TECHNICAL REPORT
Salmon Population Modeling for the SEPA EIS
Evaluation of Flood Protection in the Chehalis Basin

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Executive Summary

This report reviews modeling efforts that were employed to inform the State Environmental Policy Act (SEPA) February 27, 2020 Draft Environmental Impact Statement (EIS) regarding Chehalis Flood Protection. The EIS relies upon two computer models to provide quantitative and qualitative projections of effects of a proposed project, involving construction of a dam in the Upper Chehalis Basin and modification of the Chehalis Airport levee, on populations of Spring Chinook, Fall Chinook, coho and steelhead: (1) the Ecosystem Diagnosis and Treatment (EDT) Model and (2) the Integrated EDT-LCM Model (hereafter referred as the Hybrid Model).

Our review is limited to information contained in the EIS, (including accompanying Appendices, referenced discipline reports), and materials directly provided by the entities responsible for performing the modeling, ICF (EDT) and NOAA (Hybrid Model).

The EIS does not provide sufficient, specific information and data to permit thorough scientific evaluation of modeling procedures. There are substantial uncertainties regarding the models, methods, and parameters employed in EIS modeling. However, our review of available information regarding how the modeling was performed revealed numerous errors in modeling inputs and configuration which suggest a failure of Quality Assurance and Quality Control (QA/QC) measures to provide adequate review and oversight of the modeling process. While we conclude that the application of both the EDT Model and the Hybrid Model in the EIS is flawed, we do not disagree that the genetic diversity and abundance of populations of Spring and Fall run Chinook, coho, and steelhead originating in the subbasins above Crim Creek and from Rainbow Falls to Crim Creek would be expected to be significantly and adversely affected by late century (EIS, Exhibit 5-6, Fish and Aquatic Species Habitat p S-14 and Tribal Resources p5-15; section 5.3, p70; Exhibit 5-3-2, p74)[2], under the assumptions prescribed by the EIS, particularly those relating to climate change and development[3], and the exclusion of consideration for

[1] Both authors have extensive experience developing and reviewing fisheries, environmental, and ecological computer models and are familiar with how EDT and the Hybrid models have been applied in the EIS. Lestelle is one of the architects of the EDT Model, having been part of the original group that designed and refined the model over a period of years for applications throughout the Pacific Northwest (Lestelle et al. 1996; Mobrand et al. 1997; Lestelle et al. 2004; Lestelle 2005). Both of us, working together, assisted NOAA staff over more than two years to review and help refine a third model, a Life Cycle Model (Beechie et al. 2020), being developed under contract with the Washington Department of Fisheries and the Washington Recreation and Conservation Office to help inform planning for the Aquatic Species Restoration Plan for the Chehalis Basin. The multi-generational aspect of the Life Cycle Model was joined with EDT to form the Hybrid Model used to evaluate effects of streamflow variability in the SEPA analysis.

[2] Adverse impacts are described as "unavoidable", unless mitigation is feasible. Identification of mitigation measures and determination as to their technical and economic feasibility are left to consultation and permitting processes if the Proposed Project is approved.

[3] Outdated models and analyses were relied upon to generate inputs into EDT and the Hybrid models. Consideration of climate change effects was dominated by peak water flows and temperature, with little attention given to impacts of low flows and alteration of estuarine or marine environments or projected changes in

the potential impacts of actions which may be taken pursuant to development and implementation of the Aquatic Species Restoration Plan (ASRP).

Modeling projects that these salmonid populations would be expected to be adversely affected under both the Proposed Project and No Action Alternatives[4]. Sizes of equilibrium escapements of populations originating in two areas in vicinity of the Proposed Project are projected to be substantially reduced;). However, these effects would occur at different rates (Exhibits 5.3-3 and 5.3-4). . For the Proposed Project, adverse impacts would occur earlier with greater severity starting with construction and continuing during operations. For the No Action Alternative, effects on salmon populations would occur more gradually over a more extended period of time (Exhibits 5.3-6 and 5.3-7). These differences are significant and important because they would have very different consequences for potential habitat restoration actions in the upper Chehalis basin. Under the No Action Alternative, there would be opportunity and time to offset the potential adverse effects of climate change. In contrast, the Proposed Project would accelerate the decline of populations produced in the upper basin.

The presentation of modeling results focuses on equilibrium escapement levels and does not provide an adequate description of the significance and importance of other metrics of productivity, diversity and spatial structure for evaluating resilience and sustainability of salmon populations. The analyses are centered heavily on peak water flows; treatment of low flows, temperature, and effects on phenology (i.e., seasonally-related life history traits of species) is inadequate. Moreover, because the modeling analyses did not address harvest-related issues, information on impacts to treaty rights and harvest opportunities for in-river and marine fisheries is lacking. The significance of short- and long-term variability in survival in freshwater, estuarine, and marine environments was either entirely ignored or not adequately evaluated. Variability in survival is a critical aspect of evaluating population viability. The lack of documentation regarding model validation procedures and information necessary to evaluate the effects and magnitude of uncertainties is troubling. Although many of these considerations were acknowledged in the EIS, substantive analysis was missing.

We are concerned that the manner in which the EIS was framed in terms of the purpose, objective, and metrics for analysis largely predetermine results of the analyses and preclude consideration of other alternatives that could address the twin objectives of reducing flood damage and restoring aquatic species throughout Chehalis Basin.

We found the evaluation of climate change to be overly simplistic and not reflective of current science. A more thorough evaluation of climate change is warranted, especially since so much of the modeling analyses is based on projected impacts of suspect quality.

We are not confident in the validity and utility of results produced by the Hybrid Model, which was developed to examine potential effects of stochasticity in streamflows. Numerous errors were

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atmospheric and ocean currents. With the exception of a simplistic attempt to examine effects of variability in water flow years (evaluation of increased frequencies and changes in the magnitude of peak and low flow events or temperature, or variability in precipitation patterns within the Chehalis Basin were not included), no consideration was given to stochasticity in freshwater or marine environments and implications for survivals. The EIS states that increased development would be expected to occur if flood risk is reduced under the Proposed Project, details regarding how, where, and when increased development may occur were not provided. The inadequacy of the climate change analysis is discussed in greater detail in a companion white paper "Review of Evaluation of Impacts on Fish and Fisheries".

[4] EDT and the Hybrid models were not substantively utilized to evaluate impacts of the third Local Action alternative. EIS modeling did not substantively investigate consideration of the delta-bay and marine environments, intra and interspecies interactions, or harvest.

identified in the life stage projections produced by EDT indicating a lack of adequate quality assurance/control measures. Questions remain regarding how the stochastic modeling of water years was performed.

Therefore, while we agree with the EIS conclusions that there are significant impacts, we find that the modeling procedures were flawed owing to numerous errors and an apparent mismatch of