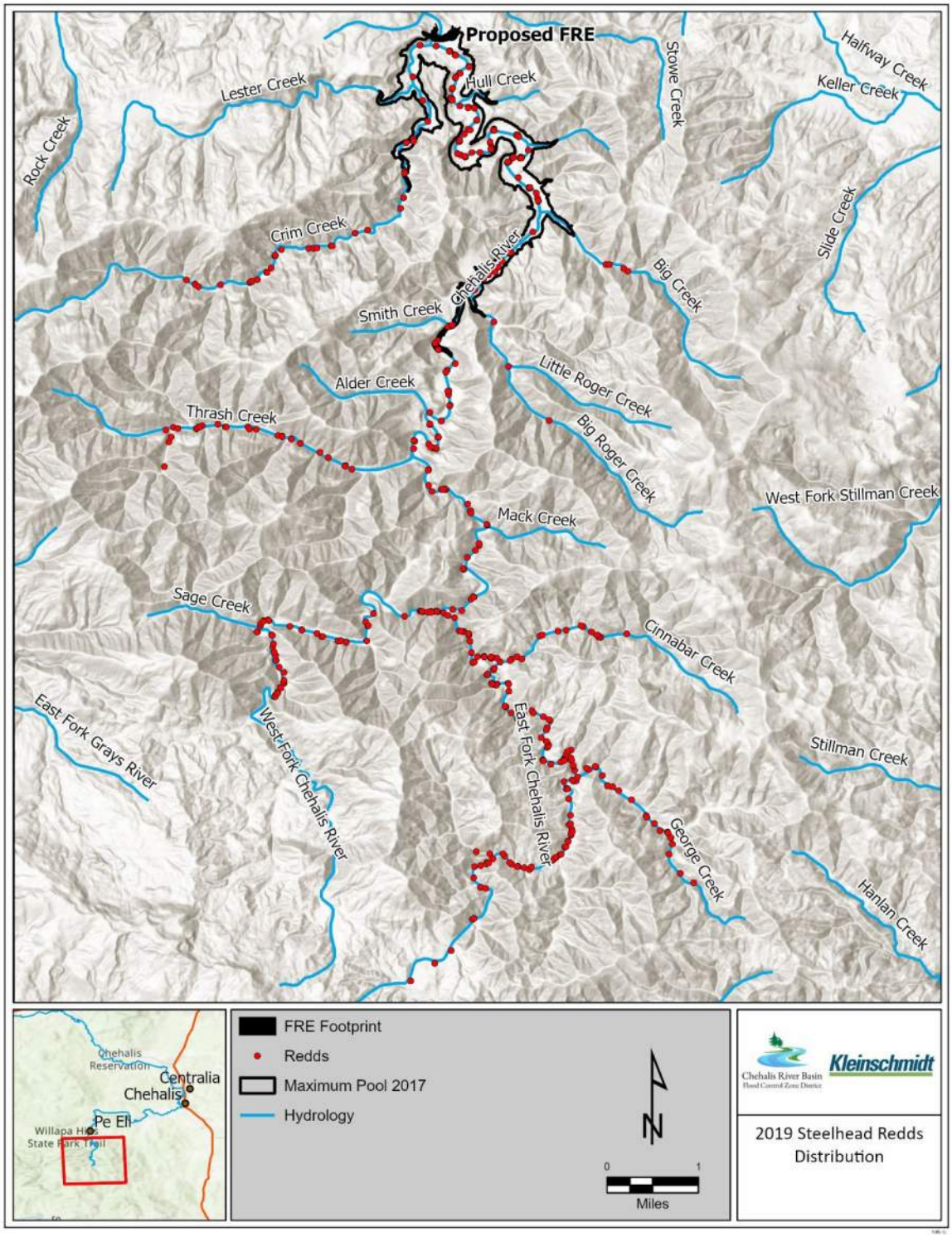


Figure 18
2019 steelhead redds across portions of the temporary pool less than or greater than 30 feet deep for 3 days with a maximum flood event.

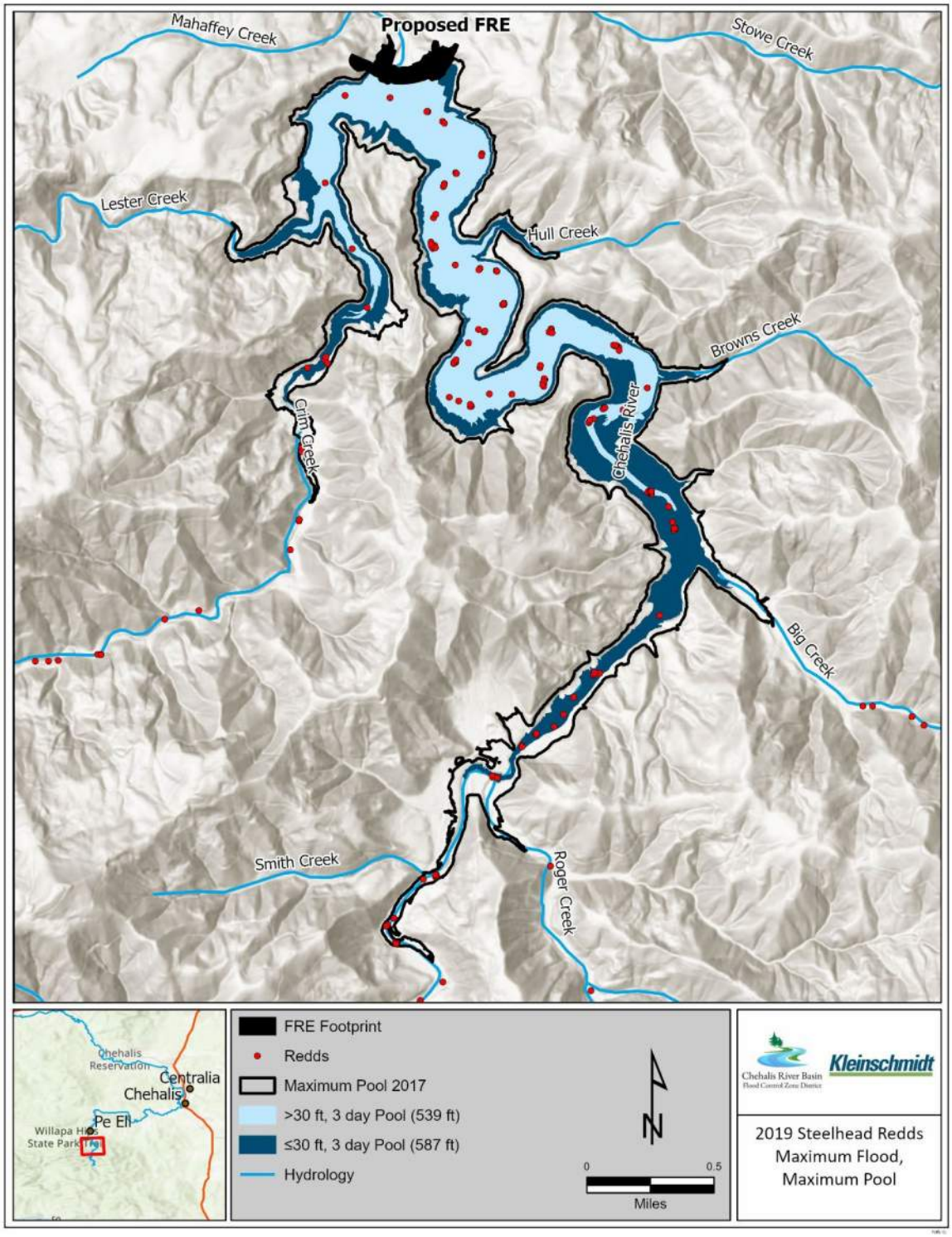


Figure 19
2019 steelhead redds across portions of the temporary pool less than or greater than 30 feet deep for 3 days with a median flood event.

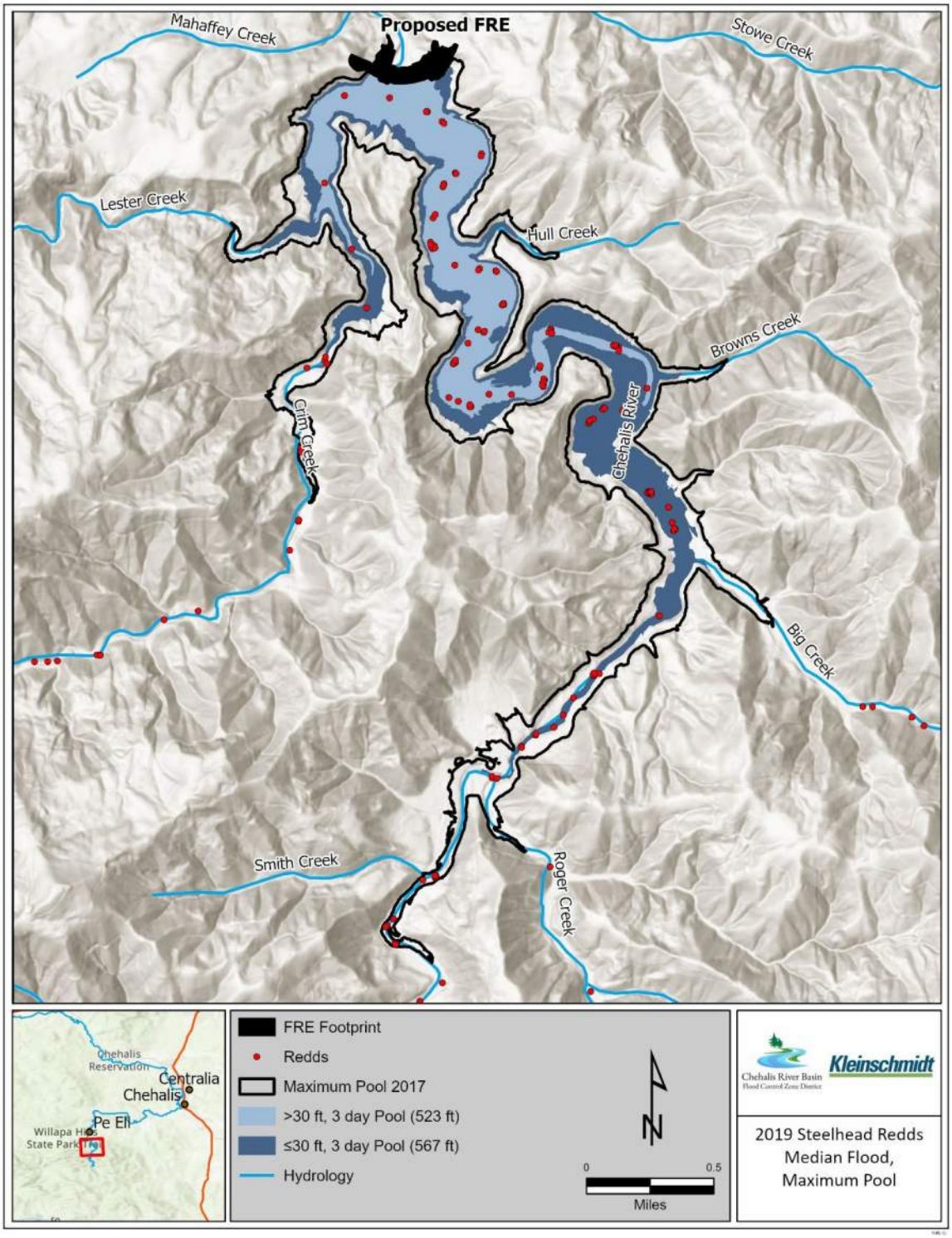


Figure 20
2019 steelhead redds across portions of the temporary pool less than or greater than 30 feet deep for 3 days with a minimum flood event.

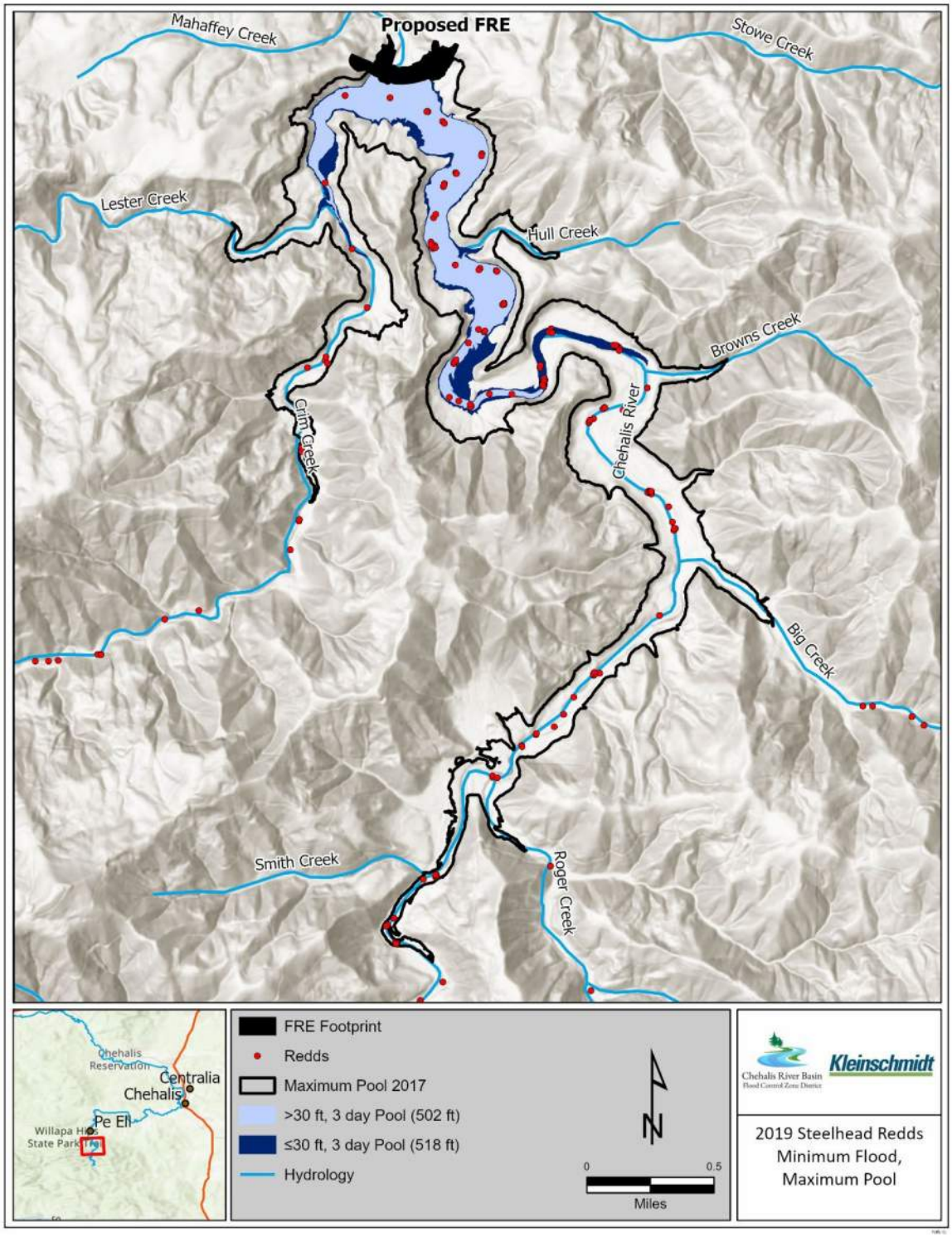
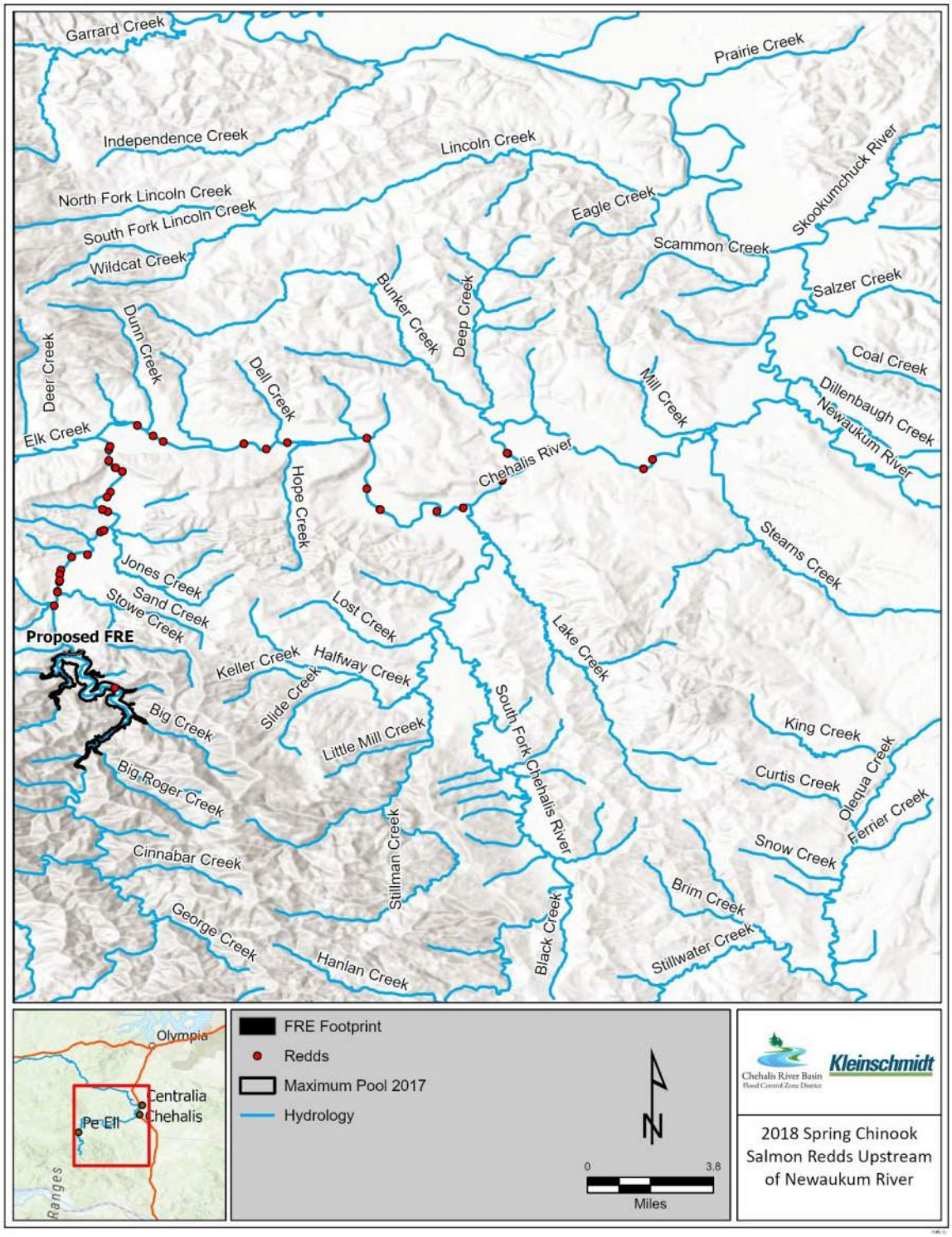


Figure 21
Distribution of 2018 spring-run Chinook salmon redds in the mainstem Chehalis River from the confluence of the Newaukum River upstream to the Forks and including tributaries upstream of Crim Creek.



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Attachment 4 – Temperature Technical Memorandum

TECHNICAL MEMORANDUM

Date: February 2, 2026
To: Kathy Burnamen, Chehalis River Basin Flood Control Zone District
From: Kai Steimle and MaryLouise Keefe, PhD, Kleinschmidt Associates
Cc: Jason Kent, PE, PMP, Kleinschmidt Associates
Re: Riparian Shade Temperature Model with 2024 Project Design and 2025 (O4P2) Operations

Introduction

Background

The Chehalis River Basin Flood Control Zone District (District) is proposing to construct a Flood Retention Expandable (FRE) facility to reduce the risk of flood damage along the mainstem Chehalis River (Figure 1). The primary purpose of the FRE facility is to reduce flooding coming from the Willapa Hills by storing floodwaters in the temporary inundation pool during major or greater floods. Thus, the FRE facility will include a temporary inundation pool that is only inundated during infrequent flood operations.

State and Federal environmental reviews of the FRE facility (Ecology 2020, 2025; Corps 2020) have determined that by temporarily storing peak flows during major flood events, operating the FRE facility would alter riparian vegetation and thereby impact riparian shade. This, in turn, was hypothesized to negatively impact water temperatures based on results from a water quality model that was refined in 2025 (PSU 2025). Due in part to the projected increases in water temperature, the environmental reviews determined that the Chehalis River Basin Flood Damage Reduction Project (Project) will have significant impacts on aquatic resources and anadromous salmonids (Ecology 2020, 2025; Corps 2020). Based on the 2025 water quality model, Ecology predicted impacts of 0.3 °C or greater downstream to approximately river mile (RM) 94.9 (downstream of Dryad, Washington) (Ecology 2025). The District's Revised Mitigation Plan (RMP; Kleinschmidt 2024a) proposed shade rehabilitation to offset potential shade loss and associated water temperature impacts. The potential for effective shade cooling is related to the interception of solar input that would otherwise increase water temperatures. For rivers, shade effectiveness is limited by the relationship between maximum tree height and the river bankfull width, with effective shading requiring tree height that is at least 1.4 times the stream width (Ecology 2007). A review of bankfull width data available for the Chehalis River in the Mitigation Area indicated that this condition would be met for the mainstem as well as major tributaries. Further, a previous sensitivity analysis by the District concluded that vegetation heights influenced modeled changes to water temperature, and that a conceptual Vegetation Management Plan (VMP) minimized temperature increases (HDR 2021).

The initial Project design located the Proposed FRE facility approximately 1.7 miles upstream from the town of Pe Ell, Washington in the upper Chehalis River watershed near RM 108.4 (Figure 1). A refined

2024 Project design incorporated three changes relevant to riparian shade and water temperature as described in the main body of this report. One change, the relocation of the large wood storage sites, would require an increased area of cleared forest and would result in a reduction in riparian shade in river reaches where the sites are located. Two additional FRE facility changes would increase riparian shade and minimization impacts from 2024. The first of these two additional changes was that the FRE was moved upstream to approximately RM 108.7, thereby eliminating riparian shade impacts in the approximate 0.25 mile reach between the 2017 and 2024 FRE locations. Second, under the 2025 Project operations model (O4P2), refined operations would result in both inundation of a slightly smaller temporary inundation pool and a faster rate of temporary inundation pool evacuation (Figure 2), which would minimize tree mortality associated with mitigation.

To evaluate potential shade impact from the revised FRE facility and 2025 operations, the District developed a 2025 Shade-a-lator model to estimate potential shade reductions and a 2025 CE-QUAL-W2 water temperature model to evaluate water temperature changes associated with the Proposed FRE facility, the implementation of a VMP, and riparian reforestation mitigation actions. The base CE-QUAL-W2 models modified for this analysis were obtained online from Portland State University (PSU) and had been developed for use in the National Environmental Policy Act (NEPA) and State Environmental Policy Act (SEPA) Draft Environmental Impact Statement (DEIS) analyses, as well as in a temperature sensitivity analysis conducted by the District (HDR 2021). Modifications to the PSU models were made to include shade input parameters that were identified from application of the Shade-a-lator model as described in the 2024 Riparian Shade Temperature Model Technical Memorandum (TM) (Kleinschmidt 2024b). This TM describes the updates made to the 2025 shade and temperature model as well as water temperature predictions based on 2024 Project operations.

Figure 1
Chehalis Basin Mitigation Area

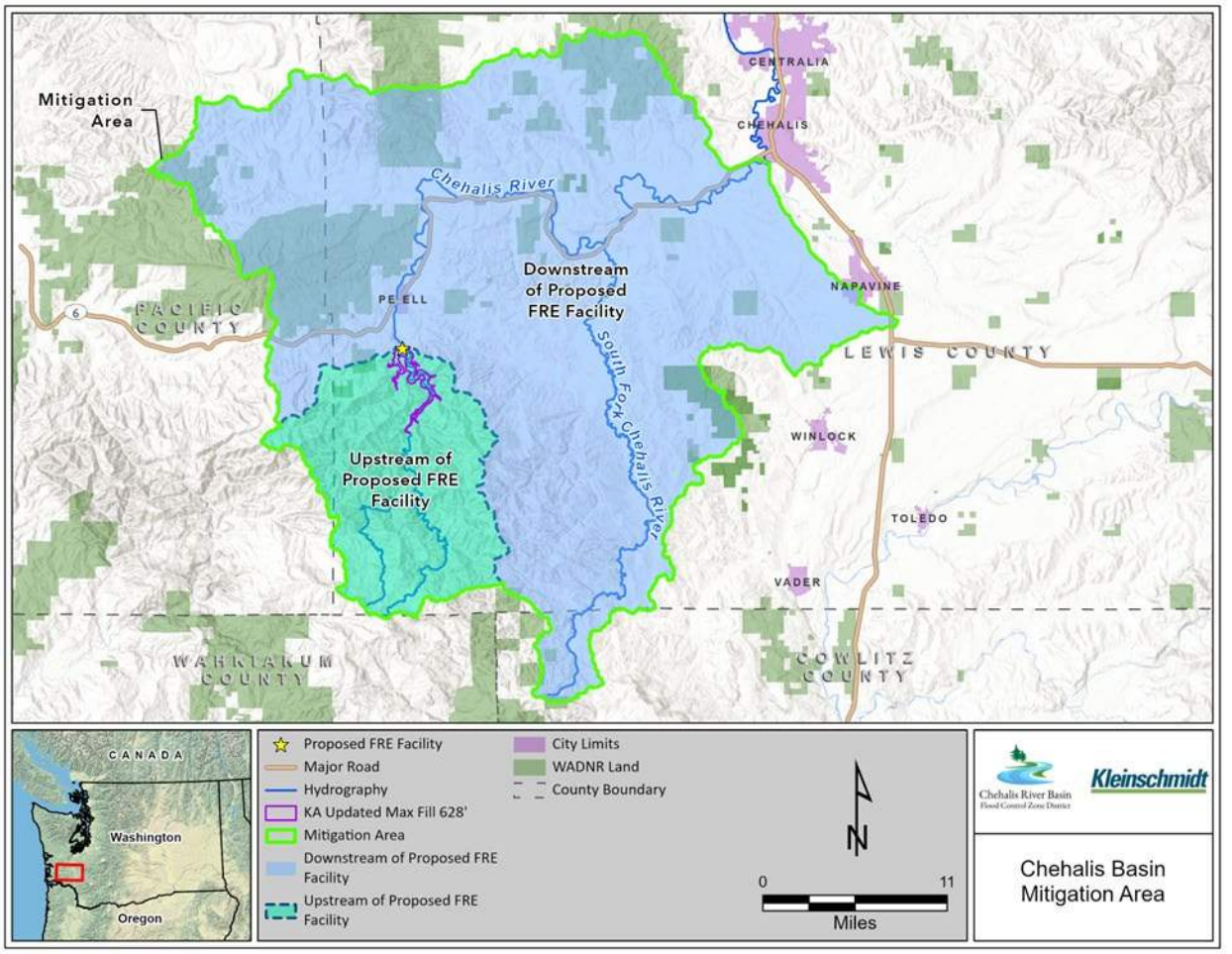
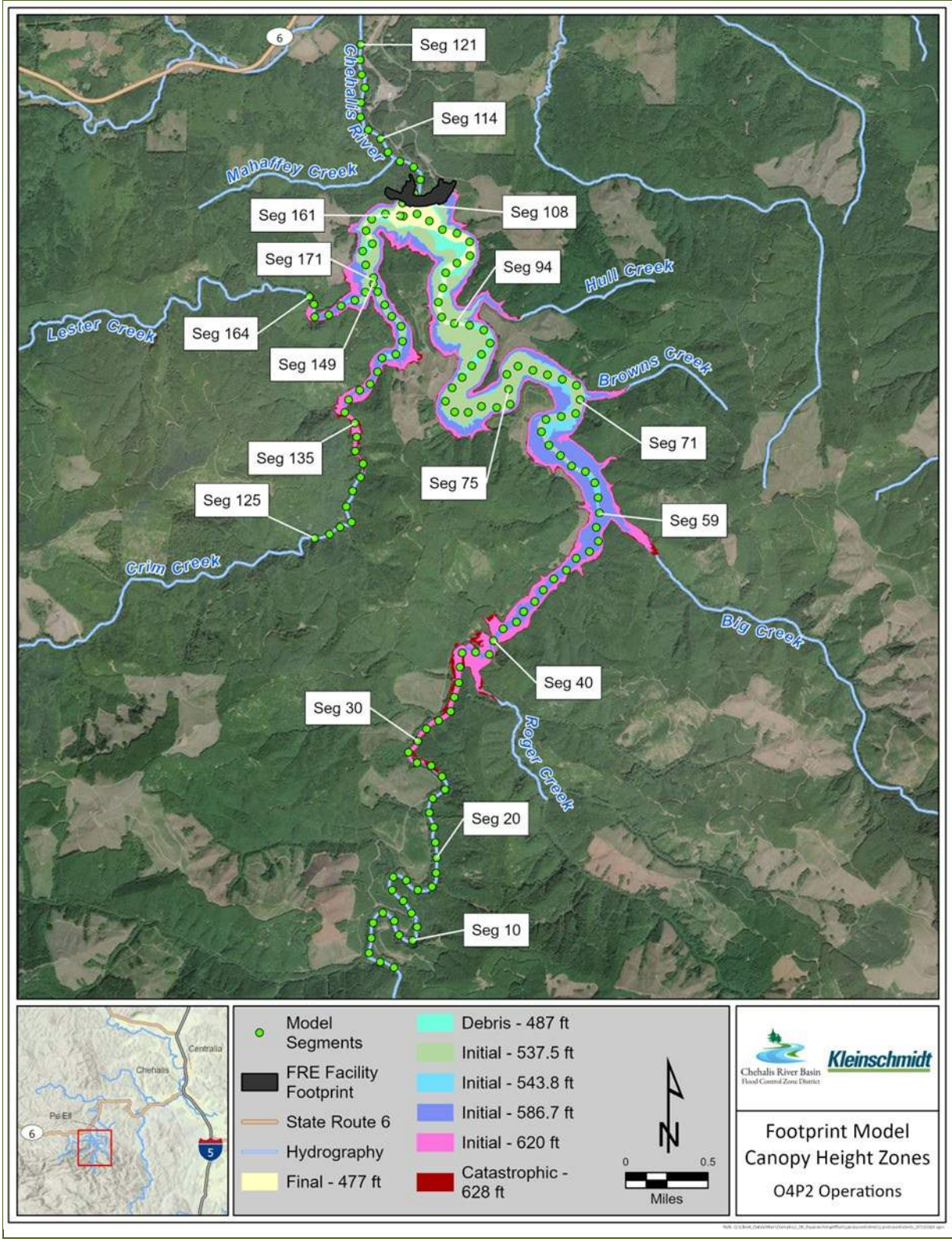


Figure 2
Footprint Model Canopy Height Zones Under O4P2 Operations



Study Area

The study area for both shade modeling and water temperature impacts included the temporary inundation pool upstream of the FRE facility to approximately Fisk Falls and downstream in the Chehalis River from the FRE facility to the confluence of the Chehalis River and the Newaukum River, near Chehalis RM 75.2.

Shade Model

The District revised their 2024 Shade-a-lator modeling tool (Boyd and Kasper 2003; Kleinschmidt 2024b) to develop a 2025 site-specific riparian shade model that reflected the 2024 project description and revised operations and mitigation actions as proposed in the 2024 RMP (Kleinschmidt 2024b). The 2025 Shade-a-lator model provided more recent information about the existing vegetation within the temporary inundation pool than the previous version, so it was used to update the 2022 Current Conditions scenario. It also incorporated refined shade parameters for the temporary inundation pool that were consistent with new expectation for vegetation heights of future plant communities using 2025 operations and implementation of the VMP (Appendix D in Kleinschmidt 2024a). The shade benefits of mitigation actions downstream of the FRE facility were quantified with Shade-a-lator. Detailed modeling methods including a description of the Shade-a-lator model and its application to development of the riparian planting mitigation actions, the CE-QUAL-W2 Model and relevant input parameters for shade, and development of the models of the Project and Mitigation Area are summarized in the Riparian Shade Temperature Model TM (Kleinschmidt 2024b).

Methods

CE-QUAL Model Inputs

As described above, the water temperature analysis was restricted to changing shade parameters within the previously developed CE-QUAL-W2 models. The shade generated by riparian vegetation is modeled in CE-QUAL-W2 using inputs describing vegetation height, distance from the stream centerline, and vegetation density or opacity (Kleinschmidt 2024b). These parameters were developed at the model segment scale for each bank. Vegetation heights were extracted from Light Detection and Ranging (LiDAR) data and used as model inputs to capture shade. Development of the modeling inputs for analysis of the 2024 Project included two updates to the previous methods. First, bankline vegetation heights were sampled along a line 6 feet shoreward of the bank, rather than along the bankline itself, to avoid underestimating riparian shade. Second, updated LiDAR was used to generate a DTM that markedly reduced the estimates of the distance between the stream centerline and riparian vegetation in Crim Creek (Washington Geological Survey 2024a, 2024b).

Model Scenarios and Assumptions

In 2024, the District modeled four scenarios under the 2017 operations model, including 2022 Current Conditions, No Vegetation, Vegetation Management Plan (VMP5), and Vegetation Management Plan

and Riparian Reforestation (Kleinschmidt 2024b). Canopy height predictions used in the VMP scenarios developed for the 2017 operations model are summarized in Table 1.

In 2025, the District modeled four new scenarios to characterize potential impacts to water temperature from inundation-induced mortality of riparian vegetation, and potential minimization through implementation of the VMP and riparian shade mitigation downstream of the FRE. The 2025 model scenarios are described in Table 2. These scenarios reflect three differences. First, in 2025 the reservoir zones shifted upstream in elevation due to Project refinements. Second, because 2025 FRE operations reduced the extent and duration of inundation as compared to 2017, this changed vegetation viability and growth. Third, these scenarios reflect consideration of both a major and catastrophic flood, whereas the 2024 analysis was limited to a catastrophic flood scenario.

Table 1
Canopy Height Surfaces Modeled in VMP Scenarios Under 2017 Operations

RESERVOIR EVACUATION AREA	FINAL	DEBRIS MANAGEMENT	INITIAL	INITIAL WATER SURFACE ELEVATION >620.0 FEET
Upper Canopy Height (feet)	NA	NA	100	Existing
Upper Canopy Cover (%)	0	0	25	Existing
Lower Canopy Height (feet)	8	8	25	Existing
Lower Canopy Cover (%)	100	100	75	Existing

Table 2
2025 Temperature Model Scenarios under 2025 (O4P2) Operations

OPERATIONAL SCENARIO	DESCRIPTION
Scenario 1: With Project, No Mitigation (1996 Flood Event [FE])	Vegetation after catastrophic flood operation
Scenario 2: With Project, No Mitigation (2015 Flood Event [FE])	Vegetation after major flood operation
Scenario 3: Vegetation Management Plan and Riparian Reforestation (1996 FE)	Vegetation after catastrophic flood operation, with implementation of Vegetation Management Plan upstream of FRE and Riparian Reforestation downstream of the FRE
Scenario 4: Vegetation Management Plan and Riparian Reforestation (2015 FE)	Vegetation after major flood operation with implementation of Vegetation Management Plan upstream of FRE and Riparian Reforestation downstream of the FRE

Current Conditions: Existing Riparian Vegetation

This analysis updated LiDAR-based baseline vegetation conditions (Washington Geological Survey 2024a, 2024b) using remote imagery. The current land designation of the temporary inundation pool and the surrounding land is forest reserve land, and its primary use is commercial forestry. Under active timber management, additional vegetative changes have occurred since the LiDAR data collection. These changes were digitized in ArcPro at a scale of 1:2000 using Maxar satellite imagery from July 2022 and used to update the Digital Surface Model for the temporary inundation pool (Maxar Technologies 2022). This scenario was named the 2022 Current Conditions scenario.

2025 Project Operations

Scenario 1: With Project, No Mitigation (1996 FE)

The District developed an estimate of future vegetation conditions, *without the VMP*, applying vegetation survival predictions based on the depth and duration of the temporary inundation pool when the FRE facility would operate. The three evacuation zones would be subject to increased frequency and duration of inundation: the Initial Evacuation Area, the Debris Management Evacuation Area, and the Final Reservoir Evacuation Area. However, the 2025 operations model lowered the upstream extent of each zone (Table 3). Trees that were inundated for more than 7 days were not expected to survive, based on observations at Mud Mountain (Appendix D in Kleinschmidt 2024a). Where inundation duration would be less than 7 days, tree survival was predicted to be selective such that shorter deciduous tree species would have higher inundation tolerance than evergreen species that grow much taller. The 1996 flood event (FE) represents an infrequent and catastrophic-type flood where the upstream extent of the temporary inundation pool would be at an elevation of 586.7 feet. The elevation threshold for inundation less than one week would be 537.5 feet (Figure 2, above). For the reach of the temporary inundation pool from 537.5 feet to 586.7 feet, the canopy height was modeled as the existing canopy height, up to 50 feet.

Table 3
Canopy Height Surface Modeled in Scenario 1 for 1996 FE Under 2025 (O4P2) Operations

RESERVOIR EVACUATION AREA	INUNDATION DURATION BY FLOOD EVENT (FE)	ELEV. RANGE (FEET)	CANOPY HEIGHT (FEET)
FINAL	>1 week 1996 FE	425.0-477.0	0
DEBRIS MANAGEMENT	>1 week 1996 FE	477.0-487.0	0
INITIAL	>1 week 1996 FE	487.0-537.5	0
	<1 week 2015 FE < 1 week 1996 FE	537.5-543.8	Existing, up to 50
	<1 week 1996 FE	537.5-586.7	Existing, up to 50
CATASTROPHIC	None 1996 FE	586.7-628.0	Existing

Scenario 2: With Project, No Mitigation (2015 FE)

The 2015 flood event represents a flood-type that has been classified as a major flood and would be expected more frequently than a catastrophic flood. This flood type would result in shorter inundation durations and a smaller inundation extent for the FRE facility's temporary inundation pool than predicted for a catastrophic flood. Vegetation was modeled similarly to 1996 WY, except that the upstream extent of the temporary inundation pool would be at 543.8 feet, and the elevation threshold for 7 days of inundation would be at 487.0 feet (Table 4, Figure 2). The elevation range that would be inundated for 7 days in 1996 FE was assumed to have a canopy height of 25 feet due given the opportunity for growth between inundation by catastrophic flood events (Table 4).

Table 4

Canopy Height Surfaces Modeled in Scenario 2 for 2015 FE Under 2025 (O4P2) Operations

RESERVOIR EVACUATION AREA	INUNDATION DURATION BY FLOOD EVENT (FE)	ELEV. RANGE (FEET)	CANOPY HEIGHT (FEET)
FINAL	>1 week 2015 FE	425.0-477.0	0
DEBRIS MANAGEMENT	>1 week 2015 FE	477.0-487.0	0
INITIAL	<1 week 2015 FE >1 week 1996 FE	487.0-537.5	25
	<1 week 2015 FE <1 week 1996 FE	537.5-543.8	Existing, up to 50
	<1 week 1996 FE	537.5-586.7	Existing, up to 50
CATASTROPHIC	None 1996 FE est	586.7-628.0	Existing

Scenario 3: Vegetation Management Plan and Riparian Reforestation (1996 FE)

The District developed an estimate of future vegetation conditions upstream of the FRE, based on active vegetation management under the VMP that would promote regrowth after inundation. The predictions of future canopy height were similar to previous modeling based on areas of inundation, but the elevations of each zone were lowered as described above. Under the VMP, the portion of the Initial Evacuation Area inundated for less than 7 days (the upstream-most area above an elevation of 537.5 feet) would be actively managed to promote taller vegetation, and taller trees could be expected to tolerate the flooding conditions anticipated in this area. An upper canopy cover of 25 percent at 100 feet was assumed with a lower canopy cover of 75 percent at a height of 25 feet (Table 5). As described above, it was assumed that vegetation could survive infrequent and short-duration inundation and no changes to existing canopy heights were assumed in the Initial Evacuation Area upstream of the inundation limit for the 1996 flood (586.7 feet). The Debris Management Evacuation Area (the middle portion of the temporary inundation pool between 477.0 to 487.0 feet) and the Final Reservoir Evacuation Area (the lowest part of the temporary inundation pool, from 425.0 to 477.0 feet, that would be inundated for the greatest duration) were modeled with the same vegetation. It was assumed that any upper canopy of standing dead trees would have fallen, so no upper canopy was assumed (reflected

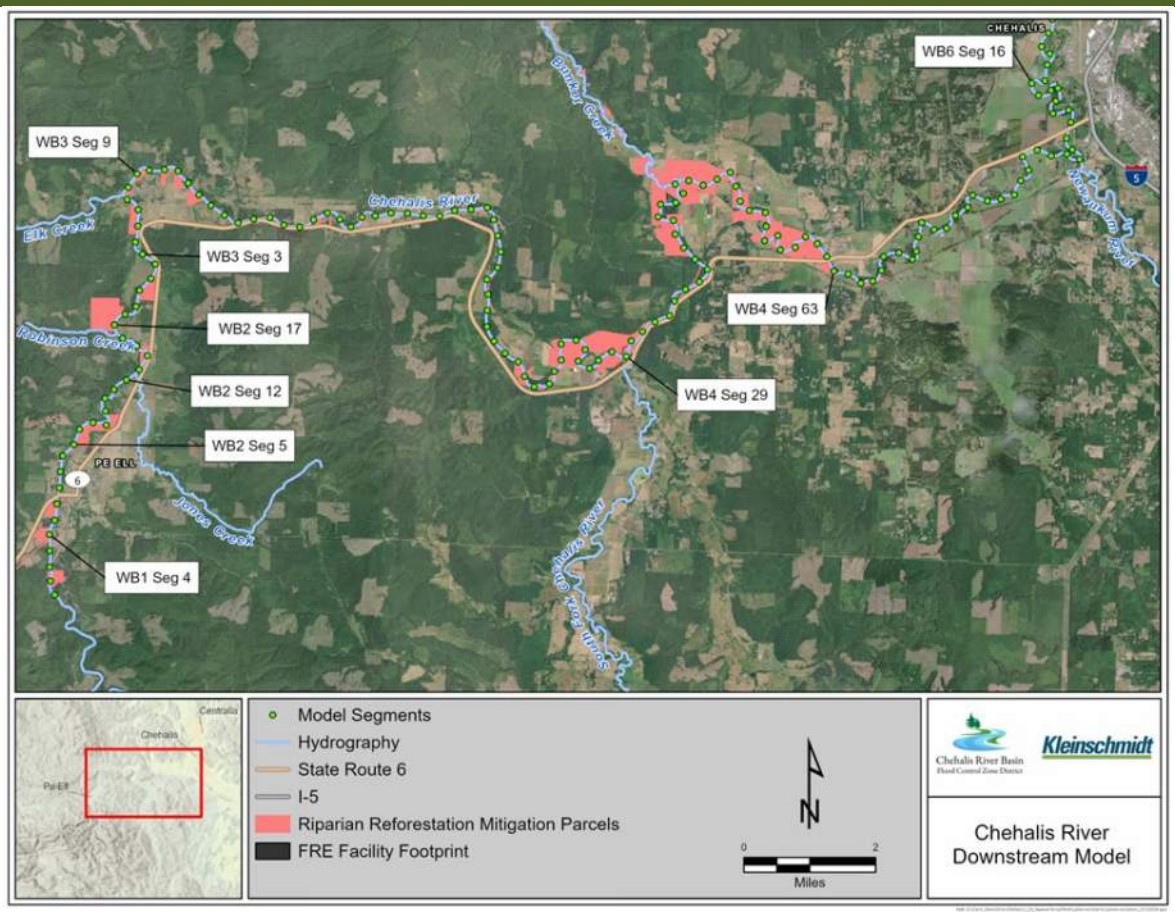
as 0 percent cover in Table 5) and the lower canopy was modeled at 8 feet, based on estimated tree regrowth rates in the VMP.

Table 5
Canopy Height Surfaces Modeled in VMP Scenario for 1996 FE Under 2025 (O4P2) Operations

RESERVOIR EVACUATION AREA	INUNDATION DURATION BY FLOOD EVENT (FE)	ELEV. RANGE (FEET)	UPPER CANOPY HEIGHT (FEET)	LOWER CANOPY HEIGHT (FEET)	LOWER CANOPY COVER (%)
FINAL	>1 week 1996 FE	425.0-477.0	NA	8	100
DEBRIS MANAGEMENT	>1 week 1996 FE	477.0-487.0	NA	8	100
INITIAL	>1 week 1996 FE	487.0-537.5	NA	8	100
	<1 week 2015 FE < 1 week 1996 FE	537.5-543.8	100	25	75
	<1 week 1996 FE	537.5-586.7	100	25	75
CATASTROPHIC	None 1996 FE	586.7-628.0	Existing	Existing	Existing

Downstream of the FRE, the District's proposed mitigation for temperature impacts is reforestation of existing degraded habitats with native riparian trees and shrubs that will enhance tree canopy and shade conditions as the vegetation matures (Figure 3). Vegetation parameters for riparian restoration sites were based on ecologically relevant planting plans that included a high diversity of native trees and shrubs that contribute to riparian ecological function. Dominant shade-producing species included black cottonwood (*Populus trichocarpa*) and red alder (*Alnus rubra*). Tree heights of 98 feet (30 meters) were based on species characteristics and the system potential vegetation identified in previous total maximum daily load modeling in analogous Northwest river systems (ODEQ 2006). Mitigation plantings were modeled within a 60-foot buffer along each streambank. This future conditions scenario was integrated into a modified continuous raster surface model.

Figure 3
Chehalis River Downstream Model Segments



Scenario 4: Vegetation Management Plan and Riparian Reforestation (2015 FE)

For 2015 FE, future vegetation conditions upstream of the FRE with active vegetation management under the VMP included higher canopy heights for the additional portion of the temporary inundation pool that would be inundated for less than 7 days (water surface elevations between 537.5 and 487.0 feet; Figure 2). An upper canopy cover of 25 percent at 50 feet was assumed with a lower canopy height of 25 feet (Table 6). In addition, regrowth in the area upstream of the maximum extent of the temporary inundation pool (543.8 feet) was assumed such that the lower canopy height could increase to 45 feet. No revisions were made to the future vegetation heights in the Debris Management Evacuation Area and the Final Reservoir Evacuation Area; similar to other scenarios, the lower canopy was modeled at 8 feet, based on estimated tree regrowth rates in the VMP.

Riparian reforestation downstream of the FRE will be unchanged across flood events and was modeled as described above.

Table 6
Canopy Height Surfaces Modeled in VMP Scenario for 2015 FE Under 2025 (O4P2) Operations

RESERVOIR EVACUATION AREA	INUNDATION DURATION BY FLOOD EVENT (FE)	ELEV. RANGE (FEET)	UPPER CANOPY HEIGHT (FEET)	LOWER CANOPY HEIGHT (FEET)	LOWER CANOPY COVER (%)
FINAL	>1 week 2015 FE	425.0-477.0	NA	8	100
DEBRIS MANAGEMENT	>1 week 2015 FE	477.0-487.0	NA	8	100
INITIAL	<1 week 2015 FE >1 week 1996 FE	487.0-537.5	50	25	75
	<1 week 2015 FE <1 week 1996 FE	537.5-543.8	100	25	75
	<1 week 1996 FE	537.5-586.7	100	45	75
CATASTROPHIC	None 1996 FE	586.7-628.0	Existing	Existing	Existing

CE-QUAL-W2 Model Outputs and Analysis

The CE-QUAL-W2 models can be set to output water temperature for any segment, time-step, or depth in the water column. For this analysis, water temperatures were output at select segments relevant to evaluating Project effects at time steps of 2.4 hours (0.1 days). The Footprint Model was configured to output temperatures at the downstream extent of Crim Creek (Segment 161) and at the location of the FRE at the time of the DEIS (Segment 114) (Figure 2). The Chehalis River Downstream Model was configured to output temperatures downstream of the FRE (WB1 Segment 4), upstream of Jones Creek (WB2 Segment 12), near Robinson Creek (WB2 Segment 17), near Elk Creek (WB3 Segment 9), at the confluence with the South Fork Chehalis River (WB4 Segment 29), and near Adna, Washington (WB4 Segment 63) (Figure 3).

Both latitude and day of the year affect the solar path and associated incoming solar radiation. When evaluating riparian revegetation effects on water temperature, it can be helpful to understand conditions both during periods of relatively high temperatures (summer) and periods when riparian shade is most effective at reducing incoming solar radiation (fall). The late summer months are when the DEISs identified water temperature increases to be greatest. The CE-QUAL-W2 model temperature outputs for the Chehalis River were summarized for the period between June 20, 2014 and September 22, 2014.

Results

The following sections describe outputs from the CE-QUAL-W2 temperature modeling for potential Project effects on riparian shade in the temporary inundation pool under the 2025 (O4P2) operations model, the effectiveness of the VMP in avoiding and minimizing those effects, and the potential for

riparian shade mitigation to address unavoided impacts downstream of the FRE. Results of the 2017 shade related temperature modeling are presented in table format for comparative purposes and to demonstrate any changes associated with the refined FRE facility location, 2025 operations, and model (Table 7).

Temperature Within the Temporary Inundation Pool Footprint

Modeling in the temporary inundation pool predicted changes in water temperature under summer low-flow conditions under 2024 Project designs and associated scenarios (Table 7). All temperature changes are characterized as the maximum change in the 7-day average of the daily maximum water temperature (7-DADMax) in degrees Celsius.

2024 Project

The 2022 Current Conditions scenario was maintained in the 2025 model as the basis for comparison with the four new future scenarios considered for the 2024 Project design. From that baseline, District-proposed avoidance and minimization measures further reduced the predicted temperature increases. The new LiDAR data used for this model depicted more accurate estimates of channel width for Crim Creek that resulted in current conditions temperature changes that also effects both potential impact and minimization temperatures at that location.

The differences in daily estimates of 7-DADMax for the summer low-flow period of June 20, 2024 to September 22, 2024 at the mouth of Crim Creek and near the FRE are presented in Figures 4 and 5. Under the With Project, No Mitigation scenarios (1996 FE, 2015 FE), removing all vegetation inundated longer than 7 days would increase stream temperatures near the FRE above the 2022 condition by up to 1.6 °C for 1996 FE and 1.2 °C for 2015 FE (Table 7). Stream temperatures at the mouth of Crim Creek under these scenarios would increase by up to 4.7 °C and 3.4 °C, respectively.

Implementing the VMP would avoid up to 1.6 °C of temperature increase at the mouth of Crim Creek and up to 0.7 °C of temperature increase near the FRE. Based on the VMP5 scenario, the residual water temperature effect (total increase to current conditions with all vegetation removed minus VMP shade reduction) for a 1996 FE event is predicted to be up to 3.1 °C at the mouth of Crim Creek and 1.0 °C near the FRE (Table 7). Although the relative change in water temperature at the mouth of Crim Creek was larger than in previous analyses, this was due to a reduction in the estimate of current conditions rather than an increase in the estimate of future 7-DADMax stream temperatures (Figure 4). Further information about this appears in the Discussion section, below. This change at the mouth of Crim Creek was not reflected in conditions at the FRE location downstream, presumable due to relatively small flow contribution of Crim Creek to the Chehalis River during summer months (Figure 5).

Table 7

Maximum Change in Modeled 7-DADMax Water Temperature During Low-flow Summer Conditions (June 20, 2014 to September 22, 2014) at the Mouth of Crim Creek and at the FRE Under Shade Scenarios

SCENARIO	2017 PROJECT		2024 PROJECT / 2025 OPERATIONS			
	NO VEGETATION	VMP5	WITH PROJECT, NO MITIGATION		VMP AND RIPARIAN REFORESTATION	
LOCATION	RELATIVE TO 2022 CURRENT CONDITIONS (2024 MODEL)		1996 FE	2015 FE	1996 FE	2015 FE
			RELATIVE TO 2022 CURRENT CONDITIONS (2025 MODEL)			
At Mouth of Crim Creek	3.6 °C[1]	1.6 °C[1]	4.7 °C	3.4 °C	3.1 °C	2.4 °C
At FRE Facility (RM 108.4/108.7)	1.9 °C	1.2 °C	1.6 °C	1.2 °C	0.8 °C	0.8 °C

[1] Water temperature estimates for 2017 Project in Crim Creek were based on outdated terrain model and are not directly comparable to other temperature estimates.

Figure 4
7-DADMax Water Temperatures at the Mouth of Crim Creek for Model Scenarios

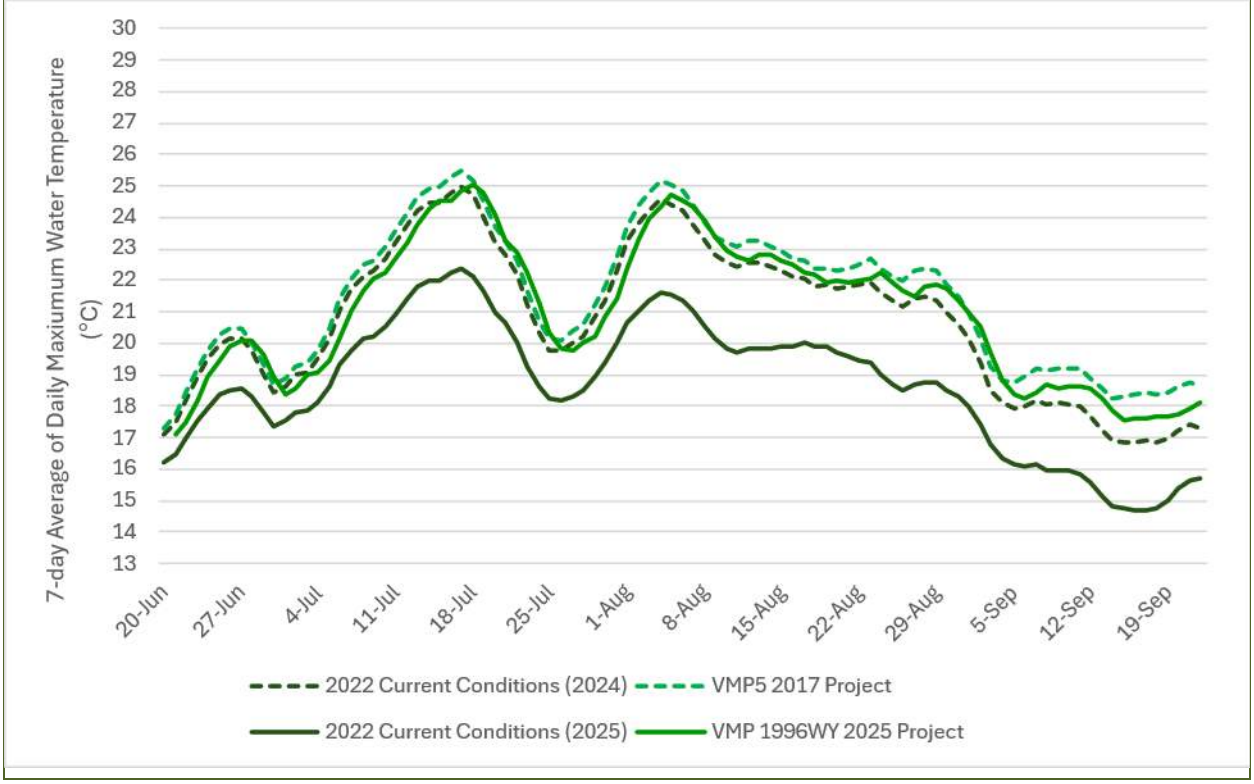
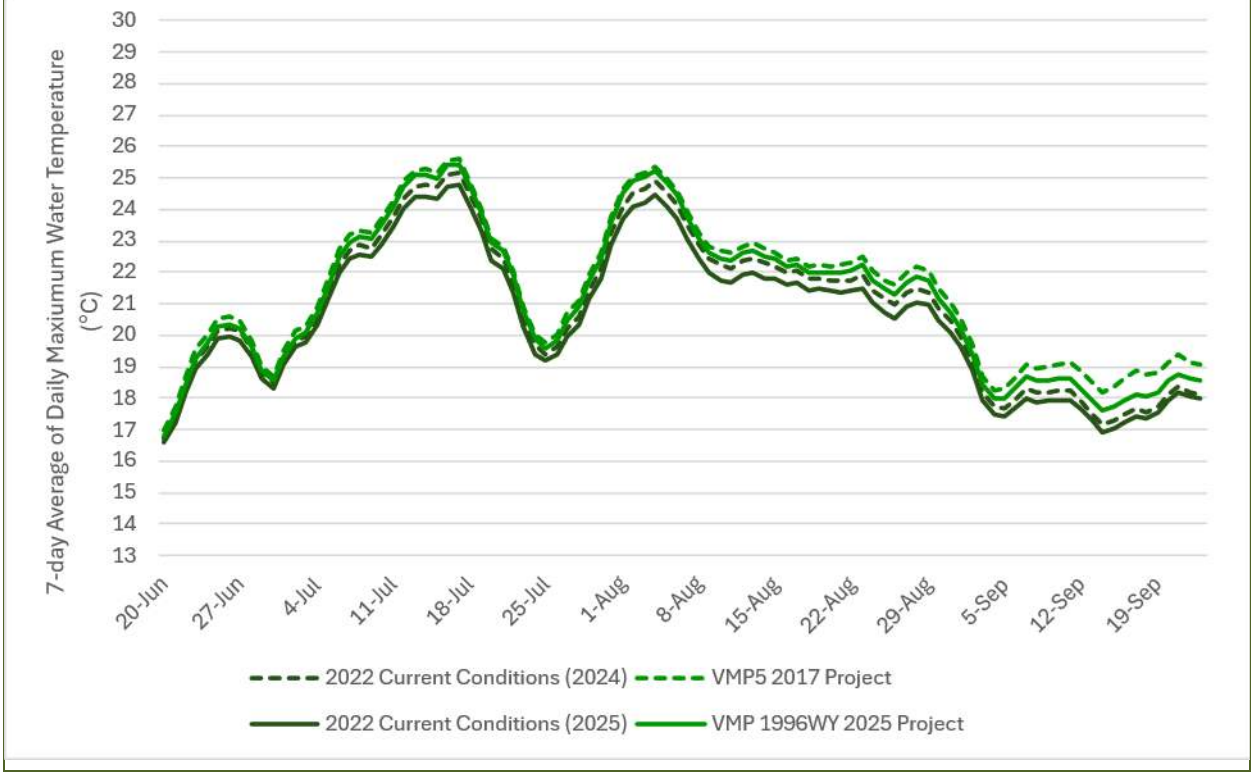


Figure 5
7-DADMax Water Temperatures at the FRE Facility for Model Scenarios



Riparian Reforestation Mitigation

In 2024, temperature modeling of the 2017 Project for the Mitigation Area downstream of the FRE facility evaluated changes in summer water temperatures under four scenarios : 2022 Current Conditions scenario, No Vegetation scenario, VMP5 scenario, and the VMP5 with Mitigation scenario (Table 8). In this 2025 temperature model, scenarios were analyzed for the refined 2024 Project: 2022 Current Conditions, With Project, No Mitigation (1996 FE); With Project, No Mitigation (2015 FE); VMP and Riparian Reforestation (1996 FE); and VMP and Riparian Reforestation (2015 FE). All temperature changes were characterized as the change in the 7-DADMax in degrees Celsius from the 2022 Current Conditions scenario. The District selected 131 parcels along the upper Chehalis River and Bunker Creek for riparian shade enhancement mitigation. The proposed riparian planting areas are along the mainstem Chehalis River between the FRE facility and Adna, Washington.

Analysis of the 2017 Project demonstrated that the No Vegetation scenario described in the SEPA DEIS (Ecology 2020), including removing all vegetation in the temporary inundation pool, would increase stream temperatures downstream of the FRE above the 2022 Current Conditions scenario by up to 1.2 °C, increase temperatures near Elk Creek up to 0.3 °C, and increase stream temperatures downstream of the South Fork Chehalis by up to 0.1 °C (Table 8). Implementing the VMP would avoid up to 0.5 °C of

temperature increase downstream of the FRE, 0.1 °C near Elk Creek, and 0.1 °C downstream of the South Fork Chehalis. Model results of the VMP5 scenario predicted reduced effects on summer water temperature, with predicted residual effects of 0.7 °C downstream of the FRE, 0.2 °C near Elk Creek (RM 100.2), and 0.0 °C downstream of the South Fork Chehalis (RM 88). Modeling of the shade mitigation downstream showed that stream temperatures downstream of the FRE would still be predicted to increase above the 2022 Current Conditions scenario by up to 0.7 °C, but the temperature increases decrease at locations downstream. With mitigation, temperature increases would be reduced to approximately 0.2 °C near the mouth of Jones Creek (RM 103.7), while no temperature effect was predicted at the confluence of Elk Creek and a small net cooling effect of -0.3 °C was predicted near the confluence of Robinson Creek increasing downstream through the mitigation planting area.

Analysis of the 2024 Project demonstrated that the refined Project design reduced the model temperature impacts. The With Project, No Mitigation scenario for 1996 FE, including mortality of all riparian vegetation inundated for longer than 7 days in the temporary inundation pool, would increase stream temperatures downstream of the FRE above the 2022 Current Conditions scenario by up to 0.6 °C and cause no increase in temperatures near Elk Creek and downstream (Table 9). Implementing the VMP and riparian reforestation along the mainstem Chehalis River would avoid up to 0.3 °C of temperature increase downstream of the FRE, and result in a net reduction of stream temperatures near Jones Creek and downstream. Modeling predicted a maximum cooling effect of between -0.3 °C and -0.5 °C between Jones Creek (RM 104) and the confluence of the South Fork Chehalis River (RM 88), with a maximum cooling of -1.2 degrees near Adna, Washington (RM 81) (Table 9). The predicted thermal benefits of shade mitigation were greatest in late September when sun angles were lower and trees blocked solar input for a greater portion of the day.

Table 8

Maximum Change in Modeled 7-DADMax Water Temperature During Low-flow Summer Conditions (June 20, 2024 to September 22, 2024) at Locations Along the Chehalis River Downstream of the FRE Under 2017 Project Scenarios

LOCATION	SEGMENT	NO VEGETATION	VEGETATION MANAGEMENT PLAN (VMP)	VMP + RIPARIAN REFORESTATION
		RELATIVE TO 2022 CURRENT CONDITIONS		
Mouth of Crim Cr.	161	3.6 °C	1.6 °C	NA
FRE Facility (RM 108.4)	114	1.9 °C	1.2 °C	NA
Downstream of FRE (RM 106.9)	WB1 Segment 4	1.2 °C	0.7 °C	0.7 °C
Upstream of Jones Cr. (RM 104)	WB2 Segment 12	0.8 °C	0.5 °C	0.2 °C
Near Robinson Cr. (RM 102.7)	WB2 Segment 17	0.6 °C	0.4 °C	-0.3 °C
Near Elk Cr. (RM 100)	WB3 Segment 9	0.3 °C	0.2 °C	-0.3 °C
Near South Fork Chehalis (RM 88)	WB4 Segment 29	0.1 °C	0.0 °C	-0.5 °C
Near Adna, Washington (RM 81)	WB4 Segment 63	0.1 °C	0.0 °C	-1.2 °C

Table 9
Maximum Change in Modeled 7-DADMax Water Temperature During Low-flow Summer Conditions (June 20, 2024 to September 22, 2024) at Locations Along the Chehalis River Downstream of the FRE Under 2024 Project Scenarios

		WITH PROJECT, NO MITIGATION		VEGETATION MANAGEMENT PLAN (VMP) & RIPARIAN REFORESTATION	
		1996 FE	2015 FE	1996 FE	2015 FE
LOCATION	SEGMENT	NO VEGETATION WHERE INUNDATED >7 DAYS, RELATIVE TO 2022 CURRENT CONDITIONS		RELATIVE TO 2022 CURRENT CONDITIONS	
Mouth of Crim Cr.	161	4.7 °C	3.4 °C	3.1 °C	2.4 °C
FRE Facility (RM 108.4)	114	1.6 °C	1.2 °C	0.8 °C	0.8 °C
Downstream of FRE (RM 106.9)	WB1 Segment 4	0.6 °C	0.3 °C	0.3 °C	0.1 °C
Upstream of Jones Cr. (RM 104)	WB2 Segment 12	0.5 °C	0.3 °C	-0.5 °C	-0.6 °C
Near Robinson Cr. (RM 102.7)	WB2 Segment 17	0.4 °C	0.2 °C	-0.4 °C	-0.5 °C
Near Elk Cr. (RM 100)	WB3 Segment 9	0.2 °C	0.1 °C	-0.3 °C	-0.4 °C
Near South Fork Chehalis (RM 88)	WB4 Segment 29	0.0 °C	0.0 °C	-0.5 °C	-0.5 °C
Near Adna, Washington (RM 81)	WB4 Segment 63	0.0 °C	0.0 °C	-1.2 °C	-1.2 °C

Discussion

The NEPA and SEPA DEISs indicated that the Project summer water temperatures would increase as the result of tree mortality and loss of shade in the temporary inundation pool. The 2024 CE-QUAL-W2 model updated the prediction of that potential effect based on 2022 conditions of the timberlands around the upper Chehalis River mainstem. The 2024 model results predicted that the construction and operation of the flow-through dam would be similar to, but slightly less than the DEIS impacts both at the FRE location and downstream. These results provide validation that the District's model is depicting a similar level of contribution of existing shade and shade loss to the water temperature in the Mitigation Area.

The District's modeling of mitigation measures outlined in the 2024 RMP predicted that shade restoration associated with the implementation of the VMP and operating the Project as characterized by 2017 operations. The 2024 refined Project design and 2025 (O4P2) operations have reduced the scale and extent of potential temperature impacts further. The O4P2 operations slightly reduced the temperature impacts of a catastrophic flood (1996 FE), and modeling of a more typical major flood (2015 FE) quantified even smaller temperature changes. When compared to the 2017 design, smaller residual temperature effects for the 2024 Project design at the FRE translated to a reduced downstream extent of temperature changes in the Chehalis River, and increased the size and extent of water temperature cooling associated with the proposed riparian reforestation between the FRE and Adna, Washington.

Although overall temperature effects were smaller for the 2024 Project and 2025 operations, a notable exception was at the mouth of Crim Creek. The Ecology temperature model, and District's analysis of the 2017 Project using that model, estimated a temperature increase of 3.6 °C for a No Vegetation scenario and a residual increase of 1.6 °C with the VMP (Table 8); the 2025 model predicted an increase of 4.7 °C for the With Project, No Mitigation (1996 FE) scenario and a residual increase of 3.1 °C with the Vegetation Management Plan and Riparian Reforestation (1996 FE) (Table 9). In investigating the cause of this counterintuitive change, the District identified that the updated terrain model reflected topography with a much narrower channel width, which increases the impact of vegetation changes on stream temperature. This temperature change reflects an improvement of model accuracy related to more current LiDAR data, rather than an increased impact of the 2024 Project design and operations model.

The model scenarios with the VMP and riparian reforestation downstream predicted that the shade-related temperature benefit would be greater in later summer months (August and September). This result is related to the arc of the sun being lower in the sky in September as compared to July and thus, increases the extent of riparian shade across the width of the river. This finding is particularly important for adult Chinook salmon, which spawn in the upper Chehalis River in September.

Similar to other riverine systems throughout the Pacific Northwest, the current riparian shade conditions of the upper Chehalis River between RMs 108 and 86 are substantially degraded and offer ample opportunity for shade enhancement that can mitigate for the residual impact upstream. The results of this temperature modeling exercise in combination with the shade supply analysis presented in the RMP (Appendix G of Kleinschmidt 2024a) demonstrate the feasibility of mitigation to offset temperature effects by restoring riparian shade and reducing the thermal input to the river from the sun.

Shade rehabilitation as mitigation to offset temperature impact has become an accepted practice in the Pacific Northwest. It has been successfully applied in Oregon to offset temperature impacts on the Tualatin, Clackamas, and Rogue rivers. The Tualatin River program has been ongoing the longest and is considered the gold standard for shade mitigation (CWS 2024) The successes achieved in each of these programs exceeded expectations with benefits that extended beyond the intended temperature reduction and included improved water quality from run off, increased counts of adult salmon, increased value of wildlife habitat, and improved recreational and esthetic values. There is every reason to expect that these ancillary benefits of native riparian habitat enhancement also will occur along the upper Chehalis River as a consequence of the proposed shade mitigation.

Ecology has guidelines applicable for this type of temperature mitigation, which the District relied upon to determine the quantity of shade mitigation proposed. As indicated in the RMP and detailed in the 2024 Mitigation Contingency plans TM, there is more shade supply available both along the mainstem river and in tributaries than what is required for mitigation. As this Project advances, it would be

possible to consider alternative configurations of shade mitigation parcels and to evaluate how to maximize the potential benefits of shade mitigation with the modeling tools developed by the District.

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Attachment 3:

Fish Passage Design Report to Inform SEPA

Chehalis River Basin Flood Control Zone District

February 4, 2026

Fish Passage Design Report to Inform SEPA

Chehalis River Basin Flood Damage Reduction Project

Lewis County, Washington

February 4, 2026

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Appendix A. In-Water Work Steps During Construction TM

Appendix B. Juvenile Fish Sounding TM

Appendix C. Fishway Lighting TM

Appendix D. Backwater Analysis Pool Frequency with Conduit Gates Open (Draft) TM

Acronyms

AWS	auxiliary water supply
cfs	cubic feet per second
Ecology	Washington state Department of Ecology
FFPF	Flood Fish Passage Facility
ft/s	feet per second
FRE	Flood Retention Expandable
FRFA	Flood Retention Flow Augmentation
ft-lbs/sec/ft3	foot-pounds per second per cubic foot
gpm	gallons per minute
HDR	HDR Engineering, Inc.
NOAA	National Oceanic and Atmospheric Administration
RDEIS	Revised Draft Environmental Impact Statement
RPDR	Revised Project Description Report
SEPA	State Environmental Policy Act
Subcommittee	Fish Passage Subcommittee
TM	Technical Memo
TWG	Technical Working Group
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	U.S. Geologic Survey
WDFW	Washington Department of Fish and Wildlife

1 Background

The Proposed Chehalis River Basin Flood Damage Reduction project (Proposed Project) objective is to implement a series of measures aimed at reducing damage to the communities of the Chehalis River Basin from Pe Ell to Cosmopolis during major flood events. Among these measures is a proposed Flood Retention Expandable (FRE) structure on the Chehalis River, south of Pe Ell, Washington.

Following submittal of the Revised Project Description Report (HDR Engineering, Inc. [HDR] 2024), a Chehalis River Basin Flood Damage Reduction draft Preliminary Design Report (PDR) was initiated to document ongoing draft design refinements, as the design process iterates toward a future 30 percent design that will be documented in a completed PDR. The draft PDR records ongoing draft design decisions, assumptions, and methods related to the development of the design of the FRE structure and related elements and collects technical details of the main features of the Proposed Project elements as they continue to develop.

A SEPA Revised Draft Environmental Impact Statement (RDEIS) for the Proposed Project was issued on November 20, 2025 with comments due February 4, 2026. To support the submission of comments on the SEPA RDEIS, some draft design elements are being formalized in reports and memoranda to describe the current state of the project design. While still not at a full 30 percent preliminary design level, these elements are at a point at which they can reasonably inform tribal governments, state and federal agencies, partners, stakeholders, and the public about the nature of the project.

2 Introduction

The proposed FRE structure includes the following fish passage components, designed to provide passage for a range of species and life stages:

- Flood Fish Passage Facility (FFPF)
- Fishways
- Fish passage conduits
- Temporary channels
- Permanent channels

The fish passage design documented herein focuses on the design updates to the outlet works, which includes the fishways and fish passage conduits. Design updates to these features include updates to the design criteria to comply with current standards and updates to previous concept-level design development. This document also includes a performance and survival assessment for fish passage during normal flow-through operation, flood retention operation, and construction. Finally, the document provides a brief description of a plan and timeline to advance the fish passage design to inform the final Biological Assessment. These activities were performed in collaboration with

Washington Department of Fish and Wildlife (WDFW) and National Oceanic and Atmospheric Administration (NOAA) Fisheries and in conjunction with other physical, biological, and engineering studies and analyses to refine the FRE Proposed Project design, evaluate potential flood damage reduction, and minimize and avoid environmental impact. The Fish Passage Technical Working Group (TWG) also provided input through design update meetings.

3 Purpose and Intent

The integration of fish passage systems is a central component of the flood damage reduction structure design. Washington State's regulatory authority defined in Revised Code of Washington 77.57.030, (Fishways required in dams, obstructions – Penalties, remedies for failure) requires that dam owners provide safe and timely fish passage for all fish species and fish life stages present in an affected area. No aquatic species are federally listed as endangered or threatened on this part of the Chehalis River. However, spring and fall Chinook salmon are prey items for the endangered Southern Resident Killer Whale.

Fish passage facility design has occurred simultaneously with facility design efforts throughout the development of the Revised Project Description Report (RPDR). This report summarizes the results and conclusions for select, critical elements of fish passage concept development performed in previous documents, including the RPDR and identifies a roadmap for fish passage design development. The information provided in and appended to this document is intended to be used by the Washington Department of Ecology (Ecology) in development of the final State Environmental Policy Act Environmental Impact Statement.

4 Design Criteria

This section describes the criteria used for the preliminary design of fish passage components for the Proposed Project. Previous development identified design criteria based on contemporary design guidance, collaboration with regulatory agencies and nonregulatory entities, and contemporary science. The previously developed design criteria have been updated to reflect current design guidance, science, and collaboration. Future design development will use contemporary guidelines, and the design will be updated accordingly. Refer to Section 7 for additional information regarding potential design criteria revision.

This section notes design criteria that have been confirmed, added to, removed from, or revised from previously published documents.

4.1 Collaboration with Technical Committees

From 2016 to 2017, the fish passage design team and members of the Chehalis Basin Strategy Flood Damage Reduction Technical Committee held nine Fish Passage Subcommittee (Subcommittee) meetings. During development of the RPDR in 2023 and

2024, the Fish Passage TWG was formed to continue coordination with members of the Subcommittee. Two TWG meetings were held during development of this study.

The TWG meetings were forums for information transfer, detailed discussion, and making recommendations to the District about the biological and technical aspects of the fish passage facility alternative development. Of primary importance were the discussion, interpretation, and formulation of design criteria.

Participants attending the Subcommittee and TWG meetings included representatives from the following organizations:

- WDFW (Subcommittee and TWG participant)
- U.S. Fish and Wildlife Service (USFWS) (Subcommittee and TWG participant)
- USACE (Subcommittee and TWG participant)
- NOAA Fisheries (Subcommittee and TWG participant)
- Washington Department of Ecology (Subcommittee and TWG participant)
- Quinault Indian Nation (Subcommittee participant; invited to participate in TWG)
- Cowlitz Indian Tribe (invited to participate in TWG)
- State of Washington Consultant Study Team (Subcommittee and TWG participant)

The Quinault Indian Nation and Confederated Tribes of the Chehalis Reservation have been invited to participate in the TWG; but at the time this document was written, neither has attended or participated in these meetings.

In addition to the Subcommittee and TWG meetings, the District's design team met separately with WDFW and NOAA Fisheries to discuss specific design aspects. From 2023 through 2025 the District's design team met with NOAA Fisheries 16 times to gather input from NOAA Fisheries on the proposed design refinements. Topics discussed in the meetings included implementation of the NOAA Fisheries climate change design guidance (NOAA Fisheries 2023a); one, two, and three-dimensional hydraulic modeling results of the proposed conduits, fishways, modifications to the permanent river channel, construction bypass channels, and existing river reaches; dual dedicated fishways; and fish sounding (Appendix B) and lighting (Appendix C). NOAA Fisheries input is reflected in the fish passage design documented in this report.

4.2 Biological Design Criteria

In 2016, the Washington State legislature created the Chehalis Basin Strategy, tasking participants with "designing and implementing on-the-ground projects to restore aquatic habitats and protect residents from flood damage." As part of the Chehalis Basin Strategy, WDFW has led an extensive field sampling program to collect data and better understand the phenology, abundance, habitat requirements, distribution, and migration patterns of fish present within the Chehalis River and, more specifically, in the potentially affected areas of the FRE structure and temporary inundation limits. Using new and historically available data, WDFW assisted the Subcommittee with biological criteria

development, including the following three primary types with the most influence on facility type, size, and configuration:

- **Selected Species and Migration Timing:** Informs the selection of species and life stages targeted for fish passage design and their seasonality, anticipated hydrologic conditions, and the timing of when the target fish species may be expected to migrate upstream and/or downstream of the facility location.
- **Species Abundance:** Informs the annual number of fish and peak daily rate of migration that the facility is designed to pass and that influences facility size and operation requirements. For clarity, species abundance numbers used in designing the fishway *do not represent current or predicted future species abundance* in the Proposed Project vicinity. Rather, these numbers were used to provide a conservative passage design that will meet passage needs under a variety of potential future fish abundance conditions.
- **Trapping and Holding Criteria:** Informs the requirements for fish trapping and holding volume, duration, temperature, and water supply.

Biological design criteria, including the above-listed bullet points, are discussed in the following subsections.

4.2.1 General Biological Design Criteria

General biological design criteria apply to all project components where fish passage must be maintained (i.e., dedicated fishways, fish passage conduits, FFPF, permanent Chehalis River and Crim Creek channels, and Chehalis River and Crim Creek construction bypass channels), unless stated otherwise.

4.2.1.1 Selected Species and Migration Timing

The selection of fish species and life stages for fish passage design was derived from field-specific data obtained by WDFW in 2015 and 2016 and readily available historical documentation developed for the Chehalis Basin. In general, Washington State interprets the Revised Code of Washington 77.57.030 to require provisions for passage of all fish and fish life stages believed to be present in the system.

For development of the general upstream and downstream fish passage criteria, anadromous and resident species known to occur in the vicinity of the FRE structure, in the temporary inundation area, and upstream of the temporary inundation area were selected as target species. These target species and their known swimming and leaping abilities were used to develop specific technical design criteria. Of the target species, salmonids, cutthroat trout, and lamprey were identified as priority species due to the greater abundance of biological, swim, and leaping data available for them as well as their importance to federal regulators and indigenous peoples. Other species known to occur downstream of the FRE site were selected for consideration but did not directly influence the development of specific technical design criteria.

The life histories and specific life stages of each target species were also considered relative to their known occurrence, distribution, and movement through the FRE site. Life

stages of specific species were selected if they have been observed moving or are believed to move through the FRE site (either upstream or downstream).

Table 1 presents the selected target fish species and their respective life stages.

Table 1. Target Fish Species and Life Stages Selected for Design Development

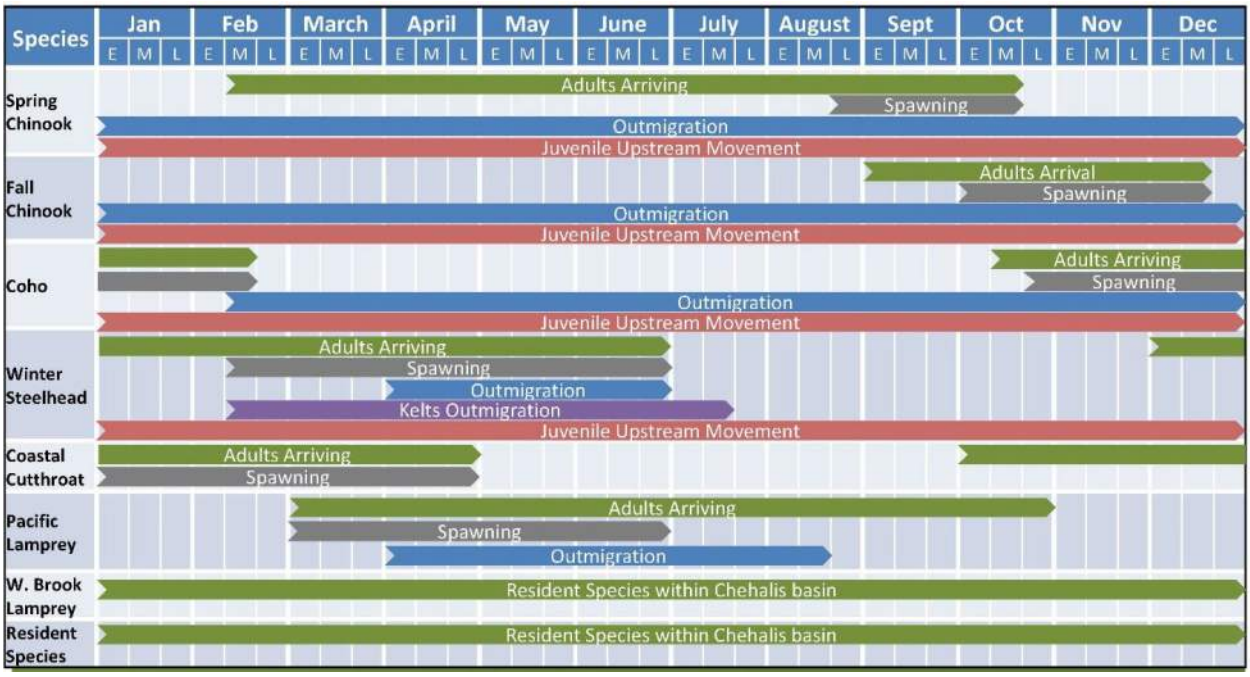
Species	Upstream	Downstream
Spring-run Chinook Salmon	Adult, juvenile	Juvenile
Fall-run Chinook Salmon	Adult, juvenile	Juvenile
Coho Salmon	Adult, juvenile	Juvenile
Winter-run Steelhead	Adult, juvenile	Adult, juvenile
Coastal Cutthroat Trout	Adult, juvenile	Adult, juvenile
Pacific Lamprey	Adult	Ammocoetes, Macropthalmia
Western Brook Lamprey	Adult	Ammocoetes, Macropthalmia
Resident Fish: river lamprey, largescale sucker, Salish sucker, torrent sculpin, reticulate sculpin, riffle sculpin, prickly sculpin, speckled dace, longnose dace, peamouth, northern pikeminnow, redside shiner, rainbow trout, mountain whitefish	Adult	Adult

Passage technologies for lamprey are relatively new, and few facilities exist in the western United States for passage or collection and transport above dams. Where applicable, readily available best practices, lessons learned from experimental facilities on the Columbia River, and interviews with researchers who specialize in understanding lamprey behavior and navigational capabilities were used to inform lamprey passage facility requirements and anticipated performance. In addition to salmonids and the anadromous Pacific lamprey, multiple resident fish species and two species of resident lamprey (Western Brook and River) are believed to inhabit and transit the proposed FRE area (Table 1). Therefore, these resident species are also included as target species.

Many of the target species have unique migration behaviors and are believed to pass upstream or downstream through the FRE site at specific times of the year. Fish species migration timing and duration influence the design and operation of proposed fish passage facilities by defining the physical, operational, and environmental conditions expected to occur while passage is required. The migration timing and duration for each selected fish species and life stage were discussed at Subcommittee/TWG meetings as new information was collected in the field and from literature sources. The resulting conclusions were used in fish passage design development (Figure 1). The selected values in Figure 1 summarize upstream migration, spawning, and outmigration periods suitable to inform robust fish passage designs. The periods shown in Figure 1

incorporate anecdotal data of species presence at the extreme ends of known movement periods and thereby are anticipated to be broader than what may actually be found in the river. Aquatic target species' actual migration and spawning periods are far more complicated and nuanced.

Figure 1. Anticipated Migration Periods of the Targeted Species and Life Stages (Periodicity)



4.2.1.2 Species Abundance

Fish abundance numbers for use in designing the Proposed Project's fish passage were evaluated by WDFW and discussed during Subcommittee meetings. As previously noted, species abundance numbers used in designing the fishway *do not represent current or predicted future species abundance* in the Proposed Project vicinity. Rather, these numbers were used to provide a conservative passage design that will meet passage needs under a variety of potential future fish abundance conditions. Specifically, abundance was described for the design in terms of peak annual and peak daily rates of migration. The peak daily rate of migration for upstream and downstream migrating fish influences the size of many fish passage components. Documents and information provided by WDFW (2016a and 2016b) during Subcommittee meetings were used in the design development of FFPF component sizes and capacities. The species abundance used in design are summarized in the subsections below.

Upstream Migration

Upstream migration rates developed for fish passage design are based on two factors: 1) historic data relative to adult spawner survey results and escapement records, and 2) proposed annual peak goals after project implementation and potential habitat restoration. Table 2 provides the design peak rate for annual migration of adult salmonids moving upstream.

Table 2. Peak Annual Upstream Migration Numbers Used to Inform FFPF Design

Species	Peak Annual Migration Numbers Informing FFPF Design
Spring-run Chinook Salmon	1,350
Fall-run Chinook Salmon	3,900
Coho Salmon	12,900
Winter-run Steelhead	5,630

The numbers for adult upstream-migrating Pacific lamprey, cutthroat trout, resident fish, and juvenile salmonids were not developed for fish passage design. Although these species are an important influence on the overall design of each fish passage alternative, their peak rate of migration is currently unknown and not anticipated to materially influence facility size, which is based on adult salmonids.

The peak daily counts of salmon and Steelhead migrating upstream were estimated as 10 percent of the maximum annual run (WDFW 1993), and peak hourly counts were estimated as 20 percent of the peak daily count based on Bell (1991) and as cited in NOAA Fisheries (2011). When both criteria results are applied, the peak hourly count is 2 percent of the annual run for each species. Using this methodology and based on the run timing information in Figure 1, a combined peak daily count of roughly 2,000 adult salmonids and a peak hourly count of 400 adult salmonids were used for design purposes.

Downstream Migration

Table 3 summarizes the total juvenile abundance numbers recommended by the TWG for use in the design of downstream fish passage for juvenile salmon and Steelhead, representing sub-adult fish produced upstream of the location selected for the FRE.

Table 3. Abundance[1] of Juvenile Salmon and Steelhead Downstream Migrants from Freshwater Habitat above River Mile 108 of the Chehalis River used to inform FFPF Design

Species	Life Stage	Migration Period	Maximum Abundance Number for FFPF Design
Coho Salmon	Fall parr	September–December	340,000
	Spring smolt	March–June	17,000

[1] Species abundance numbers used in designing the fishway *do not represent current or predicted future species abundance* in the Project vicinity. Rather, these numbers were used to provide a conservative passage design that will meet passage needs under a variety of potential future fish abundance conditions

Species	Life Stage	Migration Period	Maximum Abundance Number for FFPF Design
Steelhead Trout	Fall parr	September–December	97,000
	Spring smolt	March–June	14,500
Chinook Salmon	Subyearling (fry)	January–April	229,000
	Subyearling (parr/smolt)	May–August	114,500
	Yearling	March–June	11,000
Other Species	Data unavailable to support conclusions regarding downstream migration.		

For spring smolts, freshwater capacity and migration timing were used to predict total daily arrivals between January and August using two example migration curves originating from other river systems. Timing curve 1 represented a free-flowing river (Coweeman River), whereas timing curve 2 represented a dammed river where smolts rear in cooler stream temperatures and navigate a reservoir during their downstream migration (Cowlitz River). The daily numbers (mean and maximum values) of downstream migrants used for fish passage design were similar between the two migration timing curves when the considered species were included. However, when only Coho salmon and Steelhead trout were included, mean and maximum values were higher under timing curve 1 than timing curve 2. The difference between the two scenarios results from the smolts of Coho salmon and Steelhead trout having a more protracted migration timing under timing curve 2 than timing curve 1.

For fall migrants, timing curves were not available, and daily numbers were approximated for the design based on available information (WDFW 2016a and 2016b). Daily numbers of fall migrants used for fish passage design were based on the maximum daily values derived for spring smolts of Coho salmon and Steelhead trout increased by a multiplier of 17.0. The resulting maximum daily abundance selected for design purposes is 55,505 smolts as indicated in Table 4. As noted above, these numbers do not represent current or predicted smolt daily abundance numbers and were used to inform FFPF design features only.

Table 4. Daily Numbers of Downstream Migrant Fish Species Used to Inform FFPF Design[2]

Data include: juvenile salmon and steelhead from freshwater habitat upstream of river mile 108 in the Chehalis River.

Daily Metric	Spring Smolts (Jan–Aug)		Spring Smolts (Jan–Aug) Coho and Steelhead Only		Fall Smolts (Sep–Dec) Coho and Steelhead Only	
	Daily Abundance to Inform FFPF Design					
	Timing 1	Timing 2	Timing 1	Timing 2	Timing 1	Timing 2
Mean	1,919	1,882	203	82	3,451	1,394
Maximum	11,013	10,935	3,265	668	55,505	11,356

4.2.1.3 Resident Fish

NOAA Fisheries (2023a) and WDFW (2000a, 2000b) have established guidelines for salmonid passage facility design, but little data exists regarding the passage of lamprey and resident fish species through fish passage facilities. The Subcommittee, with support from the team's USFWS representative, assembled relevant biological data for the target resident species, lamprey, and salmonids but was unable to find data about all target resident species. A summary of the data compiled for each species is provided in Table 5. Through continued collaboration with the TWG, fish passage is being designed to accommodate the resident species listed in Table 5 to the extent possible, without adversely affecting facility performance for priority species (salmonids, cutthroat trout, and lamprey).

Table 5. Locomotive and Biological Data Availability

Species		Data Collected*	
Life Stage	Common Name	Swim Speed	Jump Height
Adult	Spring-run Chinook Salmon	●	●
Adult	Fall-run Chinook Salmon	●	●
Adult	Coho Salmon	●	●
Adult	Winter-run Steelhead	●	●
Juvenile	Spring-run Chinook Salmon	●	●
Juvenile	Fall-run Chinook Salmon	●	●
Juvenile	Coho Salmon	●	●
Juvenile	Winter-run Steelhead	●	●

[2] Species abundance numbers used in designing the fishway *do not represent current or predicted future species abundance* in the Project vicinity. Rather, these numbers were used to provide a conservative passage design that will meet passage needs under a variety of potential future fish abundance conditions

Species		Data Collected*	
Life Stage	Common Name	Swim Speed	Jump Height
Adult	Coastal Cutthroat Trout	●	●
Adult	Pacific Lamprey	●	Not applicable
Adult	Western Brook Lamprey	●	Not applicable
Adult	River Lamprey	●	Not applicable
Adult	Largescale Sucker	●	No data found
Adult	Salish Sucker	●	No data found
Adult	Torrent Sculpin	Not applicable	No data found
Adult	Reticulate Sculpin	Not applicable	No data found
Adult	Riffle Sculpin	Not applicable	No data found
Adult	Prickly Sculpin	Not applicable	No data found
Adult	Speckled Dace	●	No data found
Adult	Longnose Dace	●	No data found
Adult	Peamouth	●	No data found
Adult	Northern Pikeminnow	●	No data found
Adult	Redside Shiner	●	No data found
Adult	Rainbow Trout	●	No data found
Adult	Mountain Whitefish	●	No data found

● = Indicates a data source was identified

4.3 Technical Design Criteria

This section identifies technical design criteria, sources, and guidance for the development of fish passage designs. Technical fish facility design criteria typically fall into two categories: criteria and guidelines. Criteria are specific standards for fish passage design that require an approved variance from the governing state or federal agency before a design can deviate from the established criteria. Deviating from an agency-established criterion requires establishing a site-specific, biological- or physical-based rationale for the deviation.

In contrast, guidelines provide a range of values or specific values the designer should seek to achieve but that can be adjusted for project-specific conditions to achieve the overall fish passage objectives by supporting better performance or solving site-specific issues. Governing agencies may request adjustments to a design during development.

The technical design criteria used in the RPDR were primarily developed in previous design phases and documented in previous design documents. The NOAA Fisheries fish passage design guidance has been updated since the previous design documents. The design criteria in this report and appendices reflects design criteria from the current NOAA Fisheries guidance (2023a). If two or more agencies provide differing guidance on a design criterion, the most conservative guidance for fish passage and protection will be followed. The following documents provide the guidelines used during the previous conceptual design and the current design:

- NOAA Fisheries WCR Anadromous Salmonid Design Manual. (NOAA Fisheries 2023a)
- NOAA Fisheries WCR Guidance to Improve the Resilience of Fish Passage Facilities to Climate Change (NOAA Fisheries 2023c)
- Anadromous Salmonid Passage Facility Design (NOAA Fisheries 2011)
- Best Management Practices to Minimize Adverse Effects to Pacific Lamprey (USFWS 2010)
- Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual (WDFW 2009)
- Fishway Guidelines for Washington State (WDFW 2000a)
- Fish Protection Screen Guidelines for Washington State (WDFW 2000b)
- Water Crossing Design Guidelines (WDFW 2013)

4.3.1 General Technical Design Criteria

Technical design criteria for each fish passage component of the Proposed Project are discussed in the following subsections. General fish passage criteria apply to project components where fish passage must be maintained (i.e., conduits, fishways, FFPF, and construction bypass), unless shown otherwise.

4.3.1.1 Fish Passage Design Flows

Fish passage design flow criteria influence several factors associated with fish passage facility size and complexity. NOAA Fisheries and WDFW provide guidelines for the selection of high and low flows to be used in the design of fish passage facilities. These guidelines are based on exceedance calculations of mean daily flows but can be modified to accommodate site-specific requirements. The exceedance flows statistically represent the flow equaled or exceeded during certain percentages of the time when migrating fish may be present. The established guidelines are used to set instream flow depths, flow velocities, debris and bedload conditions, fish attraction requirements, tailwater fluctuations, and numerous other factors that a facility may experience while target fish species are migrating.

NOAA Fisheries (2023a) requires the high fish passage design flow to be the mean daily stream flow that is exceeded 5 percent of the time during periods when target fish species are migrating using the 90th percentile t-distribution of the late-century ensemble

climate change projection. WDFW (2000b) suggests a 10 percent exceedance flow be used as a high design flow using hydrologic analysis of the historic period of record. NOAA Fisheries (2023a) requires a low fish passage design flow equal to the mean daily stream flow that is exceeded 95 percent of the time during periods when migrating fish are typically present using the 90th percentile t-distribution of the late-century ensemble climate change projection. Because using the 90th percentile t-distribution for the 95 percent exceedance resulted in increased, not decreased flows, NOAA Fisheries agreed that the 95 percent exceedance should be based on the late-century ensemble mean. WDFW recommends that a low flow be established based on site-specific conditions using hydrologic analysis of the historic period of record. A flow range between the 95 and 5 percent exceedance flows based on the late-century ensemble of climate change models provides the widest range of flows for which facilities should be capable of passing fish. Therefore, this flow range is set as the design criterion for the proposed facilities.

Per *NOAA Fisheries WCR Guidance to Improve the Resilience of Fish Passage Facilities to Climate Change* (NOAA Fisheries 2023c), the effects of climate change need to be considered when establishing fish passage design flows. As the fish passage conduits have a life expectancy of more than 10 years, the Proposed Project must follow the process for long-term projects defined in Section 2.3 of the guidance. This nine-step process is underway and collaboration with NOAA Fisheries is ongoing at document publication. The current process ends with final design. A NOAA Long-Term Project Climate Change TM (HDR 2026) documents the first seven steps and is available to Ecology upon request. On September 26, 2025, NOAA Fisheries established the fish passage design flows based on this process. The high and low fish passage design flows are 3,200 and 11 cfs, respectively.

4.3.1.2 Sediment Continuity Design Flow

The Chehalis River Basin Flood Control Zone District has committed to maintaining the continuity of movement for spawning gravels passing downstream through the FRE structure. This commitment includes passing river flow at levels capable of mobilizing and transporting spawning gravel in an open channel(s) through the FRE structure. The river flow “capable of fully mobilizing the surface armor layer of spawning substrates…” is identified as the current climate 2-year flood event (Kleinschmidt 2024). Kleinschmidt states the river flow mobilizing spawning gravel is about 6,976 cfs, which corresponds to about a 2-year flood event according to the hydrologic analysis they cite. Recent hydrologic analysis by HDR has identified the Chehalis River flow for the current climate 2-year flood as 9,500 cfs (HDR 2025). The conduits are designed to pass 13,700 cfs, well above 9,500 cfs, in an open channel condition, more than is needed to pass the sediment mobilizing river flow identified by Kleinschmidt.

4.3.1.3 Fish Passage Conduits

At the time of Subcommittee consultations, the fish passage conduits were intended to provide primary, year-round, safe, volitional upstream and downstream passage for migrating adult salmon and Steelhead, resident fish, and lamprey for the full range of fish passage flow conditions as required by NOAA Fisheries criteria. During a 2014 study by

HDR, criteria used to assess the fish passage conduits was based on the 2013 *Water Crossing Design Guidelines* document, which suggests that a minimum hydraulic design target of 0.8 feet of water depth and maximum flow velocity of 2 feet per second (ft/s) be used for water crossing structures with lengths of approximately 200 feet. However, in consultation with members of the Subcommittee in 2015 and 2016, it was determined that the natural flow characteristics in this reach of the river were more restrictive to passage than WDFW's guidelines. It was agreed that the hydraulic conditions in the natural channel upstream and downstream of the passage tunnels (fish passage conduits) would negate the passage benefit of designing the tunnels to WDFW's guidelines. Therefore, the Subcommittee concluded that the proposed flow velocity and depth through the conduits mimic the flow velocity and depth occurring naturally through the existing river reach at the FRE. This premise influenced the overall approach for designing and evaluating performance of upstream and downstream passage through the conduits. As such, the proposed approach cannot be categorized as the hydraulic design method or the stream simulation method but rather a site-specific approach that incorporates elements of both.

This design approach was revisited and presented to WDFW, NOAA Fisheries, and the TWG during the course of this study, who raised no objections. The location of the existing rock-incised channel was shared with the TWG on January 17, 2024.

4.3.1.4 Swimming Capability

Swimming and leaping capabilities for target species were used in developing the draft hydraulic fish passage criteria. The Subcommittee decided fish passage through the FRE during run-of-river conditions must mimic the hydraulic conditions of the existing rock canyon located immediately downstream of the proposed FRE. Specific, measurable criteria to this effect were defined during an April 4, 2025 meeting with NOAA Fisheries. The specific hydraulic design criteria were based on the swim speed of the target species. A table of species' swim speeds was shared and discussed with NOAA Fisheries in a meeting with NOAA Fisheries on March 4, 2025. Discussion in this meeting led to establishing the hydraulic criteria. The hydraulic criteria are grouped into three ranges of river velocity based on the swim capabilities of the target species and life stages:

- 0 to < 1.5 feet per second (ft/s) resident/juvenile salmonid prolonged
- 1.5 to < 3.5 ft/s adult salmonid sustained
- 3.5 to 7 ft/s adult salmonid prolonged

These river velocity ranges and the specific fish passage requirements associated with them have not been finalized with NOAA Fisheries. For this evaluation, the following **draft passage criteria** were used where the river flow was within the fish passage design flow range:

- 0 to < 1.5 ft/s resident/juvenile salmonid prolonged and 1.5 to < 3.5 ft/s adult salmonid sustained.
- A continuous flow pathway **must be provided** through the proposed FRE structure with flow velocities within these ranges where three-dimensional computational fluid

dynamic modeling indicates a continuous pathway exists for this velocity range through the existing rock canyon 3.5 to 7 ft/s adult salmonid prolonged.

- A continuous flow pathway is **preferred but not required** through the proposed FRE structure with flow velocities within these ranges where three-dimensional computational fluid dynamic modeling indicates a continuous pathway exists for this velocity range through the existing rock canyon.

4.3.1.5 Juvenile Fish Sounding

Appendix B (Juvenile Fish Sounding TM) summarizes the research and findings related to the potential risk of juvenile entrainment in the unscreened, high velocity evacuation conduits at this location on the Chehalis River. The research and findings in this Technical Memo (TM) were discussed with NOAA Fisheries in 2025. The TM concludes that most juvenile salmonids likely would not sound deeper than 30 feet in a temporary inundation pool at the FRE structure and would have limited exposure to potential entrainment and flood operation conditions at the FRE. A hydraulic outlet that does not exclude fish or provide safe downstream passage through hydraulically favorable conditions must only discharge flow during flood retention operation when the water surface is 30 feet or more above the top of the same hydraulic outlet. Hydraulic outlets that discharge when the water depth is less than 30 feet must have a smooth inlet transition, such as curved entrances and radial gates. Accordingly, evacuation conduits will remain unscreened and the 30-foot depth threshold be used to govern evacuation operations.

4.3.1.6 Fishways

The original concept of fish passage conduits relied on multiple conduits, arrayed at staggered invert elevations, with different sizing and roughness features to support passage hydraulics across the range of fish passage design discharge. Additionally, these conduits are subject to evaluation criteria related to temporary inundation area evacuation and passage of the 2-year event, which conflict with attempts to optimize for fish passage. To meet design criteria and deconflict competing requirements, a revised conduit and stilling basin configuration is proposed to support fish passage and provide more reliable sediment throughput. This design revision includes dual outboard technical fish ladders as fishways (Figure 3; Section 5.1).

4.3.1.7 Lamprey Passage

As requested by participating resource agencies and Indian Tribes, the best available science for lamprey passage was considered throughout the design. Lessons learned from experimental facilities on the Columbia River, and interviews with researchers who specialize in understanding lamprey behavior and navigational capabilities were used to inform lamprey passage facility requirements, which are summarized in Table 6.

The following resources outline several best practices that were used to form a basis of design for lamprey passage technologies and measures:

- Technical White Paper: Practical Guidelines for Incorporating Adult Pacific Lamprey Passage at Fishways, Version 2.0 (Lamprey Technical Workgroup 2022)
- Use of Adult Pacific Lamprey Passage Structures at Bonneville and John Day Dams (USACE 2019)
- Passage Guidelines for Select Native Pacific Northwest Fish, USFW Region 1, Version 2.0 (USFW 2025)
- Technical Report 2015-5: Design Guidelines for Pacific Lamprey Passage Structures, Portland District (USACE 2015)
- Barriers to Adult Pacific Lamprey at Road Crossings: Guidelines for Evaluating and Providing Passage, Version 1.0 (Lamprey Technical Workgroup 2020)

Table 6. Lamprey Upstream Passage Criteria

Criteria	Value	Reference
Free swimming flow velocity	<2.95-3.9 ft/s	Lamprey Technical Workgroup 2022
Max burst free swimming flow velocity	<8.2-9.8 ft/s	Lamprey Technical Workgroup 2022
Ramp width	1.0 ft, min 2.0 ft, min	Lamprey Technical Workgroup 2022, USACE 2015
Resting area velocity	2.95 ft/s, max	Lamprey Technical Workgroup 2022
Water depth in ramp	1 foot, min	Lamprey Technical Workgroup 2020, USFWS 2025
Wetted Surface Finish	Smooth, 1.2 inch gap, max	USFWS 2025
Diffuser Grating	0.5 inches or less	Lamprey Technical Workgroup 2022

4.3.1.8 Trashracks

Trashracks are commonly used at fishway exits and entrances to prevent large debris from entering fish passage facilities. They are also used at fish passage conduits. Table 7 lists the design criteria for trashracks.

Table 7. Trashrack Criteria

Criteria	Value	Reference
Velocity	1.5 ft/s, maximum	NOAA Fisheries 2023a
Water depth	Equal to fish ladder exit pool depth	

Criteria	Value	Reference
Bar spacing	10 inches, minimum	
Support bar spacing	24 inches, minimum	
Slope	1 horizontal 5 vertical	

4.3.1.9 Constructed Channels

A reference reach design approach to be used for the permanent Chehalis River approach and discharge channels, for Crim Creek confluence, and for the construction phase Chehalis River and Crim Creek bypass channels (WDFW 2013, NOAA Fisheries 2023b). This approach was presented to WDFW, NOAA Fisheries, and the TWG during the course of this study, who raised no objections. The locations of the reference reaches were shown in slides at the January 17, 2024 TWG meeting.

4.3.2 General Operating Criteria

Operational trigger, rules, and frequency for impoundment events is described in the Environmental Impact Reduction Due to Refinement of Proposed Reservoir Operations and Debris Management During Retention Operations TM which is appended to the District's comments on the SEPA RDEIS. "Impoundment events" refer to flood operations triggered by high flows at Grand Mound but do not include backwater events. Backwater events are infrequent events where the river flow exceeds the open-channel capacity of the conduits, and some water is retained upstream of the FRE structure. The number and duration of backwater events that would have occurred during the historic period of record is described in Appendix D - Backwater Analysis Pool Frequency with Conduit Gates Open (Draft) TM.

During impoundment events that coincide with flood retention activities, downstream passage of outmigrating fish will be delayed. During Flood Retention Operations, the conduit gates will be operated to control flow release and retain water upstream of the facility. Outmigrating fish entering the temporary inundation area at this time will also be temporarily delayed until the pool drains and open channel river flow resumes. When the inundation pool depth is lower than the juvenile fish sounding depth, either early as the inundation pool begins filling or when it is almost fully drained, flow must be released through gates designed for fish passage or through outlets that exclude fish passage in accordance with federal and state criteria. When the inundation pool is below sounding depth, some fish may choose to pass downstream via gates designed for fish passage. Downstream passage through conduits with fully open gates will resume when normal operation resumes.

Note that backwater is expected to occur when the river's natural flow is greater than the capacity of the fish passage conduits but not enough at Grand Mound to trigger an impoundment event. Backwater is expected to occur once river flow reaches 13,700 cfs. River flow data was analyzed for the historic period 1982–2022. For this historic period, backwater events are estimated to have occurred on average once every 3.3 years and

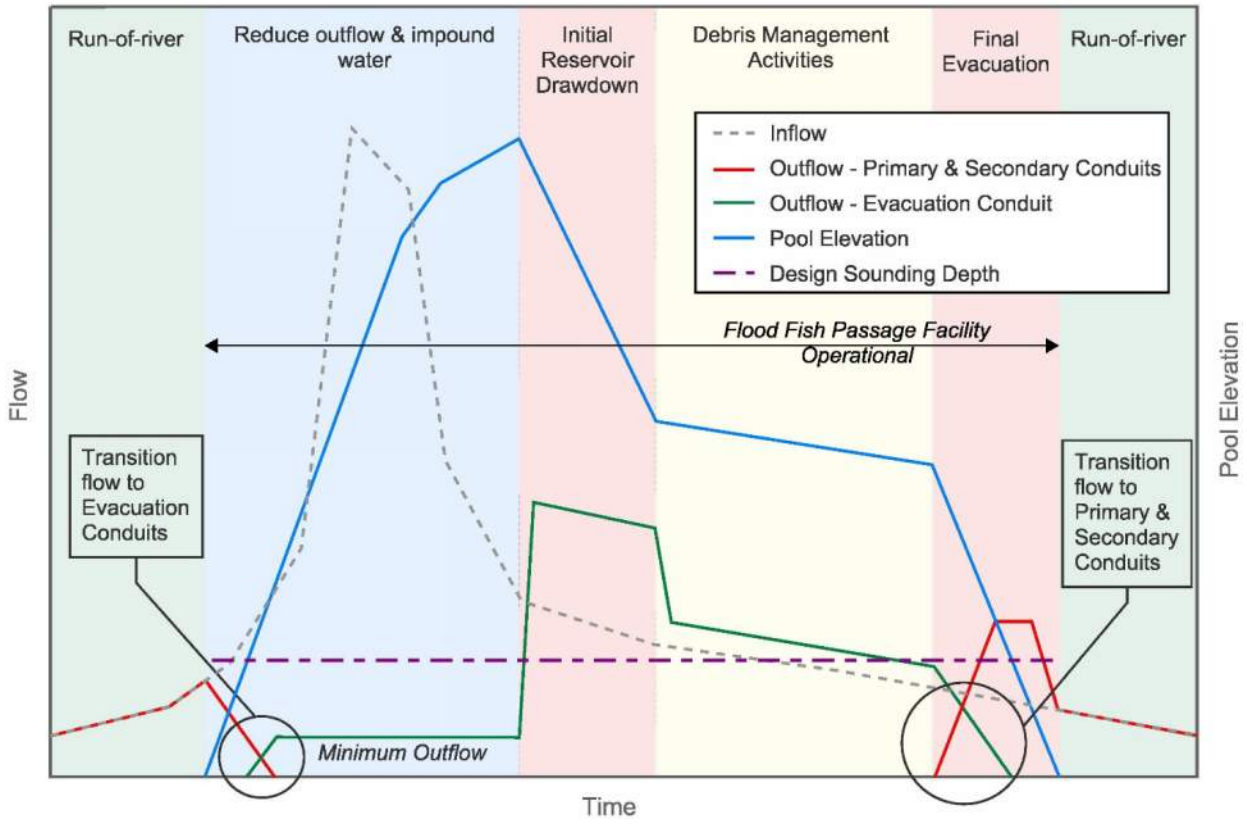
last an average of 3.6 hours, with the maximum duration being 6.5 hours (Appendix D). Backwater is expected to occur for flows well above the range of flows during which the project must provide fish passage (11 to 3,200 cfs; Section 4.3.1.1). During these temporary pooling (backwater) events, the fish passage conduit gates will not be operated and will remain fully open, and operation of the FFPF will not be required. Fish are anticipated to reside or shelter below the facility during such events (which are short in duration) and continue passage once conditions improve.

4.3.2.1 Water Supply

Water supply for the AWS and FFPF can be provided by pump station or via gravity. The Subcommittee agreed AWS may be provided solely via gravity from the impoundment pool when the impoundment pool depth exceeds the juvenile fish sounding depth. A literature review of juvenile sounding depth was conducted and discussed with NOAA Fisheries. The sounding depth used in the current design, as agreed upon with NOAA Fisheries, is discussed in Section 4.3.1.5, and documented in Appendix B. When the water depth in the inundation pool is less than the design sounding depth, water from the inundation pool must either be screened to exclude fish in accordance with NOAA Fisheries (2023a) and WDFW (2000b) guidance or provided from another source meeting the same screening requirements, such as from a pump station. Figure 2 is a graphed impoundment event example showing unscreened discharge (evacuation conduits) only being used when the impoundment pool depth exceeds the design sounding depth.

The amount of attraction flow required varies with changes in river flow. During FFPF operation all river flow at the FFPF location comes from inundation pool discharge. When the inundation pool discharge is greater than the high fish passage design river flow (refer to Section 4.3.1.1), the FFPF will continue to operate and attraction flow is not required to exceed 300 cfs. Attraction flow must be greater than 5 percent of the river flow for flows below the high fish passage design flow. AWS may not be necessary to meet this requirement at lower river flows as operational flows from the fish ladder may be sufficient to meet attraction flow requirements.

Figure 2. Attraction Water and Auxiliary Water Supply Durations During a Sample Impoundment Event



5 Fish Passage Outlet Works Design

This section summarizes the fish passage outlet works design.

FRE facility operation occurs in two main operational states:

- **Normal Operation:** When the fish passage and hydraulic outlet gates are open and the Chehalis River flows through the FRE unimpeded.
- **Flood Retention Operation:** When the fish passage gates are closed and openings on the hydraulic outlets are reduced to impound incoming floodwaters behind the FRE.

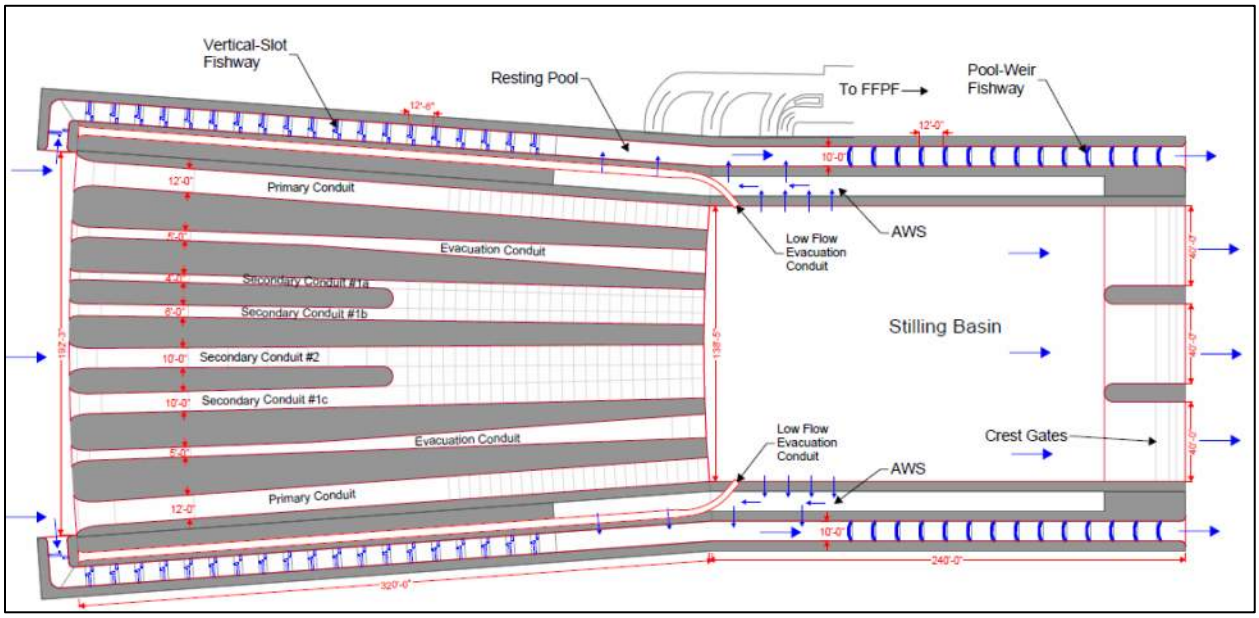
Upstream fish passage during Normal Operation is primarily provided by dual fishways located adjacent to the FRE outlet works. Passage conduits serve as secondary upstream passage pathways and the primary downstream pathway.

5.1 Fishways and Conduits

During Normal Operation, dual fishways serve as the primary feature facilitating upstream fish passage (Figure 3). The entrances to the fishways are located adjacent to the stilling basin endsill crest gates. Following input from NMFS during consultation, these gates are raised for flows within the fish passage design discharge range to serve

as a vertical passage barrier. The passage conduits remain open, except under low flow conditions, but function primarily to provide downstream passage to the stilling basin and beyond. Within the range of fish passage flows, the passage conduits will be able to support upstream escape for fish in the stilling basin due to fallback.

Figure 3. Fishway and Passage Conduit Layout

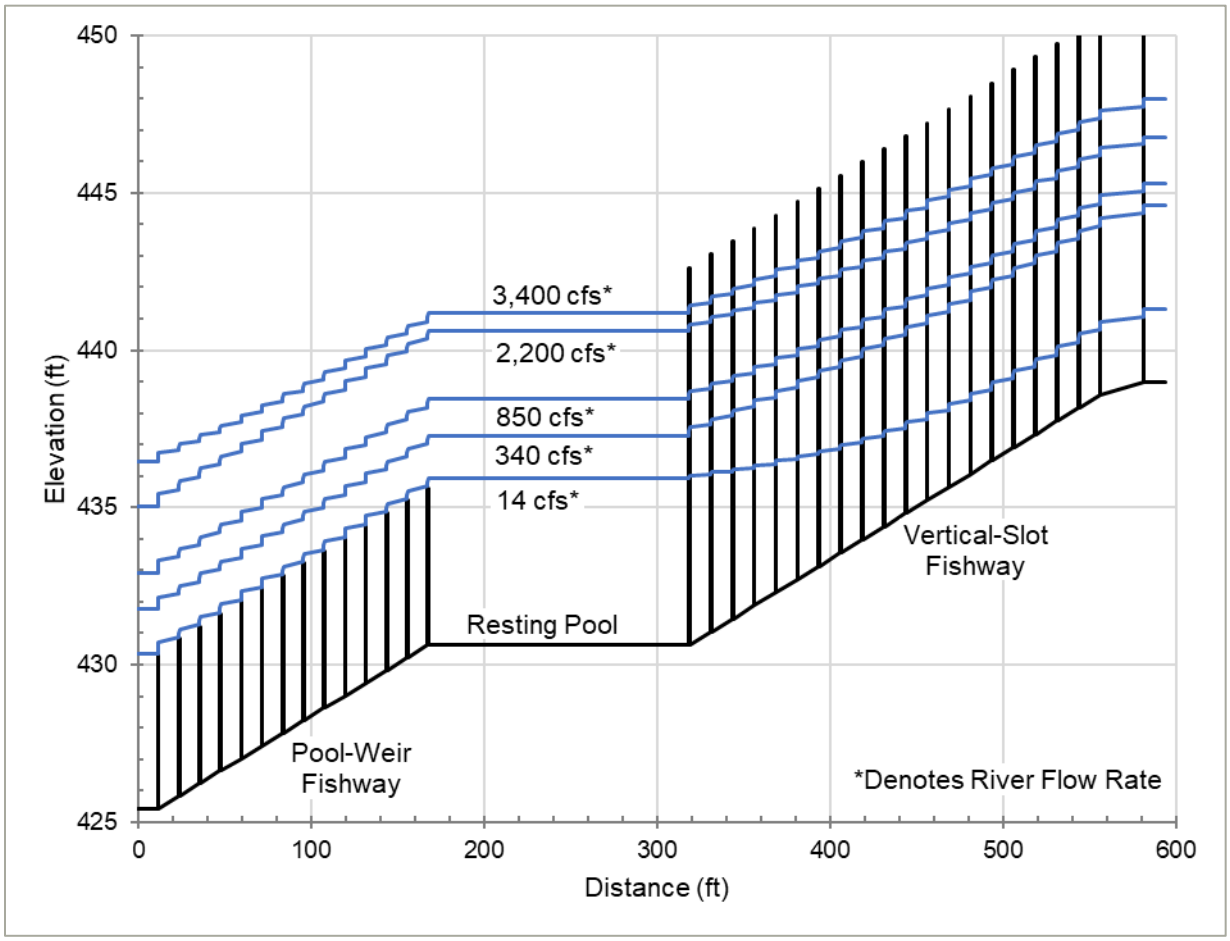


5.1.1 Fishways

Technical fish ladders consist of a concrete fish ladder passing through the FRE structure. The design target hydraulic differential between baffles in the ladder will follow standard agency design guidelines for the upstream passage of juvenile salmonids. Pool geometry will be established using NOAA Fisheries (2023a) guidelines and consider the specific baffle type selected for the ladder. A fish ladder will be composed of typical pools which may include resting pools, turning pools, and potentially multiple exit pools to account for temporary inundation area stage fluctuations. This technology requires consideration of guidance, attraction, and collection strategies for the fish ladder entrance as well as debris, temperature, and flow control provisions.

There will be two fishways on either side of the conduits to provide reliable fish passage upstream of the FRE. The fishways will consist of three main components: the pool-weir, resting pool, and vertical-slot sections. The fishway will be 10 feet wide through all the different sections. The pool-weir section will be at the fish entrance and contain a bent weir with a 90-degree V-notch for low flows. The resting pool will contain a vertical screen for additional flow from the AWS, and fish entrances on the left fishway for the FFPF. The vertical-slot section will continue through to the fish exit and have a slot width of 1.25 feet. Figure 4 shows the water surface elevations through the fishway.

Figure 4. Fishway Water Surface Profiles



5.1.2 Conduits

The fish passage primary and secondary conduits will operate with gates open for downstream fish passage and sediment transport but be closed for Flood Retention Operation. There are some instances where gates are closed to facilitate fish passage at lower flows, when only the fishways are in operation. During initial phases of flood retention, the passage conduit gates will be used to regulate the flow until flow control is transferred to the evacuation conduits. After the passage conduit gates are closed, the evacuation conduit will be used for reservoir releases. The secondary conduits will be used for emergency flood releases or reservoir drawdown when the required capacity is insufficient to meet the required flow.

The passage conduit sizing and configuration will support upstream passage for the fish passage design flow range. Under these conditions, the stilling basin endsill is raised to serve as the tailwater control necessary to support the requisite passage depth and velocity criteria.

5.1.2.1 Controlling Flow Design Scenarios

The controlling flow design scenarios were compiled to better understand and evaluate the effectiveness of the primary, secondary, and evacuation conduits to meet the potential flow requirements. During flow-through conditions, all the gates are fully open, except for during very low flow when only the fishways are operating. During flood retention, the gates are throttled or closed. Special considerations are included to ensure downstream fish passage at sounding depths under a throttled gate. The minimum flow during flood retention can occur at any elevation up to the spillway crest elevation. Design provisions include adding a narrower secondary conduit to facilitate minimum releases at lower pool elevations, and a low-flow evacuation conduit to make minimum releases at pool elevations near the spillway crest elevation. The maximum flow during flood retention is accommodated using the two evacuation conduits. If additional flow is required, then the secondary conduits will be used to supplement the maximum flow. Table 8 provides a high level summary of the controlling flow design scenarios.

Table 8. Controlling Flow Design Scenarios

Description		Value (cfs)
Flood Retention Gates Regulate Outflow	Minimum Flow	300
	Maximum Flow	10,000
Flow-Through Gates Fully Open	Fish Passage Flows	14 – 3,400
	Sediment Mobilization Flow	7,000 – 9,500
	Maximum Flow	13,700

cfs = cubic feet per second.

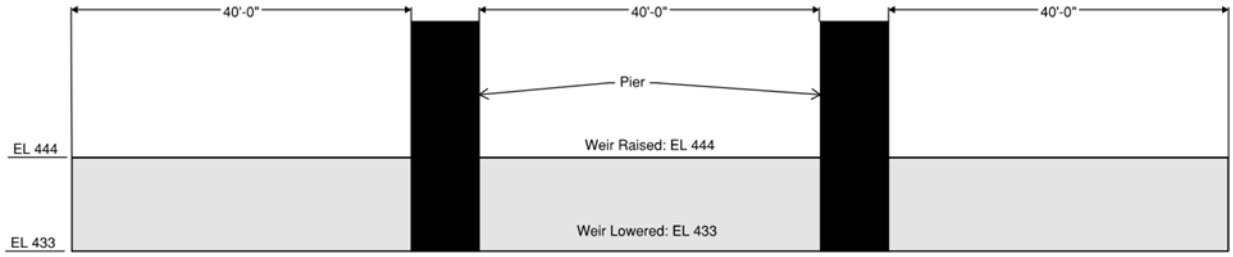
5.1.2.2 Primary and Secondary Conduits

The primary and secondary conduit features, described from downstream to upstream include the end sill, stilling basin, conduit profiles, and conduit entrance.

End Sill Crest Gates

The end sill is intended to provide sufficient backwater to prevent a hydraulic jump from forming within the conduits, thus limiting the velocity in the conduits and providing sufficient depth for fish passage. The end sill will also provide sufficient water depth in the stilling basin to provide the AWS (auxiliary water supply) to the fishways via gravity flow. Lastly, the end sill directs fish toward the fishways providing connectivity to the upstream channel. The end sill will have three 40-foot bays with two piers to house the adjustable crest gates that can be raised or lowered during times of sediment mobilization or fish passage conditions. Figure 5 shows the adjustable end sill crest gates concept.

Figure 5. End Sill Configuration

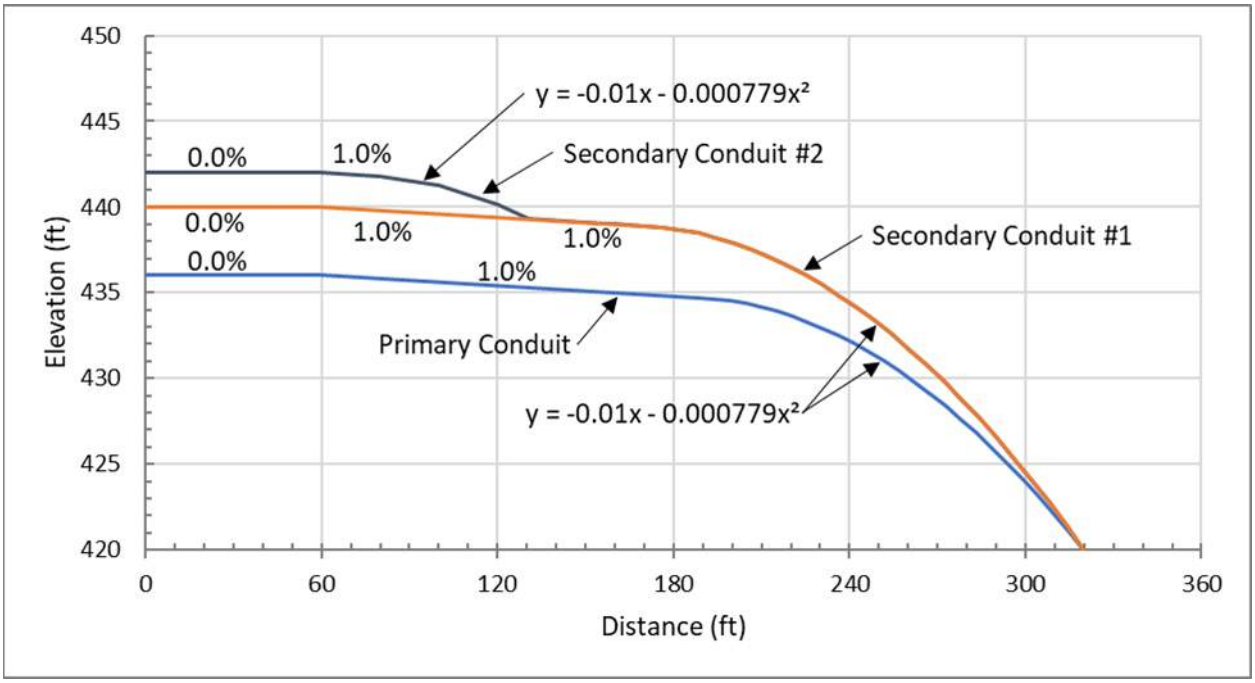


EL: elevation.

Conduit Profiles

The conduit profile is based on three sections, the horizontal section through the gates, a 1 percent slope, and a parabolic profile transitioning the conduit invert elevation into the stilling basin elevation. The parabolic profile is based on the trajectory of a jet under the gravitational forces based on calculated velocities during gate-controlled flows, which provides positive pressures on the invert during all flow events. Figure 6 shows the profile for the primary and secondary conduits.

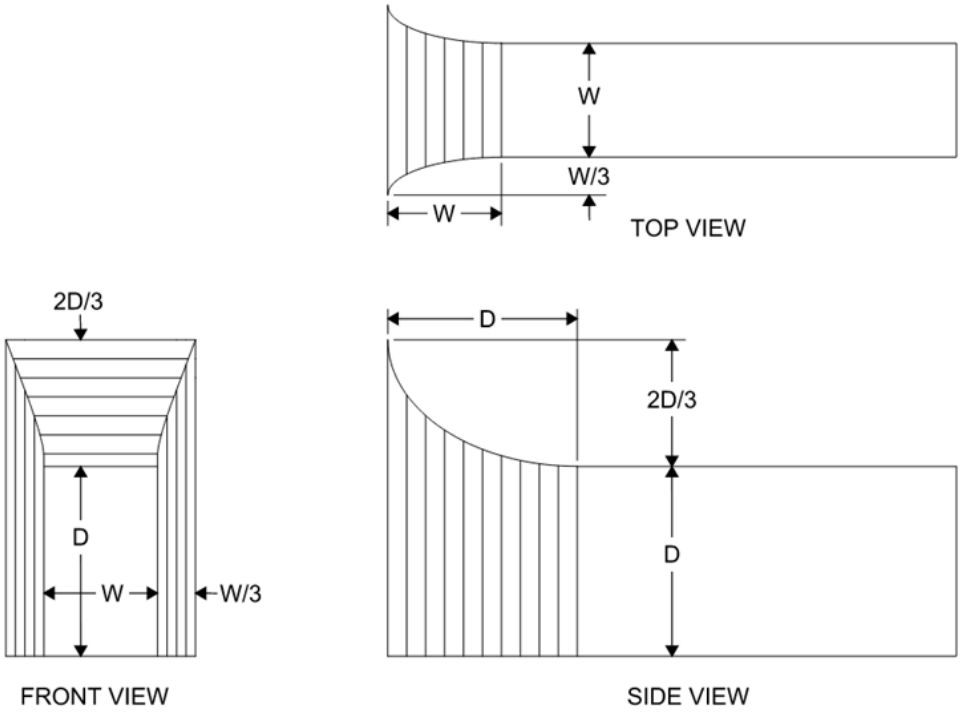
Figure 6. Profiles for Primary and Secondary Conduits



Conduit Entrance Curves

To avoid flow separation and unsatisfactory pressure conditions, a roof curve and sidewall curves were added to the primary and secondary conduit entrances. The roof and sidewall curves are based on an elliptical curve. Figure 7 shows the profile view of the elliptical roof and sidewall entrance curves based on the primary and secondary conduit height and width.

Figure 7. Plan and Section View of Entrance Curves



Conduit Water Surface Profiles

During flow-through conditions, the gates will be fully open with the flow in an open channel state through the structure. Figure 8 through Figure 10 contain the water surface profiles in each of the conduits at different river flow rates from the climate fish low flows to the 2-year (50 percent Annual Exceedance Probability) flow. The downstream end sill will sufficiently backwater the conduits to reduce conduit velocities and provide sufficient depth for the AWS flow to the neighboring fishway via a vertical diffuser screen. At the 2-year flow, the end sill crest gates will be lowered and a hydraulic jump will form within the conduits. The conduits will operate in an open channel condition for flows up to and including the 2-year event.

Figure 8. Primary Conduit Water Surface Profiles

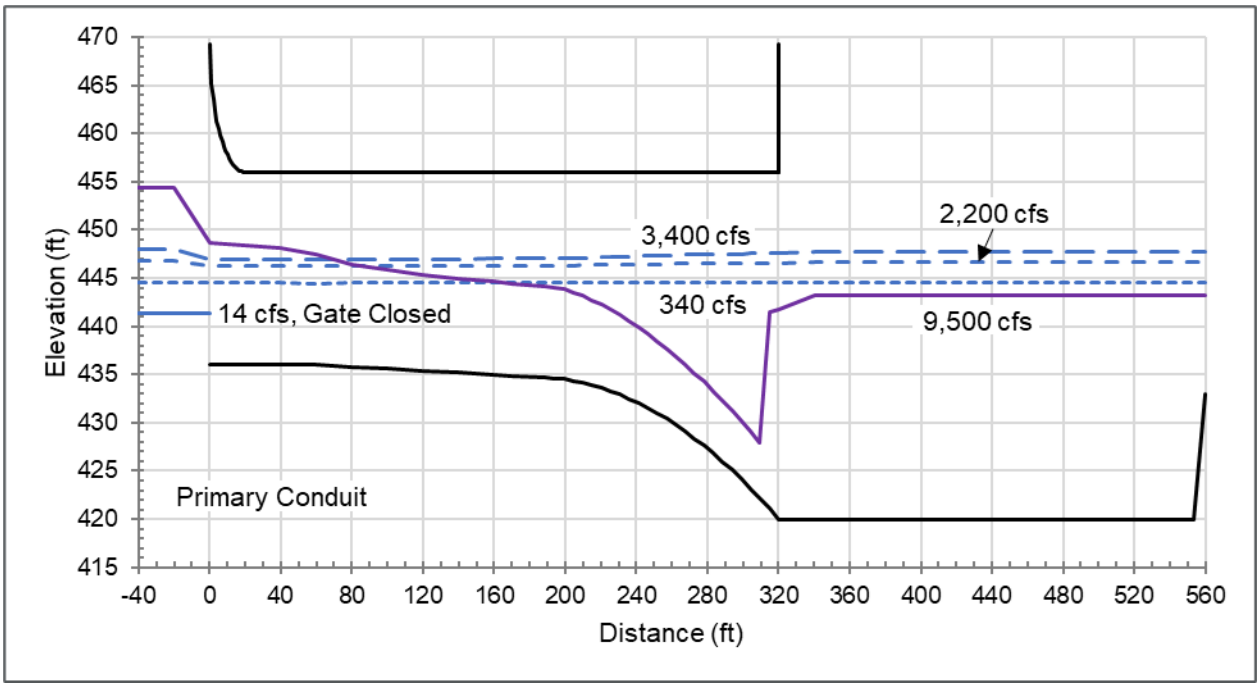


Figure 9. Secondary Conduit Number 1 Water Surface Profiles

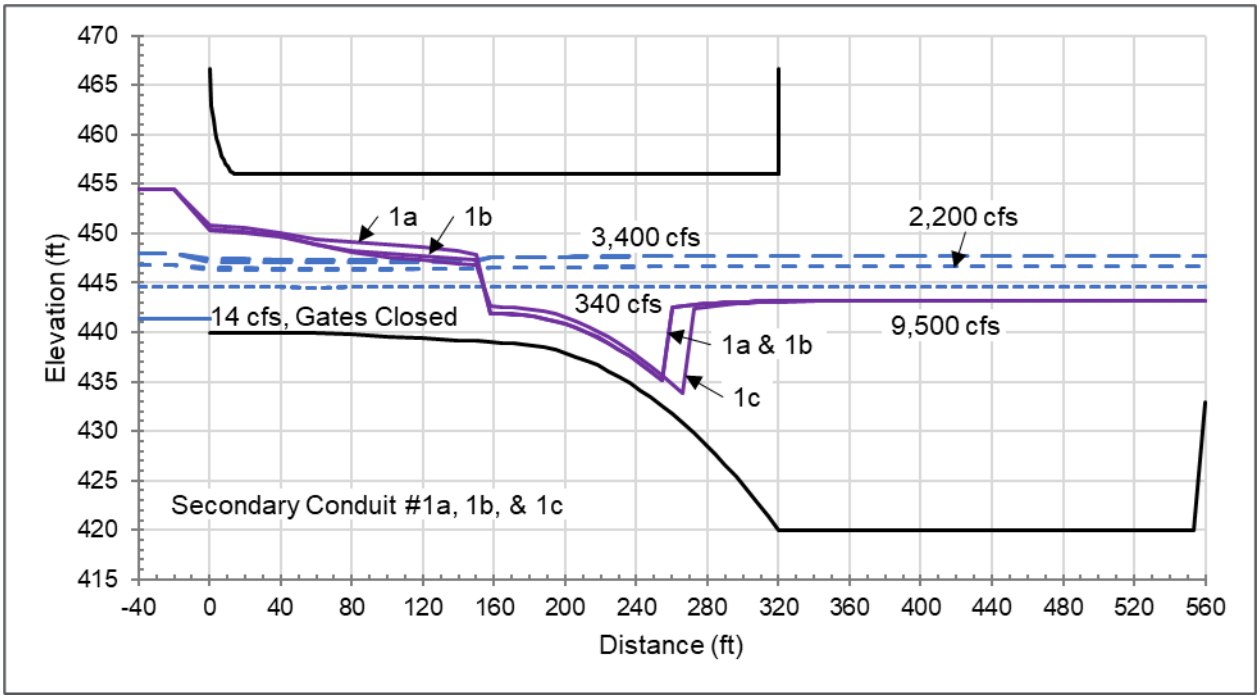
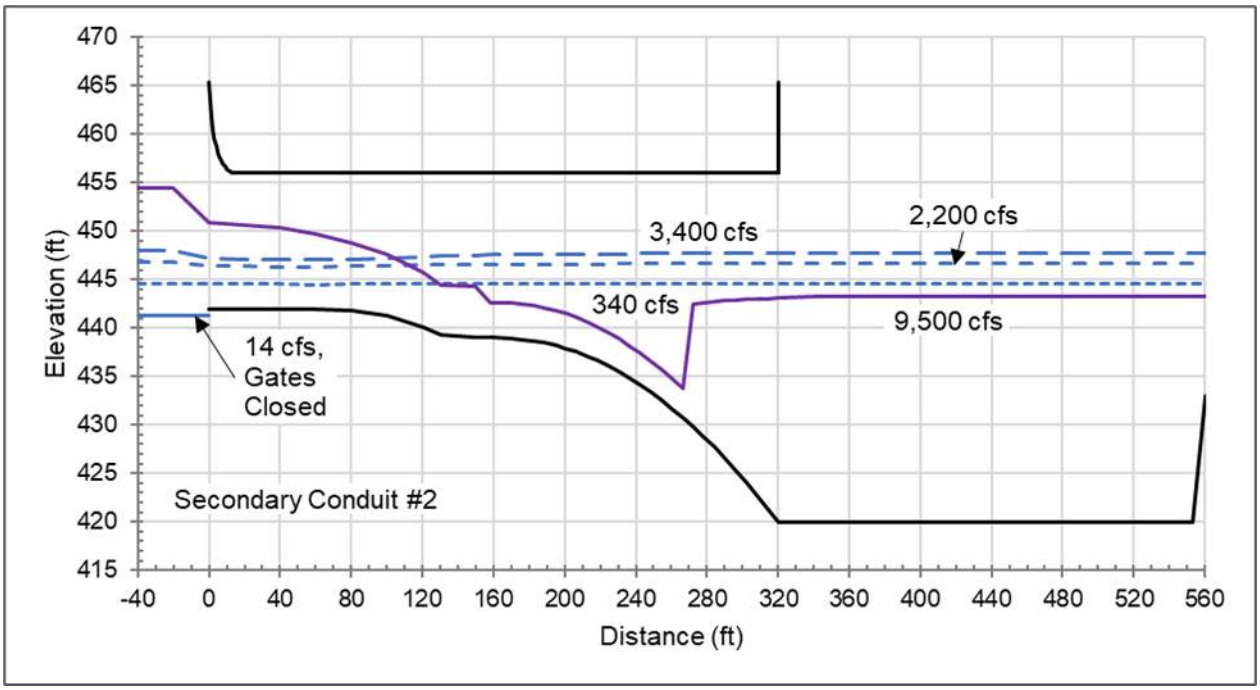


Figure 10. Secondary Conduit Number 2 Water Surface Profiles



Gate Control Flow Capacity for 10% to 80% Open

During flood retention, the primary and secondary conduit gates will be throttled or closed. Figure 11 to Figure 15 provide the gate-controlled flow for the primary and secondary conduits at gate openings between 10 and 80 percent open. The gate-controlled flows are intended to inform operations on specific gates that will best suit the desired flow rates while considering fish sounding depths before transitioning flows to the evacuation conduits.

Figure 11. Primary Conduit Gate-Controlled Flow Rates

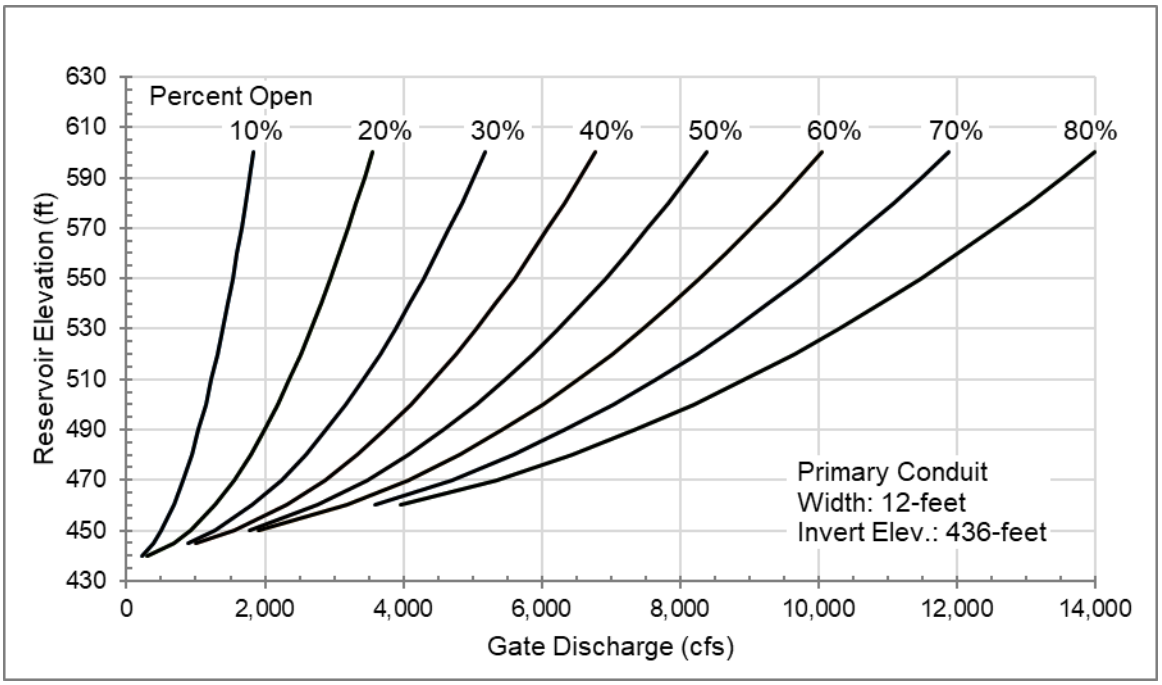


Figure 12. Secondary Conduit 1a Gate-Controlled Flow Rates

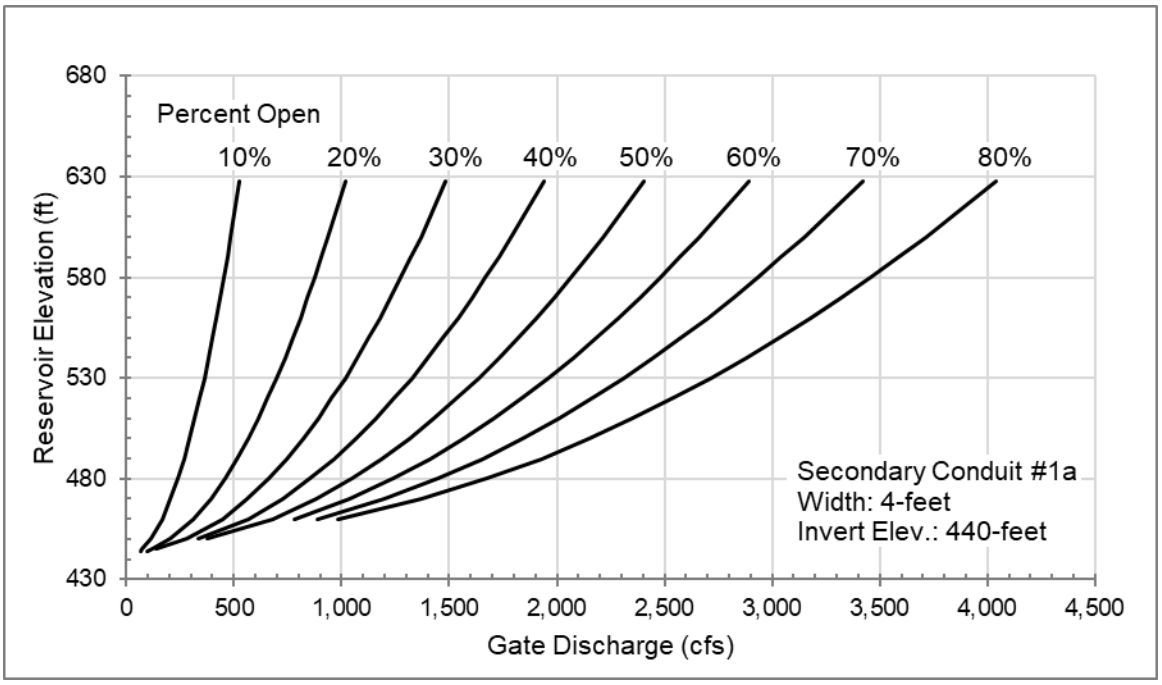


Figure 13. Secondary Conduit 1b Gate-Controlled Flow Rates

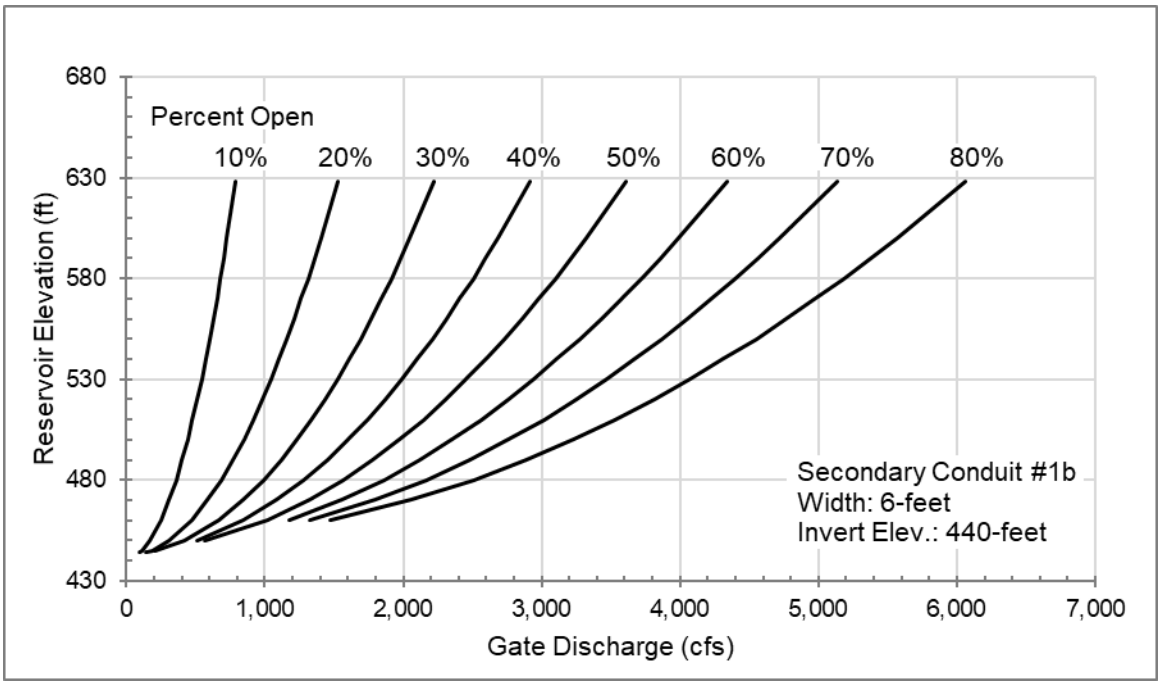


Figure 14. Secondary Conduit 1c Gate-Controlled Flow Rates

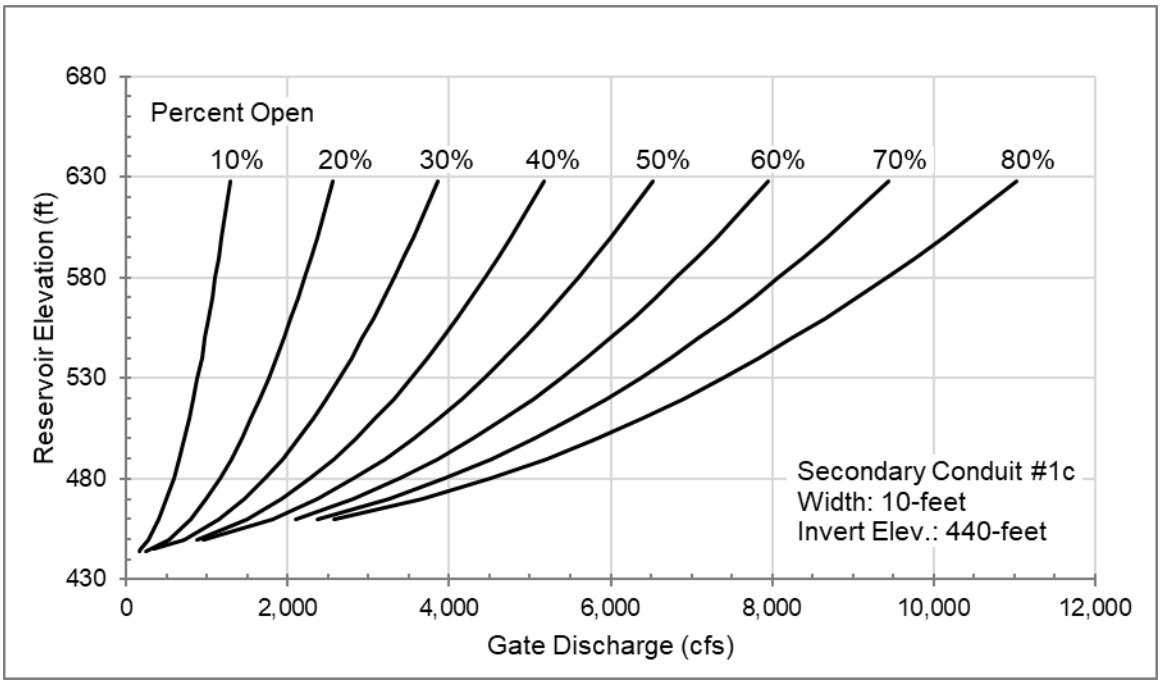
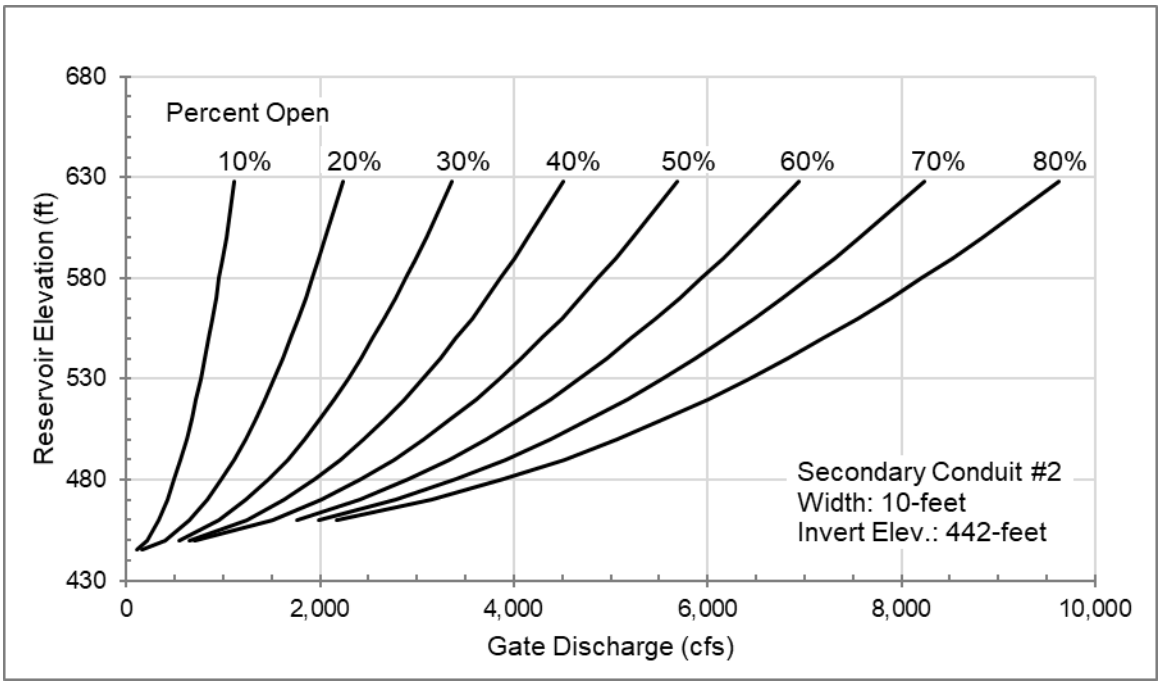


Figure 15. Secondary Conduit 2 Gate-Controlled Flow Rates



5.1.2.3 Stilling Basin Endsill and Vertical Barrier

The fishway entrance is located near the stilling basin endsill. Unlike the original concepts, the stilling basin endsill will be variable with Obermeyer weir or similar overflow concept. This endsill will be in the upright condition during normal river operations and serve as a vertical barrier. In this way, the fishway entrances will serve as the exclusive pathway for upstream movement during these periods, following input from NMFS during consultation. The variable endsill will be operated for fish exclusion during non-FRE operational periods and for conduit hydraulic capacity during evacuation operations. Detailed design of the endsill to accommodate the low fish passage design flow will occur in future phases of design development.

5.1.2.4 Evacuation Conduits

After the conduit gates are closed for flood retention, the reservoir evacuation conduits will be used for reservoir releases but only at elevations exceeding the defined fish sounding depth to provide safe downstream passage through hydraulically favorable gate conditions. The estimated sounding depth reported in the Juvenile Fish Sounding TM (Appendix B) is 30 feet. There will be two main types of evacuation conduits, one for high flows and the other for low flows. The high flow conduits will be rectangular, 5 feet wide and 9 feet tall. The low flow conduits will be a 3-foot-diameter hooded fixed cone valve supplied from a 4-foot-diameter conduit. Each of the evacuation conduits will use the stilling basin as an energy dissipater. During the maximum flow requirement, and when the upstream head is insufficient, the secondary conduits will be used to increase the release capacity. Figure 16 and Figure 17 show the gate-controlled flow rates for the evacuation and low-flow evacuation conduits, respectively.

Figure 16. Evacuation Conduit Gate-Controlled Flow Rates

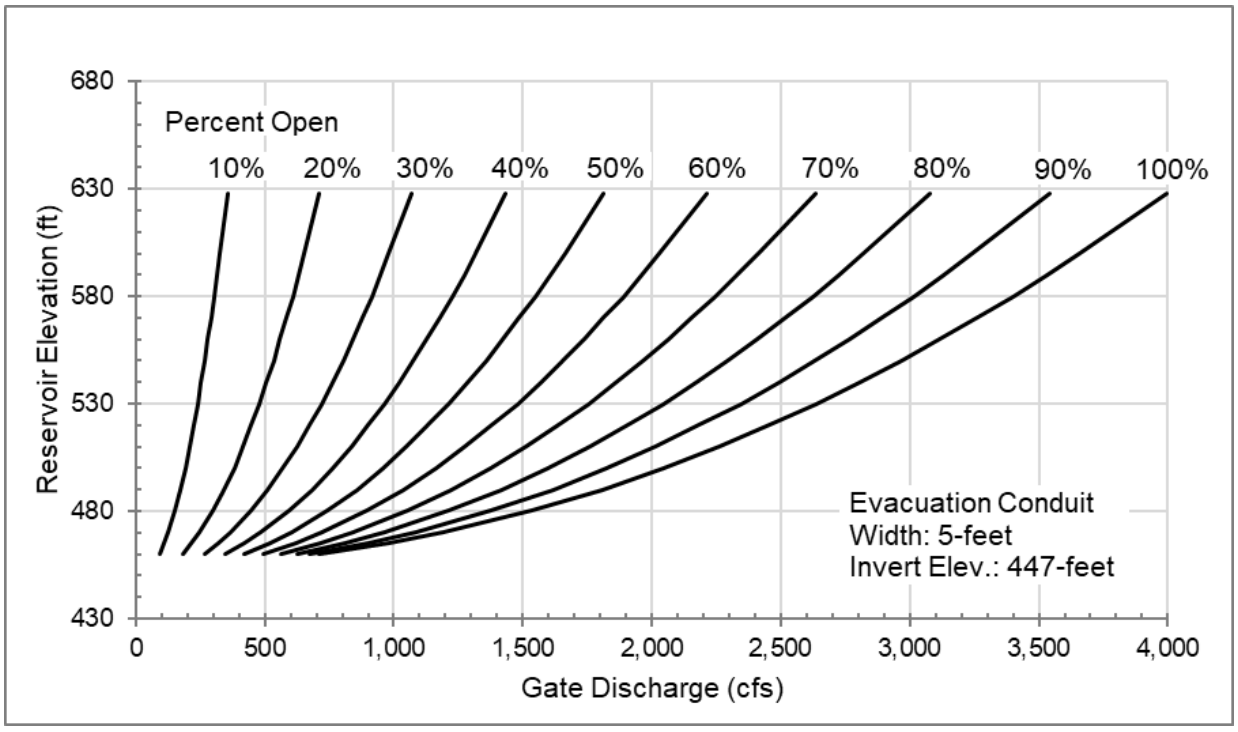
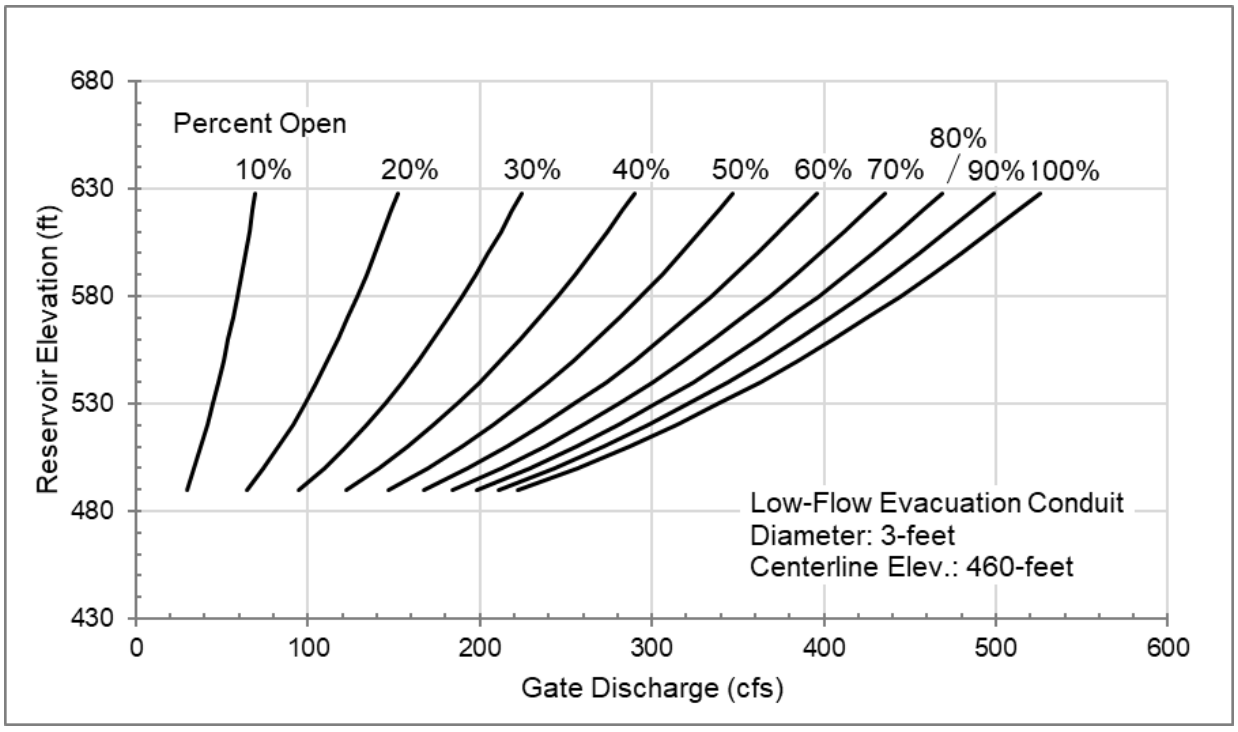


Figure 17. Low-Flow Evacuation Conduit Gate-Controlled Flow Rates



5.1.2.5 Lighting of Fish Passage Conduits

Appendix C (Fishway Lighting TM) describes the potential for artificial lighting within the passage conduits (primary and secondary conduits and the section of each fishway passing through the FRE structure) and considered literature describing the benefits and adverse effects of lighting, under different circumstances. Concern regarding fish delay or holding due to the length of the fish passage conduits if they remain unlit was shared during the January 17, 2024, TWG meeting. The TM concludes that lighting is beneficial only under certain circumstances. Accordingly, the design will not include lighting but seek to accommodate future installation of lighting based on demonstrated need. An integrated monitoring plan should be prepared to assess the need for artificial ambient lighting and evaluate its effects if implemented.

6 Fish Passage Performance

Fishways and other fish passage technologies are designed to provide continuous fish passage at the location of an instream barrier. Performance at fish passage facilities is generally characterized by the proportion of fish that can locate and traverse a fish passage facility from one side to the other. Research on fish passage performance is largely limited to facilities that consist of structures such as fish ladders or floating surface collectors, or facilities composed of natural materials (e.g., rocks and boulders), such as nature-like fishways and roughened channels. Provided herein is an assessment based on current project understanding with regards to anticipated fish passage operations and outcomes. Several terms are used to characterize the effectiveness of fish passage facilities. The term ‘performance’ is how efficiently fish are able to pass a facility, with rapid upstream movement being the most desirable outcome. Individuals may effectively move through a passage facility (“performance”) but can encounter challenges such as fallback after passing the facility, delay entering the facility, or displacement (not being able to access desirable locations). ”Mortality” indicates the complete loss of an individual. Mortality is not necessarily a direct outcome of performance. The inability to reproduce is also included as mortality if long-term displacement leads to segregation from the spawning population. The inverse of mortality is considered “survival.” Generally stated, survival is the proportion of individuals that move on to contribute to the population after encountering the fish passage facility as they otherwise naturally would.

Therefore, caution is urged when considering performance versus survival as the resilience of fish species can lead to survival, including reproduction, with imperfect conditions, such as not effectively moving through a passage facility. Based on the current design progress and available data, modeling is unable to provide direct scientifically supported estimates of mortality versus short-term displacement. It is inaccurate to assume that fish that do not move through a fish passage facility are lost to the local fish population. Fish not ascending or falling back in a fishway may hold for some time and move upstream later or may choose to not ascend but remain productive members of the population downstream of the passage facility. Therefore, populations are defined as “unaffected” or “potentially affected” to more accurately represent current

project understanding. It is anticipated that most of the affected fish will survive (as reflected in the survival estimate) but may be affected as discussed above (i.e., fallback, temporary delay, or displacement). A full discussion of unaffected and potentially affected fish for the Proposed Project is provided in Section 6.1 below.

During Normal Operation, fish passage and hydraulic outlet gates are open and the Chehalis River flows through the FRE unimpeded. During Flood Retention Operation, fish passage gates are closed, and hydraulic outlet openings are reduced to temporarily impound floodwaters upstream.

During Normal Operation, upstream passage is provided primarily by dual fishways adjacent to the FRE outlet works, while passage conduits serve as secondary upstream pathways and the primary downstream passage route. The passage conduits typically remain open and convey downstream migrants to the stilling basin and downstream river reach; within the range of fish passage flows, they may also support upstream escape from the stilling basin due to fallback. During Flood Retention Operation, upstream passage is provided by the FFPF. Downstream migrants may experience delay once the temporary inundation area exceeds approximately 30 feet above the evacuation conduits; prior to this depth, during initial retention and final evacuation, downstream passage is supported by the passage conduits. During FRE construction, the existing river, temporary bypass channels, and the completed dual fishways, conduits, and stilling basin will provide upstream and downstream passage on the Chehalis River and Crim Creek.

Several models of fish population use anticipated survival percentages to estimate potential impacts of projects on future fish populations. The discussion above and later in this section explain how it is important to account for changes to the location and timing of fish movement and reproduction and avoid potential mischaracterization of such changes as mortality. For convenience, Table 9 is provided to summarize the estimated percentage of fish encountering and passing the FRE structure and construction location and surviving beyond the structure/project area during construction and operation of the FRE facility. As noted, these survival numbers do not include fish that do not pass the FRE structure/construction location. Fish that do not pass the FRE structure should be accounted for elsewhere.

Table 9. Estimated Percentage of Fish Passing the FRE Facility/Construction Location and Surviving Beyond the FRE Facility Location for Construction and Operation of the FRE Facility[1]

Life Stage	Direction	During Construction[2]	Non-Flood Retention	Flood Retention
		(%)		
Spring-Run Chinook Salmon				
Adult	Upstream	98	95	86
Juvenile	Upstream	88	64	50
Juvenile	Downstream	99	95	60
Fall-Run Chinook Salmon				
Adult	Upstream	97	92	86
Juvenile	Upstream	88	64	50
Juvenile	Downstream	99	98	60
Coho Salmon				
Adult	Upstream	98	95	90
Juvenile[3]	Upstream	88	64	50
Juvenile[3]	Downstream	99	98	60
Steelhead[4]				
Adult	Upstream	98	95	90
Adult	Downstream	98	95	75
Juvenile	Upstream	93	79	55
Juvenile	Downstream	99	98	70
Coastal Cutthroat				
Adult	Upstream	95	85	55
Adult	Downstream	98	95	75
Juvenile	Upstream	88	64	45
Juvenile	Downstream	99	98	55
Pacific Lamprey				
Adult	Upstream	99	96	70 estimated[6]
Juvenile[5]	Downstream	98	95	40

Life Stage	Direction	During Construction[2]	Non-Flood Retention	Flood Retention
		(%)		
Western Brook Lamprey				
Adult	Upstream	99	96	70 estimated[6]
Juvenile[5]	Downstream	98	95	40

Notes

1. The percentages in this table reflect fish that reach the FRE facility location in their movement upstream and downstream, pass the facility location, and survive beyond the facility location. This does not mean that all fish outside these percentages die or fail to contribute to species population. For example, of the 45 percent of juvenile steelhead moving upstream during a flood retention event some may elect to hold until the retention event concludes then move and successfully continue their life history upstream during flow-through operation, some may successfully complete their life-history downstream of the FRE facility location, some may remain downstream of the FRE facility without successfully contributing to the species population, and some may move upstream when flow-through operation resumes without successfully contributing to the species population.
2. "During Construction" estimates are averaged across all phases of construction, including Non-Flood Retention phase.
3. Includes Coho salmon fry, transitional, and smolt life stages.
4. Downstream survival of adult steelhead was estimated because a high proportion of adults migrate downstream to re-enter the ocean and return to their natal stream to spawn again; downstream survival of adult salmon was not estimated because adults die after spawning.
5. Includes ammocoetes and macrophthalmia.
6. Pending more information being provided by the District regarding the low-velocity FFPF entrance; the proposed design is a prototype and has not been developed beyond the 30% level, nor has the prototype been installed or evaluated.

6.1 Unaffected and Potentially Affected Fish

Although the anticipated number of Potentially Affected fish presented in Table 10 (Section 6.3) and Table 11 (Section 6.4) could be lower in reality due to fish adaptability to varying environmental conditions. The species profiles below provide additional context on their resilience and ability to withstand suboptimal conditions including delayed migration to survive.

6.1.1 Steelhead and Cutthroat Trout

Steelhead or rainbow trout (*Oncorhynchus mykiss*) was one of the species evaluated. *O. mykiss* exhibits one of the most complex suites of life-history traits among Pacific salmonids (Quinn 2005). The anadromous form, which migrates to the ocean, is referred to as steelhead, whereas the resident, freshwater form is referred to as rainbow trout. Because both life-history expressions belong to the same species, they are hereafter collectively referred to as *O. mykiss* unless distinction is required. The two forms interbreed regularly, and their offspring may adopt either anadromous or resident life histories (Zimmerman and Reeves 2000; Pearse et al. 2019). Offspring of two steelhead may remain resident, and offspring of two resident parents may adopt an anadromous life history (USFWS 2026), consistent with empirical findings demonstrating significant

plasticity in migratory propensity within *O. mykiss* populations (Satterthwaite et al. 2010; Kelson et al. 2020).

Another important life-history attribute of *O. mykiss* is iteroparity (the capability to spawn more than once) whereas other *Oncorhynchus* species assessed for fish passage performance, such as Chinook (*O. tshawytscha*) and Coho salmon (*O. kisutch*), are semelparous and die after a single spawning event (Fleming and Reynolds 2004; Busby et al. 1996). Coastal cutthroat trout (*O. clarkii clarkii*), also present in the Chehalis River Basin, exhibit life histories similar to *O. mykiss*, including migration and iteroparity (Trotter 2008; Johnson et al. 1999).

During Phase 2 of construction and associated flood operations, upstream spawning migrations of adult *O. mykiss* may experience temporary delays. Individuals may require additional time to navigate modified hydraulic conditions, seek temporary refuge until passage conditions improve, spawn downstream of the FFPF, or delay spawning to a later year when hydrologic or ecological cues indicate more suitable passage conditions. Such behavioral plasticity, including flexible migration timing and variable holding behavior, is a well-documented adaptive trait in *O. mykiss* and contributes to long-term persistence of steelhead populations in dynamic and variable river environments (Sykes et al. 2009; Kendall et al. 2015). Delay in migration represents a behavioral response that enhances survival potential and should not be interpreted as mortality.

Given the documented behavioral and physiological adaptability of *O. mykiss*, as well as *O. clarkii clarkii*, it is reasonable to conclude that the performance, survival, unaffected, and potentially affected estimates presented in Table 10 and Table 11 are conservative. This behavioral flexibility is expressed by both juvenile fish navigating the system and adult fish migrating to natal grounds to spawn, and it is recognized as a key component of the species' resilience under different environmental conditions (Satterthwaite & Carlson 2015; Kendall et al. 2021).

6.1.2 Coho Salmon and Chinook Salmon

Chinook salmon (*Oncorhynchus tshawytscha*) and Coho salmon (*O. kisutch*) are two other anadromous Pacific salmon species evaluated for fish passage performance. Both species exhibit complex migration ecology involving freshwater, estuarine, and marine environments. Unlike *O. mykiss*, Chinook and Coho salmon are semelparous, meaning they reproduce once and die following spawning (EPA [2021] for Chinook; NPS [2025] for Coho). Chinook and Coho populations display substantial diversity in run timing and migration rates, traits that are influenced by climatic, hydrologic, and habitat conditions (Crozier et al. 2008; NOAA 2024a review).

During Phase 2 of construction and associated flood operations, downstream migrations of juvenile Chinook and Coho salmon may experience temporary delays. Behavioral studies demonstrate that juvenile Chinook salmon rear and feed in freshwater and migrate to the ocean within a few months of hatching as young-of-year or may choose to stay in freshwater for a full year (NOAA 2024b). In northern portions of their range, spring Chinook commonly remain in freshwater for approximately one year, but in less productive streams where growth is slower, juveniles often prolong their freshwater residency (WDFW 2026).

Migration timing in Chinook has been shown to shift with river temperature, flow, and other environmental cues—reflecting behavioral adaptation in response to environmental variability (Keefer et al. 2025; Di Prinzio et al. 2023).

As far as adult Coho salmon are concerned, they have been observed to delay movement until favorable combinations of streamflow and temperature occur, holding downstream until environmental thresholds for migration are met (Flitcroft 2022; USDA Forest Service 2001).

These migration delays represent adaptive behavioral responses, not mortality. Adult fall run Chinook salmon routinely pause migration to slow down movement until conditions improve (Goniea et al. 2006). Coho salmon similarly demonstrate condition dependent migration timing (Flitcroft 2022). Such environmentally mediated holding behavior is a well-documented aspect of Pacific salmon migration ecology.

Although Chinook and Coho salmon exhibit less life history plasticity than *O. mykiss* due to their semelparous strategy, both species show significant variation in run timing, freshwater residence, and movement strategies that enhances resilience in dynamic river systems (Hill et al. 2003; NOAA 2024). Recent research also highlights alternative juvenile migration strategies in Chinook and Coho that increase population stability (Apgar et al. 2020; Baker et al. 2025), suggesting these species retain considerable behavioral flexibility despite their reproductive constraints.

Given this natural behavioral adaptability, it is reasonable to infer that the performance and survival values reported in Table 10 and Table 11 for Chinook and Coho salmon are conservative. Similar to *O. mykiss* and cutthroat trout discussed above, migration delays should be interpreted as part of the species' adaptive response to suboptimal environmental conditions rather than as indicators of mortality.

6.2 Fish Passage Hydraulic Modeling Results

Hydraulic model results for fish passage conduits and permanent and construction bypass channels demonstrate depths and velocities at the high and low fish passage design flows similar to their analogous and reference reaches.

Two-dimensional hydraulic modeling of the construction bypass channels and the permanent river channels (RPDR Appendix D) confirm that at the fish passage design flows, flow depth and velocity within these channels are similar to, or more favorable than the reference reaches used to design the channels. At the current level of design, there is no evidence to suggest that fish passage performance through the channels will be negatively impacted by the channels themselves, when compared to the existing river at the Proposed Project location. Therefore, fish passage performance and survival through the proposed channels is assumed to match that of the existing natural channel.

Three-dimensional hydraulic modeling of the passage conduits, stilling basin, and end sill was conducted to evaluate passage hydraulics through the conduits through fish passage design flow range. While the passage conduits are not the primary migration pathway, model results depicted favorable conditions in the event of upstream migrant fallback or failure of the vertical barrier.

For an abbreviated summary of anticipated fish passage hydraulic results through the fish passage conduits, see Section 5.1, above.

6.3 Fish Passage Performance During Flood Retention Operation

During flood events, the FFPF will continue to provide upstream passage for adult salmonids and lamprey, juvenile salmonids, and resident fish. Downstream-migrating juveniles and adult species are expected to hold in the mainstem Chehalis River above the temporary inundation pool, tributaries, and the temporary inundation pool until the temporary inundation pool recedes to a level fish choose to safely move downstream through the conduits or until normal flow-through operation resumes.

A temporary impoundment event of short duration may briefly hold fish upstream, preventing downstream movement. While fish are temporarily delayed, the short-term nature of these events limits detrimental consequences to fish mortality. Predatory species generally do not have sufficient time to recruit, establish, or significantly increase in abundance during brief periods of impoundment, though opportunities for predation may occur on occasion. Importantly, a temporary passage delay does not equate to a mortality event. Because the duration is limited, key mortality drivers, such as prolonged food limitation, physiological stress, or resource depletion, are expected to remain minimal, and impounded fish can typically resume normal movement and behavior once flows return to baseline.

Upstream-migrating juvenile fish were assigned lower performance and survival values in Table 10 than adults due to uncertainties associated with their attraction to ladder entrances, greater vulnerability to predation, and variable motivation to ascend into holding galleries. Additional engineered measures that could improve juvenile attraction and safe collection include multiple low-head entrances, reduced head differentials between ladder pools, and segregation zones in holding galleries to decrease predation.

Table 10. Anticipated Upstream and Downstream Fish Passage Performance, Survival, Unaffected, and Potentially Affected Values during Flood Retention Operation

Target Species	Performance[1]	Survival[2]	Unaffected[3]	Potentially Affected[4]
	(%)			
Adult Upstream				
Spring Chinook	93	86	80	20
Fall Chinook	93	86	91	9
Coho	93	90	91	9
Winter Steelhead	93	90	91	9
Coastal Cutthroat	88	55	86	18
Pacific Lamprey	60	70	54	46
Western Brook Lamprey	60	70	54	46

Target Species	Performance[1]	Survival[2]	Unaffected[3]	Potentially Affected[4]
	(%)			
Adult Downstream				
Winter Steelhead	NA	75	NA	NA
Coastal Cutthroat	NA	75	NA	NA
Juvenile Upstream				
Spring Chinook	60	50	30	70
Fall Chinook	60	50	30	70
Coho	60	50	30	70
Winter Steelhead	65	55	36	64
Coastal Cutthroat	60	45	27	73
Pacific Lamprey	NA	NA	NA	NA
Western Brook Lamprey	NA	NA	NA	NA
Juvenile Downstream				
Spring Chinook	>90	60	54	46
Fall Chinook	>90	60	54	46
Coho	>90	60	54	46
Winter Steelhead	>90	70	63	57
Coastal Cutthroat	>90	55	50	50
Pacific Lamprey	>90	40	36	64
Western Brook Lamprey	>90	40	36	64

NA – Juvenile lamprey are neutrally buoyant and do not move under their own power so upstream movement of juvenile lamprey is not applicable.

[1] Performance, the proportion of fish expected to meet route-specific behavioral passage criteria (e.g., finding/entering the route and completing the passage) estimates for adult and juvenile upstream passage are derived from HDR (2017). Juvenile downstream performance estimates are supported by analogous pressurized conduit systems with less than 30 feet of water depth, documented in the Rocky Reach Hydro Project and Clackamas River Hydroelectric Project (Chelan County N.D.; NOAA 2018).

[2] Survival, the proportion of fish that survive the passage event, estimates provided in HDR (2017).

[3] Unaffected, the proportion of the total population expected to pass successfully and survive the passage operation.

[4] The remainder of the population that may experience delay, increased predation risk, physiological stress, or mortality.

The following paragraphs apply specifically to periods when downstream passage occurs during short duration temporary impoundment events in which the inundation pool depth remains less than the juvenile salmonid sounding depth (approximately 30 feet). Under these shallow, short-term conditions, fish continue to encounter engineered passage

routes without the protracted delays associated with deeper pools, and the survival expectations described below pertain only to these less than 30-foot events.

Downstream survival during flood retention events must consider the short duration (~4 weeks or less) and infrequent occurrence (once every 5 years to about > once per year) when a temporary pool is held upstream of the FRE structure and must consider the high passage performance through the pressurized conduits when the pool depth is below the fish sounding depth (less than 1 atmosphere). Empirical studies of juvenile passage systems throughout the Pacific Northwest consistently show that engineered bypass conduits and pipelines achieve survival rates of approximately 95 to 99 percent, corresponding to mortality of roughly 1 to 5 percent. Paired-release Passive Integrated Transponder-tag experiments in the Columbia–Snake system document survival of 95.3 to 99.4 percent for yearling Chinook and steelhead passing through pressurized bypass routes (Muir et al. 2001; Ploskey et al. 2011). NOAA and Pacific Northwest National Laboratories (Ploskey et al. 2011) analyses further report dam-passage survival near or above 96 to 98 percent across multiple years (Ploskey et al. 2011). Additional compilations from Bonneville Power Administration and NOAA annual survival programs corroborate these findings and consistently show juvenile bypass systems among the highest-survival passage routes in the hydrosystem (Muir et al. 2001; Ploskey et al. 2011).

Concerns about latent mortality associated with bypass encounters have been raised, primarily relating to stress physiology and size-selective collection. The Independent Scientific Advisory Board (2021) reviewed these hypotheses; however, even under these considerations, direct route-specific survival for bypass passage remains high, and no evidence supports immediate mortality near 15 percent. NOAA analyses similarly find little evidence of significant latent penalties attributable solely to bypass exposure (NOAA Fisheries 2018).

Juvenile downstream survival at the Proposed Project is expected to remain high, though mortality may be slightly elevated relative to fully enclosed conduit systems due to the trashrack at the downstream collection entrance. Trashrack slats are approximately 2 feet wide, with approach velocities beginning near 1.0 ft/s and increasing gradually, producing hydraulics similar to river like conditions commonly encountered by juvenile salmonids. Additional risk can occur if debris accumulates and alters approach velocities or strike potential. Accumulated debris, large woody material, and plant matter, may provide structural habitat for predatory species, increasing predation risk. Predatory species can also use large woody material or floating debris as rafts for dispersal to new locations and ambush predation. Operational mitigation measures remove debris as needed, reducing hydraulic and predator-related risks. Accordingly, any incremental mortality associated with the trashrack and debris is expected to be small, well mitigated, and within survival ranges documented for high performing bypass systems (NOAA Fisheries 2018; Muir et al. 2001; Ploskey et al. 2011).

Data is less readily available for mortality due to short-duration holding in temporary pools. Upon assessing the hydraulic modeling of the Proposed Project under multiple scenarios (see Section 6.2), a critical review was undertaken relative to standard passage criteria (NOAA 2023a-c), past design experience and outcomes, along with project-specific understanding. The result of that review led to the prescribed

downstream survival rates, shown in Table 10, in the 60 to 70 percent range based on the compilation of existing information and professional judgement. The rates provided do not fall outside of other research and findings within the literature but provide an incrementally improved and tailored assessment specific to the Proposed Project.

Recent studies from the mid-Columbia and Yakima River systems indicate improved monitoring of adult and juvenile lamprey movements, though these datasets have not yet been fully integrated into survival or performance estimates for trap and transport applications (Liedtke et al. 2022; Grote and Lampman 2025). Evidence from Tribal translocation programs indicates that adult lamprey can survive collection and transport with generally low mortality and contribute to subsequent generations; however, variable passage efficiency at salmonid-designed facilities and limited juvenile-specific data warrant conservative assumptions (Hess et al. 2023; Lampman 2021).

Adult Pacific lamprey moved upstream using trap-and-haul or lamprey-specific passage structures show strong performance, with Tribal programs demonstrating low mortality and successful reproduction that supports values higher than legacy assumptions (Hess et al. 2023; USFWS 2023; CRITFC 2025). For this assessment, adult upstream survival is represented with a value of 70. Downstream migrants will move through conduit systems modeled on tube- and culvert-type designs that have shown high volitional passage efficiency in the Pacific Northwest (Frick et al. 2017; Goodman and Reid 2017; Cates et al. 2020). Regional closed-conduit studies indicate survival typically near the upper end of bypass performance (NOAA Fisheries 2018; Muir et al. 2001; Ploskey et al. 2011; U.S. Geologic Survey [USGS] 2022), but given limited lamprey-specific data, juvenile downstream estimates are conservatively set at 40 for survival while still reflecting fish-friendly routing and analogous system performance.

6.4 Fish Passage Performance During Normal Operation

Fish passage during normal operation is provided through fishways for upstream passage of adults, juveniles, and resident fish and through conduits for downstream passage of all aquatic species and life stages. Survival numbers developed in 2016 to 2017 for the Flood Retention Flow Augmentation (FRFA) dam fish ladder alternative remain appropriate, but performance values should be reconsidered. The FRFA dam fish ladder alternative developed in support of the Programmatic EIS assumed a large permanent reservoir and therefore anticipated reduced upstream fishway performance due to delayed attraction. Under the current configuration, fishways transition directly into the flowing Chehalis River, meaning the performance percentages previously established must be reconsidered.

Adult salmonids migrating upstream through technical fishways at the Columbia and Snake River Dams exhibit high passage efficiency and effective passage performance. According to Keefer et al. (2021), performance rates of upstream passage through technical fishways at the Columbia River and Snake River Dams ranged from 92 to 99 percent across a range of species, seasonal runs, and dams considered. This study considered collected data from an 8-year period for fall and spring Chinook, Sockeye, and steelhead. The mean fishway passage efficiency was determined to be 98 percent.

Upstream juvenile passage values have been added to Table 11 to reflect the possibility that juveniles may enter fishways, while acknowledging that upstream juvenile movement is exploratory rather than required for their life history. Consistent with the 2017 Subcommittee rationale, juvenile performance values are lower than adult values due to uncertainties related to attraction, motivation, and predation risk within fishways. Conditional survival remains high, in the range of 90 percent, consistent with regional juvenile studies. Juveniles that do not enter the fishways remain downstream, and because non-entry is not equivalent to mortality, total survival (a previous considered metric by others representing 'performance survival', which indicated any performance issue lead to mortality) is not applied to juveniles in Table 11 as it is not supported that any juvenile affected by performance would lead directly to mortality.

Table 11. Anticipated Upstream and Downstream Fish Passage Performance, Survival, Unaffected, and Potentially Affected Values during Normal Operation

Target Species	Performance[1]	Survival[2]	Unaffected[3]	Potentially Affected[4]
	(%)			
Adult Upstream				
Spring Chinook	95	95	90	10
Fall Chinook	95	92	85	15
Coho	95	95	90	10
Winter Steelhead	97	95	92	8
Coastal Cutthroat	93	85	79	21
Pacific Lamprey	97	96	93	7
Western Brook Lamprey	97	96	93	7
Adult Downstream				
Winter Steelhead	98	95	93	7
Coastal Cutthroat	98	95	93	7
Juvenile Upstream				
Spring Chinook	65	64	42	58
Fall Chinook	65	64	42	58
Coho	65	64	42	58
Winter Steelhead	80	79	63	37
Coastal Cutthroat	65	64	42	58
Pacific Lamprey	NA	NA	NA	NA
Western Brook Lamprey	NA	NA	NA	NA
Juvenile Downstream				
Spring Chinook	>90	98	59	41

Target Species	Performance[1]	Survival[2]	Unaffected[3]	Potentially Affected[4]
	(%)			
Fall Chinook	>90	98	59	41
Coho	>90	98	59	41
Winter Steelhead	>90	98	64	36
Coastal Cutthroat	>90	98	59	41
Pacific Lamprey	>90	95	NA	NA
Western Brook Lamprey	>90	95	NA	NA

NA – Juvenile lamprey are neutrally buoyant and do not move under their own power so upstream movement of juvenile lamprey is not applicable.

[1] Performance, the proportion of fish expected to meet route-specific behavioral passage criteria (e.g., finding/entering the route and completing the passage) estimates for adult and juvenile downstream passage and juvenile upstream passage are derived from HDR (2017). Adult upstream performance estimates are based on performance values for technical fishways at Columbia and Snake River Dams.

[2] Survival, the proportion of fish that survive the passage event (HDR 2017).

[3] Unaffected, the proportion of the total population expected to pass successfully and survive the passage operation.

[4] The remainder of the population that may experience delay, increased predation risk, physiological stress, or mortality.

Downstream adult passage percentages from the 2017 Combined Dam and Fish Passage Report for winter steelhead and cutthroat trout are still applicable (HDR 2017). These values represent the best available performance estimates for downstream movement through fish-friendly conduits under normal operation. The Fish Passage Subgroup should confirm that including the 2017 values is acceptable for the SEPA EIS.

Downstream juvenile passage through conduits remains highly effective. During normal operation, the entire river passes through fish-friendly conduit structures, resulting in near-complete passage performance (approximately 100 percent). This is consistent with conclusions from the 2017 Subcommittee rationale. Regional data show that juvenile salmonid survival through spillways, sluiceways, and bypass conduits routinely exceeds 90 percent and often falls within the 95 to 99 percent range, as demonstrated by Muir et al. (2001) and USGS (2011). Closed-conduit systems, such as the Clackamas River bypass pipeline, achieve juvenile survival near 97 percent, which aligns with federal performance requirements. Since 2017, conduit designs have been refined and modeled to demonstrate better hydraulic conditions for downstream passage as discussed in Section 6.2, providing additional confidence that downstream survival rates are more likely to be better than those estimated by the Subcommittee in 2017 and closer to those in Muir et al. (2001) and USGS (2011). Based on these findings, downstream juvenile passage is considered approximately 100 percent, with a conservative survival estimate of approximately 98 percent.

Downstream juvenile lamprey passage has been expanded to reflect the current understanding of lamprey behavior and movement. Recent acoustic telemetry work by the USGS in the Yakima River demonstrates that juvenile lamprey have specific

movement timing and behavior but does not contradict the expectation that fish-friendly conduit structures can safely pass lamprey during downstream migration. Therefore, juvenile lamprey passage performance remains approximately 100 percent, with a survival value of approximately 95 percent to remain conservative and consistent with both the 2017 Subcommittee assumptions and contemporary regional research.

6.5 Fish Passage Performance During Construction

The construction bypass channels and permanent approach and discharge channels function differently from traditional fish passage structures and are more comparable to restoration channel designs. Their design approach is based on creating physical and hydraulic conditions that replicate those in the Chehalis River and Crim Creek near the Proposed Project. This includes matching slope, channel form, bed material, and habitat complexity along with creating depth, velocity, and flow paths consistent with adjacent natural reaches. Design guidance for this approach is provided both by NOAA Fisheries (2023a, 2023b) and WDFW (2012), with WDFW (2012) stating that this design approach "usually insures fish passage." The constructed channels are therefore intended to support passage for all species and life stages, with passage performance and survival expected to match baseline conditions in the adjacent natural channel.

Design guidance documents published by WDFW and NOAA Fisheries reinforce that passage performance through the construction bypass channels should be evaluated using design criteria that reflect natural hydraulic complexity, appropriate roughness elements, and sufficient velocity refugia based on the reference reach. The construction bypass and permanent channels have been hydraulicly modeled to demonstrate that the channels achieve hydraulic conditions suitable for upstream and downstream passage as discussed in Section 6.2. As the design progresses, channel hydraulics will be analyzed through hydraulic modeling to confirm that water depths, flow velocities, and channel roughness remain within the envelope of conditions known to support fish movement. The construction bypass channel will be required to meet state and federal fish passage and permit requirements, and passage performance reflects a project that will be designed and constructed to those standards.

Fish passage during construction varies by phase. In all phases, fish passage routes provide volitional upstream and downstream fish passage for all species and life stages. During Phase 1, passage occurs in the existing natural channel, which is unimpacted by construction activities therefore no reduction in survival or performance is anticipated in this Phase. During Phase 2, passage occurs through the construction bypass channels described above. As stated above, upstream and downstream passage performance and survival for all species and life stages is anticipated to match that of the existing natural channel. During Phases 3 and 4, upstream and downstream fish passage for all species and life stages occurs through the completed fishways, conduits, and stilling basin. Passage performance and survival for these phases is therefore consistent with the values described for fish passage during Normal Operation (Section 6.4). The combined approach provides passage conditions that remain consistent with or similar to baseline conditions during early construction phases and transition to the permanent fish passage facilities as they are brought online. Passage survival values during construction are an average of the three passage routes described in this paragraph and listed in Table 9.

7 Roadmap for Future Fish Passage Design

Fish passage design continues to be refined in discussion with NOAA Fisheries and, in future discussion, with WDFW, USFWS, and other state, federal, and indigenous members. The fish passage design will be integrated and compatible with the overall facility design. Future design phases will incorporate cross-discipline design development, design evaluations and analyses, coordination meetings, and configuration decisions to achieve a complete project. Some aspects of fish passage design that will be refined include:

- NOAA climate change guidance for long-term projects (2023a)
- FFPF
- Primary and secondary conduits
- Conduit stilling basin and adjustable end sills
- Dual dedicated fishways
- Construction bypass channels
- Permanent river and creek channels immediately upstream and downstream of the FRE structure
- Two- and three-dimensional hydraulic modeling

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Appendix A. In-Water Work Steps During Construction TM

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Technical Memorandum

Date:	Oct 11, 2024
Project:	Chehalis River Basin Flood Damage Reduction Project
To:	Chehalis Basin Flood Control Zone District
From:	Jacob Hyles, PE
Subject:	**In-Water Work Steps During Construction**

1.0 Introduction

1.1 Background

The Chehalis River Basin Flood Damage Reduction project (Project) objective is to develop recommendations for a series of measures aimed at reducing damage to the communities of the Chehalis River Basin from Pe Ell to Centralia during major flood events. Among these measures is a proposed Flood Retention Expandable (FRE) structure on the Chehalis River, south of the town of Pe Ell.

The Chehalis River Basin Flood Damage Reduction, Revised Project Description Report (RPDR) is a supplemental report documenting the relocation of and changes to the FRE facility as originally documented within the Combined Dam and Fish Passage Conceptual Design Report (HDR Engineering, Inc. [HDR] 2017) and FRE Dam Alternative Report (HDR 2018).

The RPDR describes, supports, contrasts, and illustrates the changes to the proposed upstream FRE in a single comprehensive document.

1.2 Document Purpose

As a standalone attachment to Appendix K: Constructability Report to the RPDR, this technical memorandum (TM) provides additional detail to describe flow diversion aspects of construction phasing to include:

- Major elements of in-water work associated with flow diversion,
- Planned steps to transition construction phases,
- Conditions based requirements to progress from one step to the next, and
- Discussion of next steps and items for future consideration.

1.3 Previous Related Documentation

The RPDR provides a revised project description, and details activities and studies related to new and revised project elements. In addition to Appendix K, two additional appendices provide information related to the proposed channel diversion during construction.

Appendix D2: Hydraulic Design of Fish Passage and Evacuation Conduits TM

This TM documents the hydraulic analysis of the fish passage and evacuation conduits. The TM includes the permanent approach and discharge channels. The Approach Channel connects existing reaches of Crim Creek and the Chehalis River to the FRE passage conduits. The Discharge Channel connects the passage conduit stilling basin to the Chehalis River downstream. Both channels constitute the proposed project condition but are preliminary concepts only.

Appendix D3: Chehalis Construction Bypass Hydraulic Modeling TM

This TM documents the hydraulic analysis of the proposed Chehalis River and Crim Creek construction bypass channels (Bypass Channel), which characterizes hydraulic conditions (i.e., depth, velocity) within the proposed channels in relation to cost estimating, constructability, and fish passage. The preliminary designs are based upon existing conditions within reference reaches in the vicinity of the project. The proposed Bypass Channel mimics the hydraulics of these reference reaches to support upstream and downstream movement of aquatic organisms. The Bypass Channel can contain the 25-year annual exceedance probability (AEP) discharge.

2.0 Construction Sequence Overview

2.1 FRE Construction Sequence

The general FRE construction sequence consists of five phases presented in Table 1. In order to maintain volitional fish passage in the Chehalis River throughout the overall construction period, the dam structure will be constructed in three segments. A bypass channel will be installed to maintain river flows during construction of the second segment of the facility in Phase 2. This flow will be transitioned into the permanent channel and through the FRE conduits for remaining construction during phases 3 and 4. Additional discussion is included in the RPDR.

Table 1. Construction Sequence Summary

Phase	Work	Duration (months)
0	Preliminary work independent of the river	6-12
1	Site preparation, right side foundation construction, Chehalis and Crim Creek bypass channel construction	10-12

2	Outlet works and conduit construction, left side foundation construction, grading	20-24
3	Remove bypass channel and restore vegetation, foundation closure - connect left and right foundations	10-12
4	Complete facility construction, finishing touches, finalize the facility for use	6-12

2.2 Construction Phase Transitions

The transitions between construction phases are based upon several criteria being met. For the purposes of this TM, the transitions presented here are defined by the conditions surrounding the diversion and handling of the Chehalis River and Crim Creek. Specifically, this TM details the conceptual transitions from Phase 1 to Phase 2 and from Phase 2 to Phase 3.

2.3 In-water Work Window

Based on the project design it is anticipated that permitting variances will be required to extend normal in-water work windows. The Washington State Department of Fish and Wildlife (WDFW) approved in-water work window for the Chehalis Basin upstream of the South Fork is August 1 to August 31, and the US Army Corps of Engineers (USACE) approved in-water work window for the same river reach is July 1 to August 31. To minimize impacts during construction by making use of the optimal hydrologic conditions as previously described, and to avoid impacts from continuous construction over a longer period of time, an extension of the in-water work window from July 1 to September 30 will be requested from WDFW and USACE.

2.4 In-water Work Items

Diversion structures
In-water work will include structures constructed to divert flows from one flow path to another to facilitate construction activities. These structures have not been designed, but temporary berms may need to be structurally designed, lined, or otherwise stable and suitable for sustained flows and favorable to support dewatering needs. Temporary diversion methods may be employed to reduce in-water work duration to allow for more permanent structures to be constructed.

Aquatic Species Stranding and Fish Rescue Surveys
Avoiding stranding of aquatic species is an essential activity during the in-water activities. While flow diversion activities will be planned and executed to limit stranding potential, monitoring teams will be in place to identify, recover, and re-locate stranded fish as flows recede and as conveyance channels are de-watered. As water depths reduce, corralling and seining of remaining individuals will be conducted towards the downstream channel connection. As flows become shallower, electrofishing and relocation will be conducted. Mussel salvage and relocation activities will be completed once water levels allow.

Salvage and relocation may only be conducted by personnel deemed qualified by the governing fisheries regulatory agencies. Fish salvage or relocation personnel may be government staff or private professionals, employed by the government or by the Chehalis Basin Flood Control

Zone District (District), as mutually agreed upon by the District and governing fisheries regulatory agencies. The District's construction contractor will responsible for fish exclusion, as well as coordination with and physical support of fish salvage/relocation personnel and the governing fisheries agencies. The District will require the contractor to adhere to typical construction BMPs for the protection of fish including:

- Adherence to the agency approved in-water work window.
- Coordination with agencies to implement fish salvage plans for each stage of in-water work.
- Fish salvage would be conducted in accordance with WSDOT fish exclusion protocols (WSDOT 2016).
- Electroshocking would occur in accordance with National Marine Fisheries Service (NMFS) (2000) electrofishing guidelines.
- All electrofishing will be conducted by a person with electrofishing training on-site to direct all electrofishing activities.
- All captured and collected fish will be transported to the upstream end of the project area and released at a location sufficient for fish to recover and re-orientate to the stream environment (slow moving pool habitat).
- Monitoring of temperature and dissolved oxygen during operations and subsequent refill periods.
- Screening of intakes - pump intakes must be screened compliant with NOAA-Fisheries and WDFW requirements.
- Maintaining fish screen to prevent injury or entrapment of fish.

Screened De-watering
De-watering (i.e., removing water from a surface hole or collection) may be required during brief periods and in limited locations when diversions are made from one phase to the next. De-watering will be slow, deliberate, and screened to facilitate safe and timely removal of any fish trapped in pools. The rate of dewatering will be commensurate with permit requirements from WDFW or as defined during Endangered Species Act (ESA) consultation. Contractor will be required to implement a specific de-watering rate to avoid stranding and to allow adequate aquatic species relocation.

2.5 In-water Work Tenets

The conceptual process of flow diversions as it relates to transitioning construction phases was developed with several tenets, which guide the timing and sequencing of the proposed steps. These tenets include:

1. **Limit in-water work.** Regardless of mitigation measures in-place, in-water work has the potential to be detrimental to the function and health of the river and its ecology. Reducing the duration of in-water work reduces this risk for impacts. Performing in-water work concurrently, instead of a long sequence of steps, is one way to reduce work duration.
2. **Prevent abrupt dewatering.** To limit the risk of fish stranding, diverting river flow from one active channel to another should not result in the rapid dewatering of the once active

channel. Closure of the active change, via constructed berm or other approved methodology, should allow for deliberate reduction of flows to allow fish to safely vacate.

3. **Maintain control.** Deliberate and methodical execution of the process of diverting flows is critical to diversion success and worker safety. New channels should be first opened from the downstream end. Upstream berms should be opened at a similar rate to the closure of the channels to be abandoned.
4. **Aquatic species salvage is continuous.** Pro-active efforts to exclude and remove aquatic species is a priority. Actions of each in-water work steps must be planned and executed in support of aquatic species salvage efforts as required under permit documentation.

3.0 Construction Phase Transition and In-water Work Steps

3.1 Phase 1 to Phase 2 Transition

The flows from the Chehalis River and Crim Creek will first be diverted from the existing channels during the transition from Phase 1 to Phase 2. The combined flows will be diverted from their current channels into the Bypass Channel designed and constructed for use during Phase 2 and Phase 3 of construction. This transition includes three steps and ends when the combined flows are fully diverted and when fish salvage and de-watering operations have concluded. Each step is described below, to include the conditions at the beginning and end of each step and the major actions taken during the step. An exhibit for each step is attached.

3.1.1 Step 1

Begins: Chehalis River flows through the FRE project site in the existing channel. Crim Creek flows join the Chehalis River at the existing confluence location. The Bypass Channel is constructed and ready for use, but stream flows are precluded by the natural bank serving as a barrier to flow.

Actions Taken:

Actions during this step are limited to the work necessary to remove the existing riverbank at the downstream end of the Bypass Channel. This embankment will be removed in such a manner as to reduce the duration of in-water activity. This would include excavation as much of the existing channel bank from the dry Bypass Channel, and only breaching the embankment at the end of the operation.

Ends: This step ends when the existing riverbank at the downstream end of the Bypass Channel is fully breached and flow is allowed to backwater into the Bypass Channel.

3.1.2 Step 2

Begins: This step begins when the existing riverbank at the downstream end of the Bypass Channel is fully breached and flow is allowed to backwater into the Bypass Channel. The Chehalis River flows through the FRE project site in the existing channel. Crim Creek flows join the Chehalis River at the existing confluence location.

Actions Taken:

This step is characterized primarily by the actual diversion of flows into the Bypass Channel. The specific actions include:

- Initial breach of the channel embankments to allow flow into the Bypass Channel via the Crim Creek and Chehalis River flow paths.
- Concurrent to the initial breach of the channel embankments, construction of the flow diversion features at Crim Creek and Chehalis River will be initiated. These diversion structures have yet to be engineered, but could include earthen/rock berms, piling, super sacks or other methods.
- The Bypass Channel embankment breaches are widened, allowing for a gradual increase in flow into the Bypass Channel. Simultaneously, the diversion features continues to reduce flow into existing Chehalis Channel.
- As flow in the Existing Channel is reduced, aquatic species salvage commences.
- Diversion structures will isolate the existing river channel between the Crim Creek and Chehalis flow paths into the Bypass Channel. Aquatic species salvage will be conducted, followed by dewatering, as necessary.

Ends: This step ends when Chehalis River and Crim Creek flows are completely diverted into the constructed bypass. The existing Chehalis River channel is closed at Crim Creek. The existing channel located between the Crim Creek and Chehalis portions of the Bypass is closed to stream flow and aquatic species salvage is complete. The downstream end of the Existing Channel, adjacent to the Bypass Channel outfall, is open.

3.1.3 Step 3

Begins: This step begins when Chehalis River and Crim Creek flows are completely diverted into the constructed Bypass Channel. The upstream end of the existing Chehalis River channel is closed at Crim Creek, but remains open at the downstream end, adjacent to the Bypass Channel.

Actions Taken:

This step consists of the downstream closure of the existing Chehalis River channel. The specific actions include:

- With complete diversion of streamflow into the Bypass Channel, the downstream end of the existing Chehalis River channel can be closed. This closure will be gradual and in-concert with aquatic species salvage efforts in the channel.
- As the existing Chehalis River channel will be subject to backwater conditions only, the final closure will isolate a final pool of water within the channel. This pool will be gradually dewatered via screened pumps, at a rate necessary to support aquatic species salvage as required in the approved in-water work plan.

Ends: This step ends when the existing river channel between Crim Creek and the downstream end of the Bypass Channel is closed to streamflow. De-watering is complete. Aquatic species salvage efforts are complete.

3.2 Phase 2 to Phase 3 Transition

The transition from Phase 2 to Phase 3 is the second and last proposed diversion of Chehalis River and Crim Creek flows construction. The combined flows will be diverted from the Bypass Channel into the Approach Channel. Flows from the Approach Channel will pass through the FRE via the passage conduits and stilling basin and into the Discharge Channel. The Discharge Channel will pass the combined flows back into the downstream, existing reach of the Chehalis. This transition includes three steps and ends when the combined flows are fully diverted and when fish salvage and unwatering operations have concluded.

3.2.1 Step 1

Begins: Chehalis River and Crim Creek flows pass through the FRE project site via the Bypass Channel. The FRE conduits and stilling basin are constructed and ready to receive flow. The permanent Approach Channel upstream and the Discharge Channel downstream of the FRE conduits are constructed and ready to receive flow, but flow is precluded by constructed berms at the upstream and downstream ends.

Actions Taken:

Actions during this step are limited to the work necessary to remove the constructed embankment at the downstream end of the permanent Discharge Channel.

Ends: This step ends when the berm at the downstream end of the Discharge Channel is fully breached and flow is allowed to backwater into the Discharge Channel.

3.2.2 Step 2

Begins: This step begins when the berm at the downstream end of the Discharge Channel is breached and flow is allowed to backwater into the Discharge Channel.

Actions Taken:

This step is characterized primarily by the actual diversion of flows into the permanent Approach Channel. The specific actions include:

- Initial breach of the diversion structures to allow flow into the Approach Channel via the Crim Creek and Chehalis River flow paths. This includes breaching the diversion structures isolating the portion of the existing Chehalis River channel between the Crim Creek and Chehalis River entrances to the Bypass Channel.
- Concurrent to degrading the diversion structures of the Bypass Channel, new diversion structures at the Crim Creek and Chehalis River entrances to the Bypass Channel will be initiated in order to gradually reduce flow into the Bypass Channel.
- As flow in the Bypass Channel is reduced, aquatic species salvage commences.

Ends: This step ends when Chehalis River and Crim Creek flows are completely diverted into the Approach Channel. The upstream end of the Bypass Channel is closed but remains open at the downstream end.

3.2.3 Step 3

Begins: This step begins when Chehalis River and Crim Creek flows are completely diverted into the Engineered Channel, passage conduits, and stilling basin. The Bypass Channel is closed at the upstream end but remains open at the downstream end.

Actions Taken:

This step consists of the downstream closure of the Bypass Channel. The specific actions include:

- With complete diversion of streamflow into the Approach Channel, the downstream end of the Bypass Channel can be closed. This closure will be gradual and in-concert with aquatic species salvage efforts in the channel.
- As the Bypass Channel will be subject to backwater conditions only, the final closure will isolate a final pool of water within the channel. This pool will be gradually dewatered via screened pumps, at a rate necessary to support aquatic species salvage.

Ends: This step ends when the Bypass Channel is closed to streamflow at both ends. De-watering is complete. Aquatic species salvage efforts are complete.

4.0 Next Steps

Construction activities, timing, and sequencing are still under development. Means and methods of diversion activities have yet to be determined, but should support the tenets provided here-in The in-water work sequencing presented herein is a feasible option; however, the selected contractor may develop alternative plans which will be subject to review by the District and regulatory agencies to ensure consistency with existing environmental authorizations.

5.0 References

HDR Engineering, Inc. (HDR)

2018b Fish Passage: CHTR Preliminary Design Report. February 2018.

2024a Revised Project Description Report. April 2024.

2024b Revised Project Description Report, Appendix D2: Hydraulic Design of Fish Passage and Evacuation Conduits TM. April 2024.

2024c Revised Project Description Report, Appendix D3: Chehalis Construction Bypass Hydraulic Modeling. April 2024.

2024c Revised Project Description Report, Appendix K: Constructability Report. April 2024.

National Marine Fisheries Service (NMFS)

2000. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act. Available: www.nwr.noaa.gov/ESA-SalmonRegulations-Permits/4d-Rules/upload/electro2000.pdf (October 2005).

WSDOT (Washington Department of Transportation).

2016 *Fish Exclusion Protocols and Standards.* September 2016.

6.0 Acronyms/Abbreviations

AEP	Annual Exceedance Probability
Ecology	Washington State Department of Ecology
ESA	Endangered Species Act
FFPF	Flood Fish Passage Facility
FRE	Flood Retention Expandable
HDR	HDR Engineering, Inc.
NMFS	National Marine Fisheries Service
RPDR	Revised Project Description Report
USACE	US Army Corps of Engineers
WDFW	Washington State Department of Fish and Wildlife

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Attachment A. Phase 1-2 Transition, Step 1

CONSTRUCTION IN-WATER WORK STEPS

YEAR 1
IN-WATER WORK WINDOW 1
TRANSITION FROM PHASE 1 TO PHASE 2
STEP 1

Legend

- FRE FACILITY
- EXISTING OHWM - 2YR WSEL
- 10 FT CONTOUR
- CHANNEL BREACH
- DIRECTION OF FLOW
- EXISTING RIVER BANK
- BYPASS CHANNEL EMBANKMENT
- BYPASS CHANNEL
- APPROX. SUMMERTIME WETTED AREA

UPSTREAM FISH PASSAGE ROUTE

DOWNSTREAM FISH PASSAGE ROUTE

1. BYPASS CHANNEL AND BYPASS CHANNEL EMBANKMENT ABOVE OHWM CONSTRUCTED IN THE DRY, BEHIND THE EXISTING RIVER BANK, PRIOR TO STEP 1.

2. EXISTING RIVER BANK BREACHED DURING STEP 1, CONNNECTING BYPASS CHANNEL TO EXISTING CHEHALIS RIVER. BYPASS CHANNEL BACKWATERED BY CHEHALIS RIVER. AQUATIC SPECIES EXCLUDED AND REMOVED FROM WORK AREA PRIOR TO CONSTRUCTION BELOW OHWM.

3. AQUATIC SPECIES EXCLUSION REMOVED FROM WORK AREA FOLLOWING CONSTRUCTION BELOW OHWM. AQUATIC SPECIES HAVE ACCESS TO BACKWATERED BYPASS CHANNEL.

NOTES
1. REQUESTED IN-WATER WORK WINDOW: JULY 1 - SEPTEMBER 30.
2. VOLITIONAL UPSTREAM AND DOWNSTREAM AQUATIC SPECIES PASSAGE CONTINUES THROUGHOUT CONTRUCTION.

0 425 850
Feet

EXISITING BRIDGE

CHEHALIS RIVER

RIGHT FRE FOUNDATION CONSTRUCTED IN PHASE 1

CRIM CREEK

CHEHALIS RIVER

CHEHALIS RIVER

EXISITING BRIDGE

Attachment B. Phase 1-2 Transition, Step 2

CONSTRUCTION IN-WATER WORK STEPS

YEAR 1
IN-WATER WORK WINDOW 1
TRANSITION FROM PHASE 1 TO PHASE 2
STEP 2

Legend

- FRE FACILITY
- EXISTING OHWM - 2YR WSEL
- 10 FT CONTOUR
- CHANNEL BREACH
- DIRECTION OF FLOW
- EXISITING RIVER BANK
- CONSTRUCTED EMBANKMENT
- BYPASS CHANNEL EMBANKMENT
- APPROX. SUMMERTIME WETTED AREA
- UPSTREAM FISH PASSAGE ROUTE
- DOWNSTREAM FISH PASSAGE ROUTE

1. PERFORM INITIAL BREACH OF EXISTING RIVER BANKS TO ALLOW CHEHALIS RIVER AND CRIM CREEK INTO THE BYPASS CHANNEL.

   GRADUALLY WIDEN BREACHES OF EXISTING RIVER EMBANKMENTS WHILE SIMULTANEOUSLY CONSTRUCTING BYPASS CHANNEL EMANKMENTS. AS FLOW GRADUALLY DIVERTS INTO THE BYPASS CHANNEL THE WSEL IN THE EXISTING CHEHALIS RIVER WILL SLOWLY LOWER. PERFORM AQUATIC SPECIES RELOCATION CONTINUOUSLY THROUGHOUT IN-WATETR WORK. WORK CONTINUES UNTIL EXISTING CHANNEL AREAS WITHIN THE FINAL BYPASS FOOTPRINT ARE FULLY BREACHED, BYPASS EMBANKMENTS ARE COMPLETE, AND FLOW IS FULLY DIVERTED FROM THE EXISTING CHEHALIS RIVER AND CRIM CREEK TO THE BYPASS CHANNEL.

2. RELOCATE AQUATIC SPECIES FROM THE EXISTING RIVER CHANNEL AS WSEL DROPS. PUMP OUT REMAINING WATER AND RELOCATE FISH SIMULTANEOUSLY UNTIL CHANNEL IS DRY.

3. CONSTRUCT PART OF DOWNSTREAM, LEFT BANK BYPASS CHANNEL EMBANKMENT. EXCLUDE AND RELOCATE AQUATIC SPECIES PRIOR TO STARTING IN-WATER WORK.

4. AQUATIC SPECIES HAVE ACCESS TO BACKWATERED EXISTING CHEHALIS RIVER CHANNEL.

0 425 850
Feet

EXISITING BRIDGE

CHEHALIS RIVER

CRIM CREEK

RIGHT FRE FOUNDATION CONSTRUCTED IN PHASE 1

EXISITING BRIDGE

CHEHALIS RIVER

NOTES
1. REQUESTED IN-WATER WORK WINDOW: JULY 1 - SEPTEMBER 30.
2. VOLITIONAL UPSTREAM AND DOWNSTREAM AQUATIC SPECIES PASSAGE CONTINUES THROUGHOUT CONTRUCTION.

Attachment C. Phase 1-2 Transition, Step 3

CONSTRUCTION IN-WATER WORK STEPS

YEAR 1
IN-WATER WORK WINDOW 1
TRANSITION FROM PHASE 1 TO PHASE 2
STEP 3

EXISITING BRIDGE

CHEHALIS RIVER

RIGHT FRE FOUNDATION CONSTRUCTED IN PHASE 1

CRIM CREEK

CHEHALIS RIVER

EXISITING BRIDGE

Legend

- FRE FACILITY
- EXISTING OHWM - 2YR WSEL
- 10 FT CONTOUR
- DIRECTION OF FLOW
- CONSTRUCTED EMBANKMENT
- BYPASS CHANNEL EMBANKMENT
- APPROX. SUMMERTIME WETTED AREA
- UPSTREAM FISH PASSAGE ROUTE
- DOWNSTREAM FISH PASSAGE ROUTE

1. EXCLUDE AQUATIC SPECIES FROM THE WORK AREA. GRADUALLY CONSTRUCT FINAL BYPASS CHANNEL EMBANKMENT SIMULTANEOUSLY WITH AQUATIC SPECIES RELOCATION.

2. RELOCATE AQUATIC SPECIES FROM THE EXISTING RIVER CHANNEL AS WSEL DROPS WHILE FINAL BYPASS CHANNEL EMBANKMENT IS CONSTRUCTED. PUMP OUT REMAINING WATER AND RELOCATE AQUATIC SPECIES SIMULTANEOUSLY UNTIL OLD CHEHALIS RIVER CHANNEL IS DRY AND AQUATIC SPECIES ARE SAFELY RELOCATED.

3. PHASE 2 WORK COMMENCES FOLLOWING CONCLUSION OF IN-WATER WORK WINDOW 1.

NOTES
1. REQUESTED IN-WATER WORK WINDOW: JULY 1 - SEPTEMBER 30.
2. VOLITIONAL UPSTREAM AND DOWNSTREAM AQUATIC SPECIES PASSAGE CONTINUES THROUGHOUT CONTRUCTION.

N

0 425 850
Feet

Attachment D. Phase 2-3 Transition, Step 1

CONSTRUCTION IN-WATER WORK STEPS

YEAR 3
IN-WATER WORK WINDOW 2
TRANSITION FROM PHASE 2 TO PHASE 3
STEP 1

EXISITING BRIDGE

LEFT FRE STRUCTURE, OUTLET WORKS, FLOOD FISH PASSAGE FACILITY, AND LEFT ABUTMENT GRADING

CHEHALIS RIVER

RIGHT FRE FOUNDATION CONSTRUCTED IN PHASE 1

CRIM CREEK

CHEHALIS RIVER

EXISITING BRIDGE

Legend

- FRE FACILITY
- OHWM - 2YR WSEL
- 10 FT CONTOUR
- CHANNEL BREACH
- CONSTRUCTED EMBANKMENT
- BYPASS CHANNEL EMBANKMENT
- APPROX. SUMMERTIME WETTED AREA
- EXISTING RIVER BANK
- PERMANENT CHANNEL
- DIRECTION OF FLOW
- UPSTREAM FISH PASSAGE ROUTE
- DOWNSTREAM FISH PASSAGE ROUTE

1. PERMANENT RIVER CHANNEL CONSTRUCTED IN THE DRY IN PHASE 2, PRIOR TO IN-WATER WORK WINDOW 2.

   CHANNEL EMBANKMENT CONSTRUCTED AND EXISTING RIVER BANK BREACHED DURING STEP 1. CHEHALIS RIVER CONNECTED TO PERMANENT CHANNEL AND FISH PASSAGE CONDUIT STILLING BASIN BY BREACH. FISH PASSAGE CONDUIT STILLING BASIN AND PERMANENT CHANNEL DOWNSTREAM BACKWATERED BY CHEHALIS RIVER. AQUATIC SPECIES EXCLUDED AND REMOVED FROM WORK AREA PRIOR TO CONSTRUCTION BELOW OHWM. AQUATIC SPECIES EXCLUDED FROM FISH PASSAGE CONDUIT STILLING BASIN THROUGHOUT STEP 1.

2. UPSTREAM AND DOWNSTREAM VOLITIONAL AQUATIC SPECIES PASSAGE CONTINUES VIA BYPASS CHANNEL.

NOTES
1. REQUESTED IN-WATER WORK WINDOW: JULY 1 - SEPTEMBER 30.
2. VOLITIONAL UPSTREAM AND DOWNSTREAM AQUATIC SPECIES PASSAGE CONTINUES THROUGHOUT CONTRUCTION.

N

0 425 850
Feet

Attachment E. Phase 2-3 Transition, Step 2

CONSTRUCTION IN-WATER WORK STEPS

YEAR 3
IN-WATER WORK WINDOW 2
TRANSITION FROM PHASE 2 TO PHASE 3
STEP 2

EXISITING BRIDGE

LEFT FRE STRUCTURE, OUTLET WORKS, FLOOD FISH PASSAGE FACILITY, AND LEFT ABUTMENT GRADING

RIGHT FRE FOUNDATION CONSTRUCTED IN PHASE 1

EXISITING BRIDGE

CHEHALIS RIVER

CRIM CREEK

CHEHALIS RIVER

Legend

- FRE FACILITY
- BYPASS CHANNEL EMBANKMENT
- 10 FT CONTOUR
- CHANNEL BREACH
- APPROX. SUMMERTIME WETTED AREA
- OHWM - 2YR WSEL
- CONSTRUCTED EMBANKMENT
- DIRECTION OF FLOW
- UPSTREAM FISH PASSAGE ROUTE
- DOWNSTREAM FISH PASSAGE ROUTE

1. PERFORM INITIAL BREACH OF BYPASS CHANNEL TO ALLOW CHEHALIS RIVER AND CRIM CREEK INTO THE PERMANENT CHEHALIS RIVER CHANNEL.

2. GRADUALLY WIDEN BREACHES OF BYPASS CHANNEL EMBANKMENTS WHILE SIMULTANEOUSLY CONSTRUCTING PERMANENT CHANNEL EMANKMENTS. AS FLOW GRADUALLY DIVERTS INTO THE PERMANENT RIVER CHANNEL THE WSEL IN THE BYPASS CHANNEL WILL SLOWLY LOWER. PERFORM AQUATIC SPECIES RELOCATION CONTINUOUSLY THROUGHOUT IN-WATETR WORK. WORK CONTINUES UNTIL BYPASS EMBANKMENT AREAS WITHIN THE PERMANENT CHANNEL FOOTPRINT ARE FULLY BREACHED, PERMANENT EMBANKMENTS ARE COMPLETE, AND FLOW IS FULLY DIVERTED FROM THE BYPASS CHANNEL TO THE PERMANENT CHANNEL.

3. AQUATIC SPECIES HAVE ACCESS TO BACKWATERED EXISTING CHEHALIS RIVER CHANNEL.

NOTES
1. REQUESTED IN-WATER WORK WINDOW: JULY 1 - SEPTEMBER 30.
2. VOLITIONAL UPSTREAM AND DOWNSTREAM AQUATIC SPECIES PASSAGE CONTINUES THROUGHOUT CONTRUCTION.

N

0 425 850
Feet

Attachment F. Phase 2-3 Transition, Step 3

CONSTRUCTION IN-WATER WORK STEPS

YEAR 3
IN-WATER WORK WINDOW 2
TRANSITION FROM PHASE 2 TO PHASE 3
STEP 3

EXISITING BRIDGE

LEFT FRE STRUCTURE, OUTLET WORKS, FLOOD FISH PASSAGE FACILITY, AND LEFT ABUTMENT GRADING

GHEHALIS RIVER

RIGHT FRE FOUNDATION CONSTRUCTED IN PHASE 1

CRIM CR

CHEHALIS RIVER

EXISITING BRIDGE

Legend

- FRE FACILITY
- PROPOSED OHWM - 2YR WSEL
- 10 FT CONTOUR
- DIRECTION OF FLOW
- CONSTRUCTED EMBANKMENT
- BYPASS CHANNEL EMBANKMENT
- APPROX. SUMMERTIME WETTED AREA
- UPSTREAM FISH PASSAGE ROUTE
- DOWNSTREAM FISH PASSAGE ROUTE

1. EXCLUDE FISH FROM THE WORK AREA. GRADUALLY CONSTRUCT FINAL PERMANENT CHANNEL EMBANKMENT SIMULTANEOUSLY WITH AQUATIC SPECIES RELOCATION.

2. RELOCATE AQUATIC SPECIES FROM THE BYPASS CHANNEL AS WSEL DROPS WHILE PERMANENT EMBANKMENT IS CONSTRUCTED. PUMP REMAINING WATER OUT OF BYPASS CHANNEL AND RELOCATE AQUATIC SPECIES SIMULTANEOUSLY UNTIL BYPASS CHANNEL IS DRY AND FISH ARE SAFELY RELOCATED.

3. PHASE 3, INCLUDING CONSTRUCTION OF RIGHT SIDE OF FRE STRUCTURE AND FILLING OF DRY BYPASS CHANNEL, COMMENCES FOLLOWING CONCLUSION OF IN-WATER WORK WINDOW 2.

NOTES
1. REQUESTED IN-WATER WORK WINDOW: JULY 1 - SEPTEMBER 30.
2. VOLITIONAL UPSTREAM AND DOWNSTREAM AQUATIC SPECIES PASSAGE CONTINUES THROUGHOUT CONTRUCTION.

0 425 850
Feet

Appendix B. Juvenile Fish Sounding TM

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Technical Memorandum

Date:	November 21, 2025
Project:	Chehalis River Basin Flood Damage Reduction Project
To:	Chehalis Basin Flood Control Zone District
From:	Cheyenne Ginther, HDR, Environmental Scientist Peter Drobny, HDR, Senior Fisheries Scientist Norm Ponferrada, HDR, Senior Fisheries Project Manager
Subject:	**Juvenile Fish Sounding (Draft)**

1.0 Background

The Proposed Chehalis River Basin Flood Damage Reduction project (Proposed Project) objective is to implement a series of measures aimed at reducing damage to the communities of the Chehalis River Basin from Pe Ell to Centralia during major flood events. Among these measures is a proposed Flood Retention Expandable (FRE) structure on the Chehalis River, south of Pe Ell, Washington.

The Proposed Project's draft Preliminary Design Report (PDR) documents development of the preliminary design of the FRE facility and related elements. Development of the draft PDR began following submittal of the Revised Project Description Report (HDR Engineering, Inc. [HDR] 2024), which was used as the baseline for the draft PDR, submitted for information-only purposes on June 30, 2025 (HDR 2025a). This draft PDR reflects design development that has occurred since submittal of the June 30, 2025, draft PDR.

The draft PDR documents the design basis for each Proposed Project element, including a record of design decisions, assumptions, and methods related to the development of the design of the FRE structure and related elements. The draft PDR also presents the technical details of the main features of the Proposed Project elements..

2.0 Introduction

The Chehalis River Basin Flood Control Zone District is proposing the construction and operation of an FRE structure at river mile (RM) 108.4 near the town of Pe Ell, Washington to reduce damage during a major flood. FRE facility designs, construction methods, and operation plans presented herein are subject to updates during future design phases.

The Proposed Project involves construction and operation of a flow-through dam for flood control, which is unlike a traditional detention dam. The Proposed Project's hydraulic outlets and fish passage structures will be built at the same height as the existing riverbed. Except during

operations for infrequent major storm events (defined in Section 3.0), the mainstem of the Chehalis River will flow freely through the fish passage structure system. Because flow-through dams minimally affect a river's natural flow under normal conditions, consequences such as blocking fish migration routes, accumulating sediment, restricting water flow to downstream communities, and other negative fish impacts are avoided or minimized.

The Proposed Project will not involve a permanent pool or reservoir. Rather, an area behind the dam will be inundated only temporarily when the structure is being operated for downstream flood reduction. Following passage of the peak flood flow, the inundated area will be drained and flow-through conditions re-established. There is a risk that juveniles may be entrained into hydraulic outlets while the temporary inundation pool is drained. Entrained juveniles may be at risk of injury or death if the outlets are unscreened or not hydraulically conducive to safe fish passage.

2.1 Purpose and Scope of the Memorandum

This memorandum presents available research to inform design and recommend potentially appropriate depths for hydraulic outlets to limit the risk of entrainment to fish moving downstream during temporary impoundment events. This recommendation is reached by assessing the juvenile outmigrant entrainment risk during evacuation of the temporary reservoir. The memo describes the potential risk of entrainment into the hydraulic outlet gates opening at depth due to "juvenile fish sounding" or movement into deeper water toward the end of the temporary inundation area.

The analyses focuses on salmonids, primarily spring-run and fall-run Chinook Salmon (*Oncorhynchus tshawytscha*), Coho Salmon (*O. kisutch*) and winter-run steelhead (*O. mykiss*) which are prey items for the endangered Southern Resident Killer Whale (*Orcinus orca*), resulting in their coverage under Section 7 of the federal Endangered Species Act (ESA). While this document focuses on salmonids, the project overall is designed to be relevant for a wide range of other aquatic species and life stages. Therefore, the research presented in this technical memorandum may have some applicability to other species listed in Table 1 that may be impacted by the flood retention operations due to research on the other species being limited or non-existent.

2.2 Proposed Project Overview

The FRE structure includes fish passage and hydraulic outlet gates. When a temporary reservoir is held upstream of the FRE structure, the fish passage gates are closed, and the hydraulic outlet gates will be used for reservoir releases.

3.0 Characterization of Facility Operation

For this technical memorandum, operation of the FRE facility occurs in two main operational states:

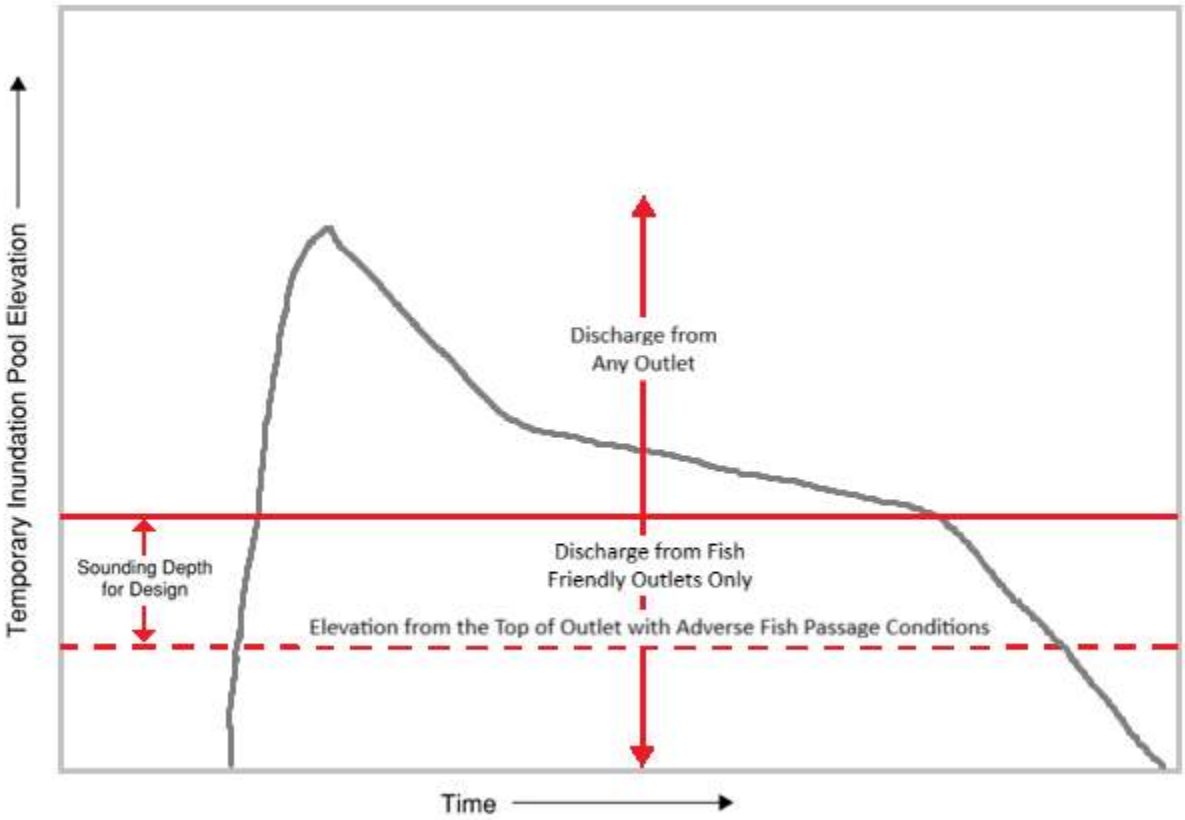
- **Normal Flow-Through Operation**: When the fish passage and hydraulic outlet gates are open and the Chehalis River flows through the FRE unimpeded.

- **Flood Retention Operation**: When the fish passage gates are closed and openings on the hydraulic outlets are reduced to impound incoming floodwaters behind the FRE.

Flood retention operation will occur when operational rules triggered. For example, an operational trigger may be that a specific flow is forecast for the Chehalis River at a specific location or river mile. Based on the hydraulic record, the hydrologic and operations modeling indicates that these events are expected to trigger flood retention operations every 4 to 5 years between the months of November to February. Flood retention operations are likely to increase every 2 to 3 years in frequency over time, during the months of November to April, due to climate changes by the year 2080 (HDR 2024b).

Error! Reference source not found. Figure 1 shows that when an impoundment event occurs, flood retention operations will trigger the fish passage gates to be closed, resulting in the reservoir elevation rising to store water and reduce flooding downstream. When the temporary reservoir elevation exceeds the depths for which fish are more likely to dive or sound, water will be released through unscreened, high-velocity hydraulic outlets. As the reservoir elevation drops, the flood retention operations eventually will switch to hydraulic outlets that exclude fish or provide hydraulically favorable conditions for downstream passage. Discharge through these “fish friendly” hydraulic outlets will continue as the facility transitions from flood retention operations to normal flow-through operations. Managing which hydraulic outlets are used based on reservoir depth will reduce the risk of entrainment to fish because discharge through any outlet will be at depths greater where fish are less likely to sound.

Figure 1. Hydraulic Outlet Operation and Sounding Depth for Design When Holding a Temporary Inundation Pool



Temperature stratification of the temporary inundation pool is not expected due to the temporary nature of the flood retention operations. Filling and draining rates for the temporary pool, and high flow rates of the Chehalis River entering the pool during and following storm events, are expected to result in high levels of mixing and turbidity, which prevent the conditions necessary for stratification. In addition, extended periods of time with low levels of mixing are necessary for stratification to occur. Impoundment events are anticipated to be of short duration – less than six weeks. This is supported by recent operations modeling. Such durations, with the high levels of mixing expected, make stratification further unlikely especially given that impoundment events are most likely to occur during the winter months when fish are less likely to sound deeper seeking cooler water temperatures. Target Species of Concern

The Proposed Project is being developed for fish passage to address fish species that use the Chehalis River, as indicated in Table 1Table 1. Although no aquatic species are federally listed as endangered or threatened in this part of the Chehalis River, under Section 7 of the federal ESA, spring-run and fall-run Chinook Salmon, Coho Salmon, and winter-run steelhead are species known to be prey items for the endangered Southern Resident Killer Whale. Therefore, this technical memorandum will focus on these three salmonid species that may indirectly impact Southern Resident Killer Whales due to potential entrainment during flood retention operations.

Table 1. Fish Species and Life Stages Selected for Fish Passage Design

Species	Upstream Passage	Downstream Passage
Spring-run and Fall-run Chinook Salmon (*Oncorhynchus tshawytscha*)	Adult, juvenile	Juvenile
Coho Salmon (*Oncorhynchus kisutch*)	Adult, juvenile	Juvenile
Winter-run Steelhead (*Oncorhynchus mykiss*)	Adult, juvenile	Adult, juvenile
Coastal Cutthroat Trout (*Oncorhynchus clarkii clarkii*)	Adult, juvenile	Adult, juvenile
Pacific Lamprey (*Entosphenus tridentatus*)	Adult	Larvae
Western Brook Lamprey (*Lampetra richardsoni*)	Adult	Larvae
Resident fish: River Lamprey, Largescale Sucker, Salish Sucker, Torrent Sculpin, Reticulate Sculpin, Riffle Sculpin, Prickly Sculpin, Speckled Dace, Longnose Dace, Peamouth, Northern Pikeminnow, Redside Shiner, Rainbow Trout, Mountain Whitefish	Adult	Adult

Source: HDR 2018

The target salmonid species (Chinook Salmon, Coho Salmon, and steelhead) are known to have unique migration behaviors that allow them to pass upstream or downstream through the FRE site at specific times of the year. As presented in Figure 2, fish species migration timing and duration influence the design and operation of proposed fish passage facilities by defining the physical, operational, and environmental conditions expected to occur while passage is required. The timing and duration of migration for these fish species and life stages were discussed at the 2016-2017 Fish Passage Subcommittee meetings (Appendix I: Fish Passage Report; HDR 2025b) as new information was aggregated and analyzed. The periods shown in Figure 2 incorporate anecdotal data of species' presence at the extreme ends of known movement periods and are potentially likely broader than what may be found in the river.

Figure 2. Anticipated Migration Periods of the Targeted Species and Life Stages (Periodicity)

The following sections focus on general information for Chinook Salmon, Coho Salmon, and steelhead in the Chehalis Basin, detailing each species' juvenile outmigration, which has a greater potential to be affected by implementation of the flood retention operations due to entrainment.

3.1 Chinook Salmon

The Chehalis Basin has both spring- and fall-run Chinook Salmon which are part of the Washington Coast Evolutionarily Significant Unit (ESU). Spawn timing is distinguished between spring- and fall-run Chinook Salmon in the Chehalis River Basin. While timing may overlap, for practical purposes, October 15th is the current accepted spawning date used to differentiate the spring-run from the fall-run Chinook Salmon (Ashcraft et al. 2017). Brown et al. (2017) found Skookumchuck and upper Chehalis Rivers spring-run Chinook Salmon introgressed with the fall-run and timing may not reflect actual run type. Brown et al. (2017) revealed that fall and spring runs were not genetically distinct and found slight differentiation between downstream and upstream collections (i.e., those upstream and downstream of the confluence with the Skookumchuck River), and states that "this was likely driven by isolation by distance." Based on this information from Brown et al. (2017), individuals that spawn upstream of the FRE have "a low degree of differentiation" from those that spawn in the mainstem Chehalis River upstream of the confluence with the Skookumchuck River (RM 67).

Most Chinook Salmon in the Chehalis Basin exhibit ocean-type life histories (Smith and Wenger 2001). Most spring- and fall-run Chinook Salmon juveniles emerge the following spring, distribute downstream, and emigrate in their first spring. A small proportion are assumed to delay emigration until the following spring to emigrate as yearlings. The following are juvenile life-history patterns for spring- and fall-run Chinook Salmon including their allocation across the modeled life-history trajectories (McConnaha et al. 2017):

- **Fry Migrant (45 percent)**: Rapid downstream migrant about 3 weeks after emerging between January to mid-March. Extended residence in the estuary.

- **Fingerling Migrant (45 percent)**: Conventional ocean-type Chinook Salmon. Soon after emergence, they begin moving downstream slowly, eventually increasing speed to enter the estuary in late spring between April to July.
- **Yearling Migrant (10 percent)**: Stream type. Spends winter in or near natal reach, eventually goes through a smoltification process (i.e., change in osmoregulation to be able to transition from freshwater to saline or ocean environments) the following spring and moves rapidly downstream to the estuary.

3.2 Coho Salmon

Coho Salmon in the Chehalis River are part of the Southwest Washington Coho Salmon ESU, for which no major spawning groups have been specified (WDFW 2019). In a genetic study of Coho Salmon in the Chehalis Basin, Seamons et al. (2019) found genetic differences between groups of Coho Salmon from the same spawning location, among spawning tributaries, and based on run timing (early and late). Coho Salmon in the upper Chehalis Basin (i.e., upstream of the proposed FRE site) were genetically distinct from Coho Salmon spawning in other locations, suggesting population differences among subbasins (Seamons et al. 2019).

Coho Salmon in the Chehalis Basin were assumed to follow a standard Coho Salmon stream-type life history (Smith and Wenger 2001). Juveniles emerge in the spring between February to May and spend the next year in various habitats within the Chehalis River Basin which includes side channels, beaver ponds, floodplain wetlands, and backwaters for overwintering and summer rearing. Emigration from the system typically occurs in the second spring after one year in freshwater between March to June. The following are juvenile life-history patterns for Coho Salmon including their allocation across the modeled life-history trajectories (McConnaha et al. 2017):

- **Resident (50 percent)**: Migrates no more than 40 kilometers (24 miles) downstream of natal reach during juvenile rearing, moves rapidly downstream in the second spring-run to the estuary.
- **Migrant (50 percent)**: Extended downstream movement including fall-run redistribution downstream. Could migrate almost to the estuary during juvenile rearing, reaching the estuary in second spring-run.

Juvenile Coho Salmon have been documented to move upstream up to a few kilometers (more than 1 mile) in some Chehalis Basin tributaries. Upstream movements primarily occurred during warmer months, which may indicate a need to access cold water refugia (Winkowski et al. 2018). Warm summer stream temperatures and the presence of competitive cyprinids in lower reaches appear to limit the amount of suitable juvenile rearing habitat in the Chehalis Basin (Winkowski et al. 2018; Winkowski and Zimmerman 2019). During 2015, juvenile salmon distribution surveys conducted upstream of the FRE site, Winkowski et al. (2016) found juvenile Coho Salmon throughout the maximum modeled FRE temporary inundation area.

3.3 Steelhead

Winter-run steelhead are present throughout the Chehalis River. The upper Chehalis River supports a relatively large number of wild winter-run steelhead (Ashcraft et al. 2017). Winter-run

steelhead spend the greatest amount of time in freshwater compared to other anadromous salmonids. Fry start to emerge from the gravels between May to September and freshwater rearing ranges from 1 to 3 years before emigration in the summer between April to August. Fry use low-velocity margin habitats after emergence and juveniles move into areas of fast water and large substrate as they grow. Like Coho Salmon, more structurally complex habitats (e.g., with more wood) can support more juvenile steelhead. The following are Juvenile life-history patterns for steelhead including their allocation across the modeled life-history trajectories (McConnaha et al. 2017):

- 85 percent spend 2 years in freshwater; 15 percent spend 3 years in freshwater.
- **Resident (50 percent)**: Stays relatively close to natal reach before smolting.
- **Transient (50 percent)**: Alternating periods of rearing and migration throughout the summer rearing period in all pre-smolting years.

4.0 Fish Sounding Behavior

Juvenile fish passage through the FRE structure and expected juvenile fish migration depths when faced with a temporary passage barrier are discussed in the following sections.

4.1 Downstream Juvenile Salmonid Fish Passage at FRE

When open during Normal Operations, the fish passage gates will help facilitate the downstream juvenile salmonid passage. When closed during Flood Retention Operations, a small number of outmigrating fish could potentially sound to 30 feet or more depending on outmigrant size of the temporary inundation area is evacuated, there is a risk that juvenile salmonids may be entrained into the evacuation conduits outmigrants and length of impoundment, which if (i.e., 0or greater) may put them at risk of entrainment in the hydraulic outlets (Dauble et al. 1989; Li et al. 2015; Smith 1974). The depth at which fish are likely to sound is further described in Section 5.2. It is important to understand that the FRE is being designed to reduce the impact on juvenile salmonids during the flood retention operations (as stated in Section 3.0), which would be expected to typically occur outside outmigration timing (as shown in Figure 2).

Coho Salmon and steelhead rear in the Chehalis River for more than 1 year and up to 2 years, respectively, before outmigrating. In contrast, both spring and fall Chinook Salmon from the upper Chehalis Basin outmigrate to the estuary as parr, or, in limited cases, fry (Campbell et al. 2017). According to Miller-Nelson et al. (2024), a juvenile salmonid monitoring study in 2023 using a rotary screw trap at RM 94.3 on the upper Chehalis River mainstem near Pe Ell determined the following:

- Of 820 Coho Salmon captured, 274 scale samples were collected, with 95.6 percent being successfully aged finding that the outmigrants were predominantly of the yearling (or 1+) age class (98.5 percent) with a small group of 2+ year-old (1.5 percent) outmigrating.
- Of 591 steelhead captured, 250 scale samples were collected, with 79.6 percent being successfully aged finding that the migrants had a mix of Age-1 representing 33.7 percent,

Age-2 representing 65.3 percent, and Age-3 representing 1 percent of juveniles outmigrating.

- A total of 7,723 Chinook Salmon outmigrants were captured, and no scale samples were taken because they were all assumed to be subyearlings based on their fork length between 45 to 150 millimeters.

When comparing the data derived from McConnaha et al. (2017), the authors used an Ecosystem Diagnosis and Treatment model to evaluate the biological significance of environmental changes regarding regarding the potential of the basin to support salmonids at basin and sub-basin scales due to flood damage reduction and habitat restoration actions. Whereas Miller-Nelson et al. (2024) focused on captured salmonids in the upper Chehalis Basin downstream of the proposed FRE, both assumed juvenile Coho Salmon and steelhead are highly mobile during the summer low-flow period in the upper mainstem Chehalis River due to the variable ages observed in outmigrants throughout the Chehalis River. Therefore, these age ranges should be considered as larger, older fish may distribute deeper into the water column compared to smaller, younger fish, leaving them more vulnerable to entrainment during flood retention operations.

Findings from McConnaha et al. (2017) and Nelson et al. (2024) are further corroborated by local data collected in summer 2015 where juvenile salmon distributions were surveyed around and within the inundation area of the proposed temporary reservoir, in the upper mainstem Chehalis River near the upper extent of the reservoir inundation area at RM 116 and extending approximately 10 RM upstream (Winkowski et al. 2016). Juvenile Coho Salmon and trout (cutthroat and rainbow/steelhead) were found throughout the proposed temporary reservoir inundation area, which includes stretches of the upper mainstem Chehalis River and 10 RM of several small tributary creeks. Juvenile Coho Salmon and trout were also observed in reaches above the proposed temporary reservoir inundation area. Subyearling and yearling steelhead rear in the area throughout the summer, moving frequently upstream and downstream at the proposed FRE facility site, presumably to forage and maintain optimal body temperature and condition (Winkowski and Zimmerman 2017). Unlike Coho Salmon and steelhead which rear for longer periods in freshwater, subyearling juvenile Chinook Salmon rear in the upper Chehalis River above the proposed FRE facility during their first spring and summer with outmigration from the upper Chehalis Basin generally complete by August (Winkowski and Zimmerman 2017).

Most juvenile salmon and steelhead in the Chehalis River will likely will have migrated downstream from the headwaters to rear in other freshwater habitats in the lower mainstem, off-channel, or floodplain wetlands prior to migrating to the ocean (Schroeder et al. 2025). Ocean migration would occur during the typical outmigration window between February to August, depending on species as detailed in Section 4, outside expected impoundment events that would be expected to occur between November to February that would trigger flood retention operations. This has been observed in other coastal rivers, but this behavior is not well defined for the Chehalis River populations. Juvenile Coho Salmon and steelhead that reside in freshwater longer compared to juvenile Chinook Salmon are likely to be most impacted by the expected impoundment events because they may use upstream rearing sites and need to

access habitats downstream during these high winter flood events, which provide foraging opportunities and refuge from predators and other environmental stressors. Additionally, climate change may also impact timing of these impoundment events (i.e., more variable weather pattern timing), which would result in all other juvenile salmonid species potentially being affected by impoundment events if the flood retention operations occurred during their typical outmigration timing, increasing their risk of entrainment.

4.2 Juvenile Migration Depths

Operation of the FRE for flood control may have unintended consequences when activated to prevent downstream flooding as it can increase juvenile salmonids' potential risk of entrainment into the hydraulic outlets that operate at depths deeper than the fish passage outlets. The ability of juvenile fish to redistribute, both upstream and downstream, into favorable rearing habitats, has also been deemed important to the continued viability of many stocks. Fish migration and passage behaviors have a strong influence on the selection of routes associated with depth, especially for juvenile salmonids which typically prefer to stay in the top 20 feet of the water column as they migrate downstream (NOAA Fisheries 2019). However, according to Ploskey et al. (2006), vertical distribution data usually showed that more than 80 percent of the fish were in the upper 49 feet of the water column.

Faber et al. (2005) looked at smolt-sized fish which included Chinook Salmon, steelhead, Coho Salmon, and Sockeye Salmon (*Oncorhynchus nerka*) at The Dalles Dam on the Columbia River. During the spring, 80 percent of fish were above 5.6 meters (18.4 feet) and 4.7 meters (15.4 feet) of depth during the day and night, respectively. During summer, fish were similarly distributed in the day and night with 80 percent of the fish in the upper 4.5 meters (14.8 feet) and 4.7 meters (15.4 feet) of the water column, respectively. The vertical distribution of smolt-sized fish was also found to be skewed toward the upper water column for all season/diel categories. They also found that smolt-sized fish were distributed deeper in the water column in the center of the channel than near the edges.

A study focused on juvenile Coho Salmon at the Merwin Dam on the Lewis River found that 72 percent of Coho Salmon distributed from the surface to the upper 10 feet (Erho 1964). However, the incidence of Coho Salmon in deeper nets increased as the season progressed with only 52 percent distributing from the surface to the upper 10 feet and 40 percent distributing from 10 to 20 feet by June. It was theorized that surface temperature rising from 5.6 degrees Celsius (ºC) in March to 14.7ºC in June may have resulted in Coho Salmon distributing deeper into the water column.

Another study focused on the Lower Monumental Dam on the Snake River, which has a reservoir with a maximum depth of 115 feet, had two sampling stations established: one station sampled to a depth of 48 feet and one sampled to a depth of 96 feet. The study found that 58 percent of juvenile Chinook Salmon and 36 percent of juvenile steelhead traveled in the upper 12 feet of the reservoir as shown in Table 2 (Smith 1974). Of fish caught in the upper 12 feet, most were predominantly found between the surface and 6 feet.

Table 2. Vertical Distribution of Juvenile Chinook Salmon and Steelhead Caught at Shallow and Deep Stations in the Forebay of the Lower Monumental Dam in 1973

Shallow and Deep Stations Combined				
Depth (feet)	Chinook Salmon		Steelhead	
	# of Fish	Percent	# of Fish	Percent
0 – 12	143	58	441	36
12 – 24	63	26	291	24
24 – 36	19	8	189	15
36 - 48	4	2	106	8
48 – 60	3	1	61	5
60 – 72	6	2	62	6
72 – 84	2	1	32	2
84 – 96	5	2	48	4

Source: Smith (1974)

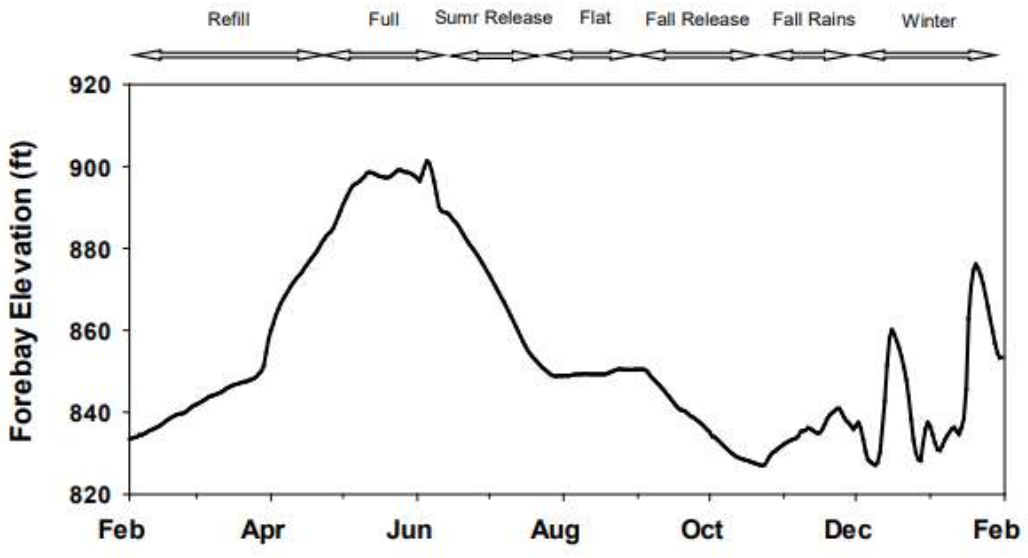
Vertical fish distribution was also examined to determine changes between day and night periods. Smith (1974) found that juvenile Chinook Salmon were observed to be more surface-oriented at night, with 60 percent being captured in the upper 24 feet of the reservoir. Steelhead were observed to be more surface-oriented during the day, with 74 percent being captured in the upper 24 feet of the reservoir. Therefore, steelhead were found to be more surface-oriented during the day whereas juvenile Chinook Salmon were more surface-oriented at night.

A study by Li et al. (2015) focused on juvenile Chinook Salmon and steelhead and compared data across two years (2012 and 2013) in the forebays of two dams on the Snake River, Little Goose Dam and Lower Monumental Dam. The study found that the median depth at which juvenile salmonids approached turbines ranged from 2.8 to 12.2 meters (9.2 to 40 feet), with depths varying by species/life history, year, location (which dam) and diel period (denoting a 24-hour period). The study also showed that fish with estimated deeper vertical depth distributions resided deeper in the forebay prior to passing through the turbines (≤18.4 meters [≤60.4 feet] at Little Goose Dam and 17.0 meters [55.8 feet] at Lower Monumental Dam) compared to those passing through the juvenile bypass system (≤13.0 meters [≤42.7 feet]) at Little Goose Dam and 13.8 meters [45.3 feet]) at Lower Monumental Dam (Li et al. 2015). This was reconfirmed by Li et al. (2018) where they found that juvenile salmonids that passed through deeper routes swam deeper in the water column when approaching the dams which increased the probability of powerhouse passage (i.e., turbine) significantly. While subyearling Chinook salmon that were detected at least once shallower than 12.5 meters (41 feet) were more likely to be guided by the spillway weir.

Li et al. (2015) also noted that most (75 percent) of the fish that passed at night had acclimation depths of ≤7.0 meters (≤30.0 feet), while most of the fish passing during the day had acclimation depths of ≤5.0 meters (≤16.4 feet). For all three species in 2012 and 2013, there were higher percentages of fish acclimated at depths >10 meters (>32.8 feet) for night- versus day-passed fish. Therefore, if operation of the FRE to control flooding occurred during the night, fish are assumed to be more likely to be able to handle passing through the hydraulic outlets at a deeper depth than those that approach the FRE during the day.

While it does appear juvenile salmonids are capable of acclimating to greater depths, Khan et al. (2012) found that juvenile Chinook Salmon and steelhead remained surface-oriented (i.e., above 10 meters [32.8 feet]) 62 percent of the time during the refill and full pool periods to 80 percent of the time during the flat elevation and fall release periods at the Lookout Point Dam on the Middle Fork Willamette River. During these periods, water temperatures from the surface to 5 meters (16.4 feet) ranged from 19.5ºC in August to 12.1ºC in November and were much cooler at depth, ranging from 11.7ºC in August to 10.6ºC in November, at 30 to 35 meters (98.4 to 114.8 feet) depth. Figure 3 shows the daily average surface elevation level of the forebay at the Lookout Point Dam from February 2010 to January 2011. The surface elevation level at the forebay paired with the water temperature may indicate why fish are more likely to remain surface-oriented versus diving deeper as typically when reservoir water temperatures are high in surface water, fish tend to move to deeper, cooler water. Regardless of temperature, the highest percentage of fish (30 to 60 percent) remained between 5 and 10 meters (16.4 and 32.8 feet) which was a prevalent behavior for juvenile salmonids.

Figure 3. Daily Average Surface Elevation (feet above mean sea level) of the Forebay at the Lookout Point Dam from February 2010 to January 2011



Source: Khan et al. (2012)

Lastly, Beeman et al. (2014) studied in-reservoir movements and dam passage of juvenile Chinook Salmon and steelhead at the Detroit Reservoir and Dam, near Detroit, Oregon. They

found that the depths of tagged fish within 25 meters of the dam varied between species, reservoir elevation, and diel period. When the reservoir elevation was greater than the spillway ogee of 1,541 feet during the spring study period, the mean hourly depths of Chinook Salmon ranged from 10.4 to 29.1 feet and were slightly deeper during the day than during the night. When the reservoir elevation was less than 1,541 feet during the spring study period, which occurred as the reservoir was filling in March and April, Chinook Salmon showed a large variation in depth-distribution across a 24-hour period; however, only eight tagged fish were present during that condition. Their individual mean hourly depths ranged from 16.0 to 139.0 feet, with mean values of 104.5 feet during the day and 28.5 feet during the night. Steelhead depths were shallower and less variable than Chinook Salmon depths during the spring study period. Their mean hourly estimated depths ranged from the surface to 7.1 feet and were similar during the day and night.

4.3 Biological Mechanisms Influencing Fish Depth

To better understand why juvenile fish are distributed in the upper portions of the water column, biological mechanisms should also be reviewed. Juvenile fish activity is largely focused on survival and growth due to the limited physical resources they have in younger life stages (developing muscles, minimal fat stores). Bioenergetics is a research area that describes the balance of fish activity in a biological way.

Fish bioenergetics can be described as an energy budget where fish balance energy gained from ***I*** (ingestion: total energy gained) and lost through ***G*** (growth: increase in length and weight over time), ***A*** (activity: physical movements such as swimming, foraging, social interactions, evading predators, and search for suitable habitats), ***M*** (metabolism: chemical processes that convert food into energy in order to maintain life), ***R*** (reproduction: development of gonads: ovaries & testes and production of gametes: eggs & sperm), ***E*** (excretion: expelling or removal of metabolic waste through fecal matters, ammonia, urea, or uric acid), and ***SDA*** (specific dynamic action: digestive processes, nutrient absorption and assimilation; Mayfield and Cech 2004). A simplified bioenergetics equation is modeled below:

$$I = G + A + M + R + E + SDA$$

The bioenergetic demands of juvenile salmonids typically increase with activity level during foraging and searching for suitable habitats (Hartman & Hayward 2007). The presence of predators increases stress levels, as well as burst swimming to evade these predators lead to exhaustion which carries significant bioenergetic costs to juvenile salmonids. As a result, fish tend to inhabit waters with easily accessible and ample amounts of prey items for consumption to continue to have high amounts of stored energy for maintenance, growth, and reproduction to increase survival. This physiological ecology and response reflect the dynamic nature of adjustments aimed at optimizing the bioenergetic balance between consumption and expenditure across changing environmental conditions. More simply stated, bioenergetic success is represented by feeding with minimal effort.

The vertical habitat preferences of juvenile salmonids are generally driven by bioenergetics requirements that ensure that energy intake is maximized, and energy expenditure is minimized.

Since salmonids are primarily visual feeders, occupying the upper portions of water column maximizes energy intake relative to the cost of foraging. In addition, the upper water column tends to be better oxygenated, which supports aerobic metabolism and reduces the energy cost of respiration (Brett 1971, Quinn 2018). By remaining near the top of the water column where prey density is higher, juvenile salmonids can maximize foraging efficiency and achieve a positive energy balance that supports growth. Conversely, deeper portions of the water column often provide fewer prey resources and reduced light for visual feeding, which lowers potential for prey interaction and consumption. Additionally, deeper habitats may increase metabolic rates by swimming against stronger currents and respiratory demands if dissolved oxygen levels are reduced at depth (Gregory and Levings 1998). Vertical distribution of juvenile salmonids is not fixed, but instead reflects dynamic adjustments aimed at optimizing the bioenergetic balance between consumption and expenditure across changing environmental conditions.

The bioenergetics of salmon biology support that juvenile fish do not regularly invest in energetic activity to reach dark, less productive, water depths with little overall potential for benefit (i.e., feeding). Because impoundment of the dam is only expected to occur during flood events over short periods of time, high turbidity would be expected with low penetration of sunlight into the reservoir. With the photic zone (penetration of sunlight to support photosynthesis) being shallow, growth of primary producers (e.g., phytoplankton) and zooplankton at depth is limited, which limits food resources and habitat for macroinvertebrates. Therefore, juvenile fish would tend to occupy the upper water column near the surface to forage on macroinvertebrates associated with the presence of lower trophic level organisms.

While juveniles may infrequently occur at greater depths largely due to passive drift in larger rivers (undertow) or predator avoidance (being chased), the biological drivers behind their bioenergetic ‘budget’ of a juvenile salmon largely results in occupying shallower biologically productive water depths relative to the proposed project diversion.

5.0 Conclusion

Effects on juvenile fish outmigrating downstream in the Chehalis River are expected when flood retention operation occurs, and discharge from outlet gates is reduced to impound floodwater behind the FRE structure. During the portion of flood retention operations when the temporary inundation pool elevation is high the pool is evacuated using unscreened, high velocity hydraulic outlets. Pool evacuation using unscreened, high velocity outlets poses a risk of injury or death to juvenile outmigrants that may become entrained into these hydraulic outlets.

There is a depth at which the risk of fish entrainment is low enough to allow discharge through unscreened, high velocity outlets. It is critical to understand the vertical migratory behavior of fish as they approach the outlets so the hydraulic outlets can be design to operate to reduce risk to juvenile fish. Vertical migration is a typical phenomenon for salmonids and vertical distribution factors during downstream migration vary within reservoirs (e.g., species, diel changes, seasonally, annually, location, temperature, reservoir elevation). To reduce the risk to outmigrants, reservoir releases should occur via unscreened, hydraulic-only outlets at pool depths with low risk of entrainment or via outlets that exclude fish or provide safe downstream

passage through hydraulically favorable conditions. The temporary reservoir elevation at which the depth above an active, unscreened, hydraulic-only outlet has an acceptably low risk of potential entrainment is shown in Figure 1 and described in Section 3 for a typical impoundment event.

In general, the research summarized in this document supports that juvenile salmonids (i.e., Chinook Salmon, Coho Salmon, and steelhead) typically prefer to stay in the top 20 feet of the water column as they migrate. However, study results vary, showing most fish observations from the surface down to maximum depths ranging from approximately 15 to 49 feet. The deeper depths at which are found to sound to are more likely to occur if fish are given time to acclimatize to deeper water columns. Fish are unlikely to acclimatize at the FRE given that storm events are sudden and the impoundment of water behind the FRE structure will be brief and infrequent. Ultimately, water depth preferences are driven largely by bioenergetics requirements, which dramatically reduce entrainment risk into the hydraulic outlets at depths greater than around approximately 20 to 30 feet with reducing risk as depth increases (Sections 4.1 and 4.2).

At a 30-foot depth, the differential ratio of the intake opening to the surface area near the dam is conservatively <0.01 percent. This mitigates much of the risk of entrainment, and even continues to decrease significantly at greater depths. However, an unknown but likely small percentage of fish could sound to depths greater than 30 feet if impoundment conditions persist long enough depending on species, specific life stages (e.g., fry, juvenile, etc.), water temperatures, time of day, and other factors. Additionally, flood retention operation is anticipated to occur about once every 4-to-5-years when the facility first begins operations and increase to once every 2-to-3-years based on recent climate projections. Further, operations are modeled to potentially occur between the months of November to February early in the life of the project and may occur between November and April by the year 2080. which would further increase juvenile salmonids' risk of entrainment. Most juvenile salmon and steelhead in the river will outmigrate after potential flood retention operations may occur early in the project's life (February to August), thus reducing exposure to potential entrainment even further. Exposure to potential entrainment may increase under future climate conditions, but would only increase potential exposure for two additional months of the seven month outmigration period.

HDR discussed the research and findings in this memo with NOAA Fisheries in 2025 (HDR 2025b; Appendix A). It was agreed that most juvenile salmonids likely would not sound deeper than 30 feet in a temporary inundation pool at the FRE structure and would have limited exposure to potential entrainment and flood operation conditions at the FRE. A hydraulic outlet that does not exclude fish or provide safe downstream passage through hydraulically favorable conditions must only discharge flow during flood retention operation when the water surface is 30 feet or more above the top of the same hydraulic outlet. Hydraulic outlets that discharge when the water depth is less than 30 feet must have a smooth inlet transition, such as curved entrances and radial gates. The design direction agreed upon in the meeting, summarized here, is consistent with and supported by the findings documented in this memo and will be incorporated into the project design.

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7.0 Acronyms

ºC	degrees Celsius
FRE	Flood Retention Expandable
HDR	HDR Engineering, Inc.
NOAA	National Oceanic and Atmospheric Administration
PDR	Preliminary Design Report
Proposed Project	Proposed Chehalis River Basin Flood Damage Reduction project
RM	river mile
RPDR	Revised Project Description Report
USFWS	United States Department of Fish and Wildlife
WDFW	Washington Department of Fish and Wildlife
WSEL	water surface elevation level

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Appendix C. Fishway Lighting TM

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Technical Memorandum

Date:	November 21, 2025
Project:	Chehalis River Basin Flood Damage Reduction Project
To:	Chehalis Basin Flood Control Zone District
From:	HDR
Subject:	**Fishway Lighting (Draft)**

1.0 Background

The Proposed Chehalis River Basin Flood Damage Reduction project (Proposed Project) objective is to implement a series of measures aimed at reducing damage to the communities of the Chehalis River Basin from Pe Ell to Centralia during major flood events. Among these measures is a proposed Flood Retention Expandable (FRE) structure on the Chehalis River, south of Pe Ell, Washington.

The Proposed Project's draft Preliminary Design Report (PDR) documents development of the preliminary design of the FRE facility and related elements. Development of the draft PDR began following submittal of the Revised Project Description Report (HDR Engineering, Inc. [HDR] 2024), which was used as the baseline for the draft PDR, submitted for information-only purposes on June 30, 2025 (HDR 2025). This draft PDR reflects design development that has occurred since submittal of the June 30, 2025, draft PDR.

The draft PDR documents the design basis for each Proposed Project element, including a record of design decisions, assumptions, and methods related to the development of the design of the FRE structure and related elements. The draft PDR also presents the technical details of the main features of the Proposed Project elements.

2.0 Introduction

The draft PDR also presents the technical details of the main features of the Proposed Project elements. The FRE structure includes the following fish passage components, designed to provide passage for a range of species and life stages:

- Flood Fish Passage Facility
- Outlet Works, including Fish Passage Structures
- Temporary Channels
- Permanent Channels

Both upstream and downstream passage are considered to include all life-stages of the species listed in Table 1 (Section 4.0).

As used in this Technical Memorandum, “fish passage structures” refers to the pathways designed for upstream and downstream fish passage in the facility. These may be dedicated fishways, the facility’s primary or secondary conduits designed to accommodate fish passage, or other structures that accommodate fish passage. The broader term “fish passage structures” is used because the lighting concerns for these pathways are generally the same regardless of the type of pathway.

3.0 Fishway Lighting

The outlet works consist of conduits and fishways through the base of the FRE structure allowing the Chehalis River to pass through during normal flow-through operation (normal operation). The conduit and fishway gates are normally open for fish passage and only closed for flood retention. When the FRE structure operates to retain flood water (flood retention operation) the fishway gates are closed and the conduits are used for reservoir releases. During flood retention operation fish passage through the outlet works ceases. Fish passage during flood retention operation is described in Appendix I: Fish Passage Report (HDR 2025).

Artificial lighting of the fish passage structures, including pathways through the outlet works, was investigated as a potential mitigation strategy to improve fish passage throughout the year during normal operation. This technical memorandum includes a review of relevant literature to understand how lighting may be used to improve fish passage through the fish passage structures. The affected region of the Chehalis River Basin is characterized by migratory anadromous and other native fish species with reportedly varying levels of behavioral response to artificial light frequency and intensity. Given the varied responses of fish to light, knowledge gaps exist and need to be locally examined prior to final design recommendations. This technical memorandum offers a literature-informed review of artificial lighting impacts on fish passage, drawing from peer-reviewed studies and existing reports on species behavior and light sensitivity. While localized information and studies are key to understanding the benefit of lighting, the results of several studies provided herein highlight the potential outcomes of incorporating lighting to improve fish passage.

Artificial illumination around fish passage systems has been reported to assist and improve fish passage efficiency and restore longitudinal riverine connectivity. Several research and case studies emphasize the need for a holistic approach towards designing a functional fishway, including fish interactions with their environment. In a 2012 study, Vowles and Kemp argue that understanding the relationship between hydrodynamic cues and various environmental stimuli are critical towards implementing safe and successful lighting approaches (Vowles and Kemp 2012). However, there are mixed reviews on the effects of artificial light at night (ALAN) with researchers and industry members often noting an increased effect of predation on smolt or juvenile salmonids when exposed to high light levels at night. Other research studies have posted that varying light levels can act as an attractant or a deterrent (Table 2).

Evidence from Mueller and Simmons (2008), Tetard et al. (2019), Vowles and Kemp (2012), and others shows that juvenile salmonids may be attracted to low-intensity lighting (~0.25 lux, equivalent to moonlight) but startled or deterred by intensities above 400 lux. For some species

(e.g., Topeka shiner, fathead minnow), studies found no significant behavioral change in response to culvert lighting, highlighting the need for site-specific observation (Table 3).

The 2022, National Oceanic and Atmospheric Administration (NOAA) Fisheries West Coast Region Anadromous Salmonid Design Manual (National Marine Fisheries Service [NMFS] 2022) states:

> *"Ambient lighting should be provided throughout the fishway, and abrupt lighting changes should be avoided (Bell 1991). In enclosed systems, such as transport tunnels, provisions for artificial lighting should be included. In cases where artificial lighting is required, lighting in the blue-green spectral range should be provided. Artificial lighting should be designed to operate under all environmental conditions at the installation. These lighting criteria are based in part on laboratory studies where a majority of Chinook and sockeye salmon and steelhead entered the lighted orifice when given a choice between a dark experimental orifice and a lighted control orifice where head was equal between the two orifices (Weaver et al. 1976)."*

NMFS (2022) recommendations also state that "lighting conditions upstream of a bypass entrance should be ambient and extend downstream to the structure or device controlling bypass flow."

Therefore, according to NMFS guidance, provisions for artificial lighting should be provided in transport tunnels, such as fish passage structures that pass through the base of the FRE structure, but does not require that artificial lighting be used. The recommendation to install provisions for artificial lighting but nor specifically recommending its use is consistent with the variability in outcomes noted in the studies described above and the need to understand the specific environmental conditions and potential impacts of lighting unique to each project and situation. Where artificial lighting is used, should be designed to mimic ambient light conditions, avoiding high-intensity illumination and minimizing abrupt light transitions. In applications such as orifice or fishway entry lighting, night-time light levels should not exceed 0.25–3.3 lux, depending on target species and context, as recommended by field-tested studies (Mueller and Simmons 2008; Tetard et al. 2019; Vowles and Kemp 2012).

Determining appropriate lighting conditions requires localized investigation. Fish behavior should be evaluated continuously across seasons and flow regimes, potentially including passive integrated transponder or acoustic telemetry, underwater cameras, or eDNA. These data are integral in building a species- and site-specific knowledge base. Developing and creating a system that provides light timing and intensity flexibility would allow for this monitoring to occur and adjustments to be made following construction of the facility. To avoid disrupting natural behavior, lighting should not be used to attract fish unless supported by empirical evidence local to the fishway. If used, lighting should be integrated thoughtfully with other components to enhance passage efficiency.

Table 1 lists target fish species and illustrates the varied response of species and life stage to different ambient lighting strategies across relevant studies as evidence to support the need for

fishway lighting. While some reports reveal a negative (deterrent) response to artificial light, others show specific frequencies/wavelengths can assist fish passage by acting as an attractant.

Table 1. Target Fish Species and Life Stages Selected for Design Development

Species	Upstream	Downstream
Spring-run Chinook salmon	Adult, Juvenile	Juvenile
Fall-run Chinook salmon	Adult, Juvenile	Juvenile
Coho salmon	Adult, Juvenile	Juvenile
Winter-run Steelhead	Adult, Juvenile	Adult, Juvenile
Coastal cutthroat trout	Adult, Juvenile	Adult, Juvenile
Pacific lamprey	Adult	Ammocoetes, Macropthalmia
Western brook lamprey	Adult	Ammocoetes, Macropthalmia
Resident fish, including river lamprey, largescale sucker, Salish sucker, torrent sculpin, reticulate sculpin, riffle sculpin, prickly sculpin, speckled dace, longnose dace, peamouth, northern pikeminnow, redside shiner, rainbow trout, mountain whitefish	Adult	Adult

Table 2 documents behavioral responses of key native fish species to artificial lighting or shaded conditions across various life stages. Findings are paraphrased for clarity and based on peer-reviewed and agency reports. Table 3 provides observed responses of non-target or related fish species to artificial lighting or shaded environments (included for comparative context).

Table 2. Light Response of Target Fish Species

Family	Species	Life Stage	Key Finding	Citation
Cottidae	Torrent Sculpin, Reticulate Sculpin, Riffle Sculpin, Prickly Sculpin	Adult	No behavioral response to light recorded.	No Data
Cyprinidae	Northern Pikeminnow, Speckled Dace, Longnose Dace, Northern Pikeminnow, Peamouth, Redside Shiner	Adult/ Other	Behavioral changes under artificial light, including altered passage or detection. No significant behavioral avoidance to reduced light conditions in culverts.	Celedonia et al. 2008; Kozarek et al. 2017
Salmonidae	Coastal Cutthroat Trout, Mountain Whitefish, Rainbow trout, Winter-run Steelhead, Brown Trout	Juvenile	Context-dependent responses to artificial light in that they were often attracted to low-intensity light (<50 lux) but startled by or avoided high-intensity light (>100 lux). Behavior included increased aggregation near illuminated structures, delayed migration, altered diel patterns, and elevated stress under continuous exposure. Some studies also observed optimal swimming and welfare at moderate light levels.	Mueller and Simmons 2008; Tétard et al. 2019; Kemp et al. 2006; Liu et al. 2025; Tabor et al. 2004; Jensen 2023
Salmonidae	Chinook, Coho, and Sockeye Salmon	All	Light influenced movement or habitat selection across life stages. Avoidance of high-velocity acceleration zones under light may reflect stress or risk sensitivity.	Celedonia et al. 2008; Jensen 2023; Kemp et al. 2006; Mueller and Simmons 2008; Tabor et al. 2004; Tetard et al. 2019
Salmonidae	Juvenile Salmonids	Smolt	Experienced delays or disrupted movement under ALAN.	Mueller and Simmons 2008
Salmonidae	Steelhead trout	Smolt	Higher passage under light; larger fish favored short weir under light	Kemp et al. 2006

Table 3. Light Response of Related Fish Species

Family	Species	Life Stage	Key Finding	Citation
Anguillidae	European Eel (*Anguilla anguilla*)	Silver eel	Tended to avoid illuminated areas, possibly to reduce predation risk.	Vega et al. 2024
Centrarchidae	Carnivorous Fish (e.g., *Micropterus salmoides*)	Mixed	Carnivorous species had higher mean detection rate and relative read abundance under ALAN; *Micropterus salmoides* only detected under ALAN.	Oyabu et al. 2023
Cyprinidae	European Gudgeon (*Gobio gobio*)	Adult	Experienced delays or disrupted movement under artificial light exposure	Tarena et al. 2024
Cyprinidae	Italian Riffle Dace (*Telestes muticellus*)	Adult	Showed no significant behavioral response to light or shade.	Tarena et al. 2024
Cyprinidae	Himalayan trout *Schizothorax waltoni*	Adult	Strong attraction to green and blue light, repulsion from red and yellow light. Suggests green/blue for guidance to safe areas, red/yellow for deterrence.	Xu et al. 2022
Gadidae	Cod (*Gadus morhua*)	Juvenile	Light reduces upper codend entry only at night; No effect of illumination during the day.	O'Neill et al. 2022
Gadidae	Haddock (*Melanogrammus aeglefinus*)	Juvenile	Fewer enter upper codend under illumination and at night; Illumination and diel cycle reduce the proportion entering upper codend. Significant length interaction observed.	O'Neill et al. 2022
Salmonidae	Atlantic Salmon and European Eel (*Salmo salar; Anguilla anguilla*)	Fry; Migratory	Experienced delays or disrupted movement under artificial light exposure.	Vega et al. 2024; Riley et al. 2013
Salmonidae	Atlantic Salmon (*Salmo salar*)	Adult	Despite expectations, successfully navigated a dark, low-velocity tunnel without lighting. Upstream migration confirmed via resistivity counter, even under sub-optimal hydraulic condition.	Rogers and Cane 1979

Family	Species	Life Stage	Key Finding	Citation
Salmonidae	Atlantic Salmon (*Salmo salar*)	Smolt (Early Migration)	Reduced entry into lit bypass zone, but increased passage rate; experienced delays or disrupted movement under artificial light exposure.	Tétard et al. 2019; Vega et al. 2024
Cyprinidae	Fathead Minnow, Topeka Shiner (*Pimephales promelas*; *Notropis topeka*)	Adult	No statistically significant trend in selection or movement through shaded versus unshaded areas.	Kozarek et al. 2017
Salmonidae	Sea Trout (*Salmo trutta*)	Adult	Successfully passed through the long, dark tunnel. Performance not improved by lighting; illumination deemed unnecessary.	Rogers and Cane 1979

4.0 Conclusion and Recommendations

Ultimately, this memo concludes that lighting is beneficial only under certain circumstances. Therefore, lighting is not proposed as a stand-alone solution for fishways. Instead, it should serve as a supportive element within a broader passage design. The design should allow for lighting to be installed post-construction, so that as literature and knowledge on this subject evolve, lighting can be added based on demonstrated need.

There is a body of evidence from empirical research to suggest positive benefits and describe a need for fishway lighting, but only under specific conditions. However, the evidence also suggests that artificial lighting used in inappropriate conditions can negatively impact fish behavior. NMFS (2022) specifically states the need for ambient lighting provisions throughout a fish passage. In instances where rates of passage are recorded, or otherwise known, to be sub-optimal, ambient fishway lighting should be included based on best available practices and NOAA guidelines. In these instances, adaptive lighting and management plans should be strongly considered, and a fish passage monitoring program established. To avoid disruption in natural fish behavior, fishway lighting to attract fish when there is no data to support this need, should be avoided. The goal is for lighting to be one of many fishway system components that act in concert to optimize and regulate fish passage for critical periods such as out-migration and should only be used when a conduit or tunnel system is disallowing or detracting fish away from traveling through the system.

Due to the equivocal benefit of lighting unless it is tailored to specific locales, fish populations, and conditions, ambient fishway lighting will be considered during design of the FRE passage conduits and fishways to ensure lighting solutions can be reasonably added post-construction. An integrated monitoring plan should be prepared to assess the need for artificial ambient lighting. While lighting is not currently proposed, the design should allow for lighting to be added if future monitoring or evolving literature demonstrates a need. If lighting is installed, its effectiveness and potential adverse effects will be evaluated. This issue can be addressed through permitting as knowledge on the subject continues to develop. Lighting conditions should be expected to fluctuate annually. Understanding water velocity rates in conjunction with the light intensity during specific times of year to monitor and manipulate light presence and intensity, is integral for facilitating effective fish passage.

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6.0 Acronyms/Abbreviations

ALAN	artificial light at night
HDR	HDR Engineering, Inc.
FRE	Flood Retention Expandable
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PDR	Preliminary Design Report

Appendix D. Backwater Analysis Pool Frequency with Conduit Gates Open (Draft) TM

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Technical Memorandum

Date:	January 9, 2026
Project:	Chehalis River Basin Flood Damage Reduction Project
To:	Chehalis Basin Flood Control Zone District
From:	HDR
Subject:	**Backwater Analysis Pool Frequency with Conduit Gates Open (Draft)**

1.0 Background

The Proposed Chehalis River Basin Flood Damage Reduction project (Proposed Project) objective is to implement a series of measures aimed at reducing damage to the communities of the Chehalis River Basin from Pe Ell to Centralia during major flood events. Among these measures is a proposed Flood Retention Expandable (FRE) structure on the Chehalis River, south of Pe Ell, Washington.

The Chehalis River Basin Flood Damage Reduction, draft Preliminary Design Report (PDR) documents development of the preliminary design of the FRE facility and related elements. Development of the draft PDR began following submittal of the Revised Project Description Report (HDR Engineering, Inc. [HDR] 2024), which was used as the baseline for the draft PDR. This draft PDR reflects design development that has occurred since submittal of the June 30, 2025 draft PDR (HDR 2025).

The draft PDR documents the design basis for each Proposed Project element, including a record of design decisions, assumptions, and methods related to the development of the design of the FRE structure and related elements. The draft PDR also presents the technical details of the main features of the Proposed Project elements.

2.0 Introduction and Purpose

The Chehalis Basin Flood Control Zone District is proposing to construct a new flood retention structure to reduce damage to life and property along the Chehalis River (Proposed Project). Design of the proposed FRE structure is at a preliminary level of development.

This Technical Memorandum documents the hydraulic analysis of the frequency and time duration of when a backwater is created, with the conduit gates fully open, when river flows exceed 13,700 cubic feet per second (cfs).

3.0 Level Pool Routing

River flow data was analyzed from 1982 to 2022 for when river flows exceeded 13,700 cfs. The conduits begin to flow full and create a backwater at flows greater than 13,700 cfs. Dates identified where the gates were triggered to close for flood retention were not included in this analysis. A level pool routing analysis was conducted for each time the river flow exceeded 13,700 cfs. Figure 1 shows the estimated conduit capacity with the gates fully open. Figure 2 shows the storage volume upstream in relation to when the conduits begin to create a backwater. Using the river flow as the inflow and the conduit capacity as the outflow, the change in storage was, or backwater, evaluated, and the time required for the backwater to dissipate was calculated. Table 1 shows the results of the level pool routing for each event that exceeds 13,700 cfs. The duration between the 12 events range from 1.2 hour to 6.5 hours, with the average being 3.6 hours.

Figure 1. Estimated Conduit Capacity with Gates Fully Open

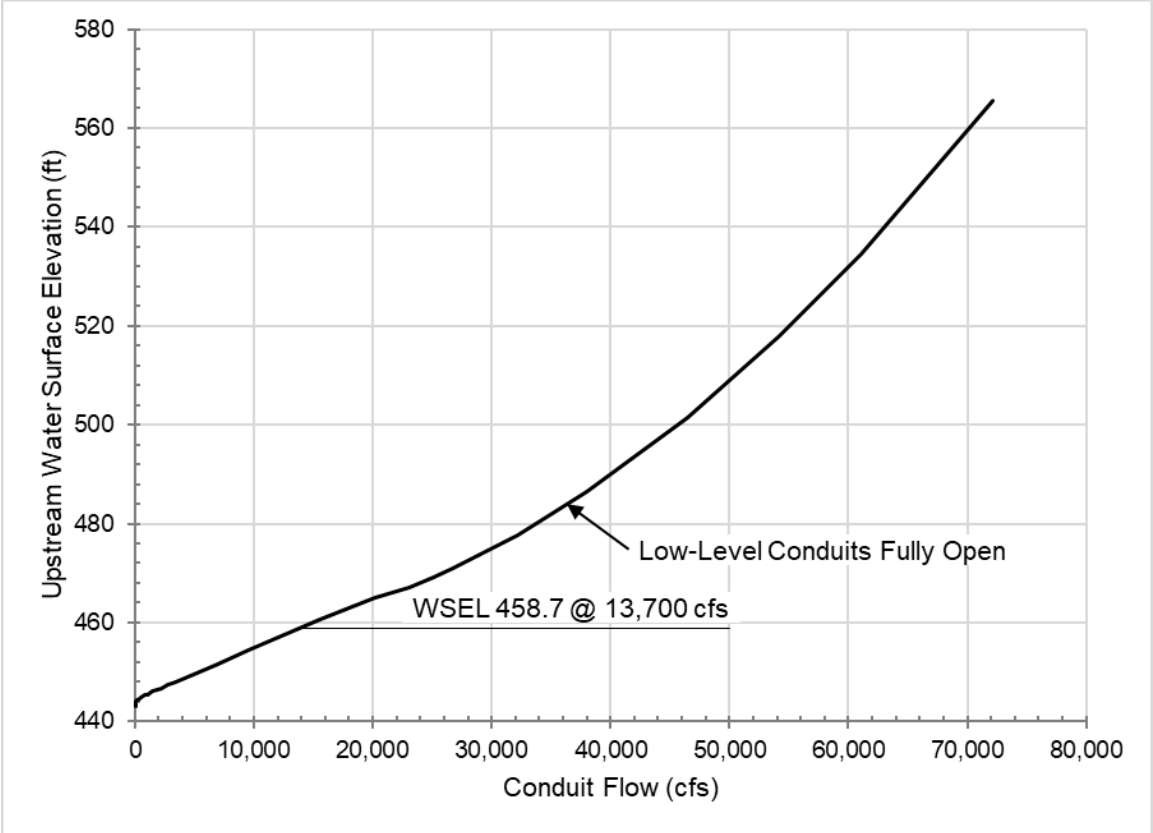

Figure 2. Storage Volume in Relation to Conduit Capacity at 13,700 cfs

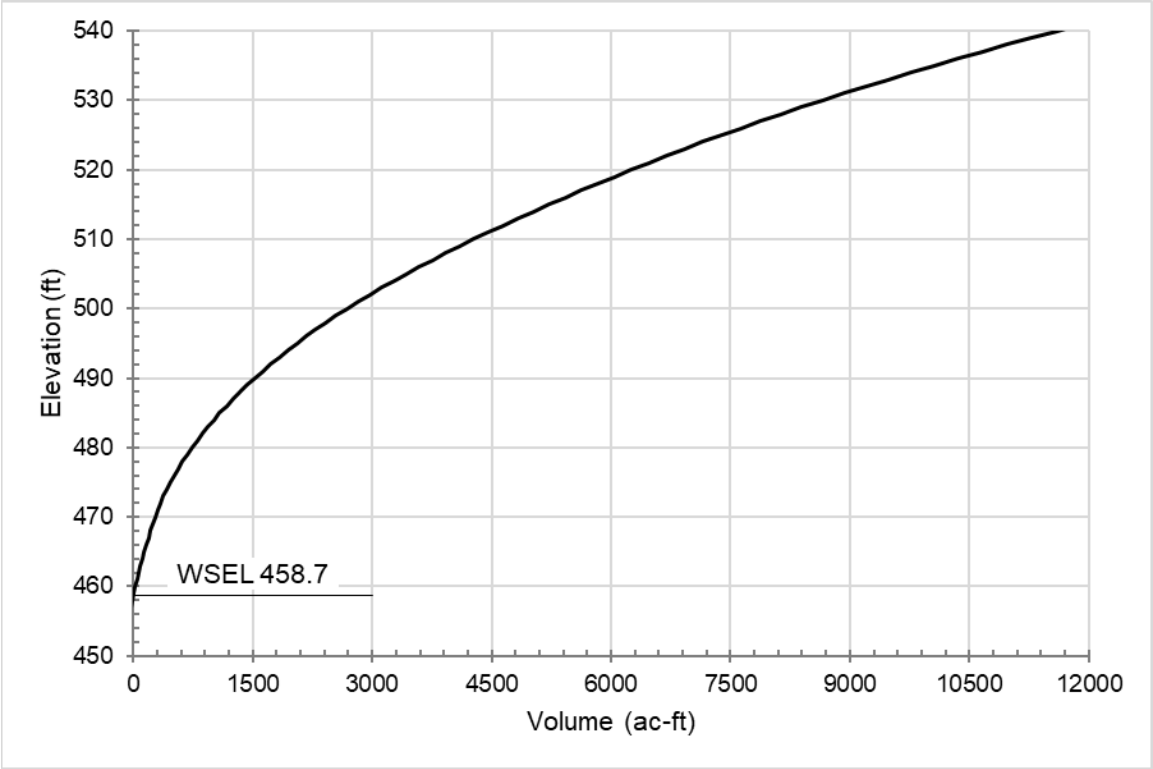

Table 1. Routing Results for each Flow Condition Exceeding 13,700 cfs

Starting Date	Duration (hours)	Peak Inflow (cfs)	Max River Elevation (feet)	Max Storage (ac-ft)	Max Additional Area Due to Storage (ac)
2/23/1986	1.2	13,909	458.9	3.3	0.3
11/25/1998	2.5	14,335	459.3	11.8	0.7
11/14/2001	3.8	16,075	461.1	46.8	2.4
1/17/2005	6.5	16,297	461.3	51.8	2.7
12/14/2006	1.6	14,152	459.1	7.2	0.5
11/12/2008	1.2	13,765	458.8	1.0	0.1
11/19/2012	5.1	14,764	459.8	21.0	1.1
1/5/2015	5.8	16,326	461.3	52.7	2.7
10/31/2015	4.7	16,427	461.4	55.0	2.8
11/13/2015	3.5	15,900	460.9	42.9	2.3
2/9/2017	3.4	14,792	459.8	20.7	1.1
12/19/2019	3.7	14,053	459.1	6.5	0.5

ac = acre; ac-ft = acre-feet

4.0 References

HDR Engineering, Inc. (HDR)

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2025 *Draft Preliminary Design Report: Flood Retention Expandable Structure*, Chehalis River Basin Flood Damage Reduction Project, Lewis County, Washington, June 30, 2025.

5.0 Acronyms/Abbreviations

ac	acre
ac-ft	acre-feet
cfs	cubic feet per second
FRE	Flood Retention Expandable
HDR	HDR Engineering, Inc.
PDR	Preliminary Design Report
Proposed Project	Proposed Chehalis River Basin Flood Damage Reduction project

Attachment 4:

Water Demand During Construction (Draft) Technical Memorandum

Chehalis River Basin Flood Control Zone District

February 4, 2026

Technical Memo

Date:	February 4, 2026
Project:	Chehalis River Basin Flood Damage Reduction Project
To:	Chehalis Basin Flood Control Zone District
From:	HDR
Subject:	**Water Demand During Construction (Draft)**

1.0 Background

The Proposed Chehalis River Basin Flood Damage Reduction project (Proposed Project) objective is to implement a series of measures aimed at reducing damage to the communities of the Chehalis River Basin from Pe Ell to Cosmopolis during major flood events. Among these measures is a proposed Flood Retention Expandable (FRE) structure on the Chehalis River, south of Pe Ell, Washington.

Following submittal of the Revised Project Description Report (HDR Engineering, Inc. [HDR] 2024), a Chehalis River Basin Flood Damage Reduction draft Preliminary Design Report (PDR) was initiated to document ongoing draft design refinements, as the design process iterates toward a future 30 percent design that will be documented in a completed PDR. The draft PDR records ongoing draft design decisions, assumptions, and methods related to the development of the design of the FRE structure and related elements and collects technical details of the main features of the Proposed Project elements as they continue to develop.

A SEPA Revised Draft Environmental Impact Statement (RDEIS) for the Proposed Project was issued on November 20, 2025 with comments due February 4, 2026. To support the submission of comments on the SEPA RDEIS, some draft design elements are being formalized in reports and memoranda to describe the current state of the project design. While still not at a full 30 percent preliminary design level, these elements are at a point at which they can reasonably inform tribal governments, state and federal agencies, partners, stakeholders, and the public about the nature of the project.

2.0 Introduction

This Technical Memorandum documents a construction water demand assessment to inform evaluation of the Proposed Project's environmental impacts. The water demand assessment includes the evaluation of the peak and average water demand anticipated throughout construction. This document concludes with suggested next steps in the development of this portion of the project's design.

3.0 Water Demand During Construction

3.1 Introduction

Construction will require water to support concrete production, aggregate processing, embankment compaction, construction offices, and various other requirements. The demand flow rate for construction water will vary throughout the construction period. Seasonal influences will also affect water demand. HDR evaluated the average monthly and annual water demand as well as a potential peak demand based on construction operations for the Proposed Project. This chapter introduces key assumptions for these water demands.

3.2 Peak Daily Demand

The peak construction water demand is based on mixing and placement of roller-compacted concrete (RCC) and conventionally placed concrete (CVC) at the same time. Production rates are based on HDR's project experience from other similar projects. The daily peak water demand for these activities is uncertain. A likely daily peak would be approximately 0.54 cubic feet per second (cfs). A conservatively low daily peak estimate should not be considered to be lower than 0.49 cfs. Similarly, a conservatively high daily peak estimate is unlikely to be more than 1.08 cfs. Uncertainty comes from RCC production variability, seasonal weather variability, contractor water storage facilities, RCC temperature requirements and the placement season, and other potentially significant factors. The water use estimates seek to reasonably assess peak uses that should be expected at this early stage of design and planning. Peak demand per month (1.08 cfs) for an average month (22 working days) equals 47 acre-feet (ac-ft).

Table 1. Peak Water Demand Assumptions

Assumptions
14,000 cubic yards (cy) RCC/day
10% Water/cy RCC
1,000 CVC cy/day
60 lb water/cy CVC

Table 2. Peak Daily Water Demand Volumes

100%	90%	200%
0.54 cfs	0.49 cfs	1.08 cfs

3.3 Average Monthly Demand

To preliminarily assess the water demand, HDR identified 17 activities throughout construction that cause most of the water consumption during construction. The construction water demand varies by activity over the duration of the project. The activities are listed as follows:

- Haul Road Dust Control
- Excavation/Embankment and Staging Area Dust Control
- Embankment and Borrow Moisture Conditioning
- Potable Water for Warehouses, Offices, Shops
- Staging and Work Area Maintenance
- Dam Foundation Cleaning
- Foundation Drilling and Grouting
- Slope Stabilization
- Drilling for Instrumentation
- Aggregate Crushing/Dust Control
- Aggregate Wet Screening/Washing
- RCC Mixing
- RCC Mix Cooling (Aggregate/ Equipment)
- RCC Curing
- CVC Mix Cooling
- CVC Mixing and Delivery
- Project/Equipment Cleaning and Maintenance

Each of the activities has water consumption, quantity, and duration assigned. These values are based on HDR's construction professionals' judgments of similar activities during other construction projects as well as the FRE Opinion of Probable Construction Cost and unfinished draft biological assessment.

The summary of key assumptions of all 17 activities is provided in Table 3. Each activity's water demand has a low and high range. The low range is typically 80 percent of the calculated water demand, the high range is about 150 percent respectively.

Table 3. Key Water Consumption Assumptions Associated with Each Construction Activity

Summary of Tasks that Require Water		Quantity		Consumption Rate		Application Frequency		Duration	
1	Haul Road Dust Control	696,960	sq ft	0.1	ga/sq ft/pass	2	passes/shift	750	shifts
2	Excavation/Embankment and Staging Area Dust Control	1,150,000	sq ft	0.1	ga/sq ft/pass	2	passes/shift	425	shifts
3	Embankment and Borrow Moisture Conditioning	12,516	ton	3.0	% per dry weight	22	each/month	5	months
4	Potable Warehouses, Offices, Shops	75	ppl	15.0	gpd/person	–	–	1,500	days
5	Staging and Work Area Maintenance	3,632,920	sq ft	0.0	ga/sq ft/pass	1	passes/shift	1,500	shifts
6	Dam Foundation Cleaning	600,000	sq ft	200.0	each	1.2	ga/min	100	shifts
7	Foundation Drilling and Grouting	80,000	ft	50.0	ga/LF	–	–	–	–
8	Slope Stabilization	520	LF	5.0	ga/LF	–	–	–	–
9	Drilling for Instrumentation	4,000	ft	5.0	ga/LF	–	–	–	–
10	Aggregate Crushing / Dust Control	–	–	100.0	gpd	–	–	558	days
11	Aggregate Wet Screening / Washing	–	–	21,600.0	gpd	–	–	–	–
12	RCC Mixing	1,815,000	cy	33.0	ga/cy RCC	–	–	–	–
13	RCC Mix Cooling (Aggregate/ Equipment)	217,800	cy	–	–	20	ga/cy	–	–
14	RCC Curing	43,578,720	sq ft	0.1	ga/sq ft of lift	–	–	–	–
15	CVC Mix Cooling	19,320	cy	–	–	20	ga/cy	–	–
16	CVC Mixing and Delivery	161,000	cy	50.3	ga/cy CVC	–	–	–	–
17	Project/Equipment Cleaning and Maintenance	–	–	423.3	gpd AVER	–	–	–	–

Notes: sq ft: square feet; LF: linear feet; cy: cubic yards; ga: gallon(s); gpd: gallons per day; ppl: people

Each activity is then assigned a schedule. The construction schedule is 5 years. The water demand schedule is shown in Attachment 1. The total high water demand of each activity is divided by the number of months of that activity occurring. Table 4 provides the monthly high water demand by month. The maximum monthly high water demand for each month is selected for further analysis. Restoration activities will continue in Year 6 with 40 ac-ft to cover dust control, plant watering, and equipment cleaning.

Table 4. Monthly High Water Demand

Month	Y1	Y2	Y3	Y4	Y5	MAX
	(ac-ft)					
January	3.1	5.2	16.2	3.1	16.0	16
February	6.9	5.2	16.2	3.1	16.0	16
March	6.9	5.2	18.2	3.1	16.0	18
April	25.1	5.2	18.2	21.3	27.0	27
May	36.1	36.4	29.2	32.3	27.0	36
June	36.1	36.4	29.2	32.3	27.4	36
July	32.3	52.6	34.7	32.3	14.1	53
August	32.3	34.3	34.7	34.2	14.1	35
September	32.3	29.1	29.6	34.2	14.1	34
October	32.3	27.2	29.2	47.3	3.1	47
November	3.1	16.2	18.2	18.0	3.1	18
December	5.2	16.2	18.2	17.8	3.1	18

3.4 Summary of Preliminary Monthly Demand

HDR assumes a weighted average of 70 percent of the high monthly average demand and 30 percent of the peak monthly demand to cover the average and peak demand throughout construction. The weighted average of the maximum average monthly demand and peak monthly demand is shown in Table 5. The demand volume over the course of a peak demand year is broken down into periods corresponding with the minimum instream flow periods (Table 19 below) to facilitate direct comparison. Weighted average volumes below are also provided in units of acre-feet for general size comparison to the proposed, full temporary inundation pool for the permanent project (62,000 ac-ft). The weighted average January water demand of 25.5 ac-ft, for example, originates from 70 percent of 16.2 ac-ft plus 30 percent of 47.3 ac-ft.

Table 5. Weighted Average Peak Water Demand During Construction

Periods	70%	30%	Weighted Average Demand (ac-ft)	Weighted Average Demand (cfs)*
	Needed By Month (MAX) (ac-ft/period)	Needed Assuming 22d x Peak (ac-ft/period)		
Jan 1–Jan 31	16.2	47.3	25.5	0.43
Feb 1–Feb 28	16.2	42.5	24.1	0.45
Mar 1–Mar 31	18.2	47.3	26.9	0.45
Apr 1–Apr 30	27.0	45.7	32.6	0.57
May 1–May 14	16.3	20.5	17.6	0.68
May 15–May 31	20.1	25.2	21.6	0.68
Jun 1–Jun 14	16.9	20.5	18.0	0.70
Jun 15–Jun 30	19.5	23.6	20.7	0.70
Jul 1–Jul 14	23.6	20.5	22.6	0.88
Jul 15–Jul 31	29.0	25.2	27.9	0.88
Aug 1–Aug 14	15.5	20.5	17.0	0.66
Aug 15–Aug 31	19.1	25.2	20.9	0.66
Sep 1–Sep 30	34.2	45.7	37.6	0.65
Oct 1–Oct 14	21.2	20.5	21.0	0.81
Oct 15–Oct 31	26.1	25.2	25.8	0.81
Nov 1–Nov 14	8.4	20.5	12.0	0.47
Nov 15–Nov 30	9.7	23.6	13.9	0.47
Dec 1–Dec 30	18.2	45.7	26.4	0.46
Average	**19.7**	**30.3**	**22.9**	**0.63**

* Assumed 24hr/day for every day in the period
Note: Periods are chosen to match WAC Base Inflow Requirement Periods
Source: Washington State Legislature (2023)

3.5 Buffer Factor and Peak Demand Conclusion

Although construction water demands per period are not expected to exceed weighted peak estimates (Table 5), it is technically possible that multiple needs and factors will align concurrently. Such conditions may occur if mixing and placement of roller-compacted concrete (RCC) and conventionally placed concrete (CVC) are completed simultaneously, and compounding conditions requiring more water are present, such as elevated air temperatures. While it is reasonably certain to conclude that the weighted average peak values presented in Table 5 will support construction needs, in the unlikely event that all compounding factors occur simultaneously, a conservative estimate is that these conditions could occur for up to 10 days per construction year, requiring up to 20 percent of water in addition to the weighted average peak estimates.

As an example, for the month of January, the weighted average peak construction water need is 0.43cfs. In a highly unlikely scenario in which multiple high water-use activities occurred simultaneously, application of a 20 percent buffer would result in the need for up to 0.52 cfs for that construction day, returning to the average high or average weighted peak requirement the following day. For the month of July, when average weight peak construction water needs are expected to be the greatest (0.88 cfs), application of an additional 20 percent buffer on top of the already-conservative weighted average peak would equate to approximately 1.06 cfs for that month only. The Yearly Average weighted average peak construction water need is 0.63 cfs per Table 5, and 0.76 cfs respectively with the applied buffer.

4.0 Next Steps

Future phases of design development should continue to analyze sources of water supply in relation to demand, in conjunction with a water rights legal consultant, to develop a plan for construction water supply and potential mitigation. Potential multi-purpose and temporary-turned-permanent water storage options should be considered as they may have the potential to provide mitigation benefits at longer timescales than temporary storage needed for construction.

Future phases of design development should also include a risk analysis considering natural variability in water supply availability. A risk analysis for different exceedance flow rates should include how risks could be mitigated in future. The risk analysis should refine and identify potential water supply sources and consider the process for obtaining temporary water rights through the Washington State Department of Ecology. Risk mitigation should consider how much risk is delegated to the construction contractor, how much risk the owner/operator will take on, and what risk mitigation measures and temporary infrastructure to include in the design documents. Possible scenarios, including risk reduction and mitigation measures, should be considered for cost and schedule impacts.

5.0 References

HDR Engineering, Inc. (HDR)

2024 *Revised Project Description Report: Flood Retention Expandable Structure*, Chehalis River Basin Flood Control Zone District, Lewis County, Washington. April.

2025 *Draft Preliminary Design Report: Flood Retention Expandable Structure*, Chehalis River Basin Flood Damage Reduction Project, Lewis County, Washington, June 30.

Washington State Legislature

2023 Washington Administrative Code 173-522-020 Establishment of Base Flows. https://app.leg.wa.gov/WAC/default.aspx?cite=173-522-020. Certified on February 20.

6.0 Acronyms/Abbreviations

ac-ft	acre-feet
cfs	cubic feet per second
CVC	conventionally placed concrete
cy	cubic yards
HDR	HDR Engineering, Inc.
RCC	roller-compacted concrete
FRE	Flood Retention Expandable
PDR	Preliminary Design Report
RDEIS	Revised Draft Environmental Impact Statement

Attachment 1. Construction Activities and Schedule

		Year 1												Year 2											
		January	February	March	April	May	June	July	August	September	October	November	December	January	February	March	April	May	June	July	August	September	October	November	December
1	Haul Road Maintenance					x	x	x	x	x	x							x	x	x	x	x	x		
2	Excavation/Embankment Dust Control				x	x	x	x	x	x	x							x	x	x					
3	Embankment and Borrow Moisture Conditioning		x	x	x	x	x																		
4	Potable Warehouses, Offices, Shops	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
5	Staging and Work Area Maintenance	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
6	Dam Foundation Cleaning																			x	x				
7	Foundation Drilling and Grouting																	x	x	x	x	x			
8	Slope Stabilization																		x	x					
9	Drilling for Instrumentation																								
10	Aggregate Crushing / Dust Control												x	x	x	x	x	x	x	x	x	x	x	x	x
11	Aggregate Wet Screening / Washing												x	x	x	x	x	x	x	x	x	x	x	x	x
12	RCC Mixing																			x	x	x	x	x	x
13	RCC Mix Cooling (Aggregate/ Equipment)																			x	x				
14	RCC Curing																			x	x	x	x	x	x
15	CVC Mix Cooling																								
16	CVC Mixing and Delivery																								
17	Project/Equipment Cleaning and Maintenance	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
18	Demolition and Saw Cutting Dust Control																								

		Year 3												Year 4											
		January	February	March	April	May	June	July	August	September	October	November	December	January	February	March	April	May	June	July	August	September	October	November	December
1	Haul Road Maintenance					x	x	x	x	x	x							x	x	x	x	x	x		
2	Excavation/Embankment Dust Control																x	x	x	x	x	x	x		
3	Embankment and Borrow Moisture Conditioning																								
4	Potable Warehouses, Offices, Shops	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
5	Staging and Work Area Maintenance	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
6	Dam Foundation Cleaning																						x	x	
7	Foundation Drilling and Grouting																				x	x	x	x	x
8	Slope Stabilization																					x	x		
9	Drilling for Instrumentation																								
10	Aggregate Crushing / Dust Control	x	x	x	x	x	x	x	x	x	x	x	x												
11	Aggregate Wet Screening / Washing	x	x	x	x	x	x	x	x	x	x	x	x												
12	RCC Mixing	x	x	x	x	x	x	x	x	x	x	x	x										x	x	x
13	RCC Mix Cooling (Aggregate/ Equipment)							x	x																
14	RCC Curing	x	x	x	x	x	x	x	x	x	x	x	x										x	x	x
15	CVC Mix Cooling							x	x	x															
16	CVC Mixing and Delivery			x	x	x	x	x	x	x	x	x	x										x	x	x
17	Project/Equipment Cleaning and Maintenance	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

		Year 5											
		January	February	March	April	May	July	August	September	October	November	December	January
1	Haul Road Maintenance				x	x	x	x	x	x			
2	Excavation/Embankment Dust Control												
3	Embankment and Borrow Moisture Conditioning												
4	Potable Warehouses, Offices, Shops	x	x	x	x	x	x	x	x	x	x	x	x
5	Staging and Work Area Maintenance	x	x	x	x	x	x	x	x	x	x	x	x
6	Dam Foundation Cleaning												
7	Foundation Drilling and Grouting												
8	Slope Stabilization												
9	Drilling for Instrumentation										x	x	
10	Aggregate Crushing / Dust Control												
11	Aggregate Wet Screening / Washing												
12	RCC Mixing	x	x	x	x	x	x						
13	RCC Mix Cooling (Aggregate/ Equipment)												
14	RCC Curing	x	x	x	x	x	x						
15	CVC Mix Cooling						x						
16	CVC Mixing and Delivery	x	x	x	x	x	x						
17	Project/Equipment Cleaning and Maintenance	x	x	x	x	x	x	x	x	x	x	x	x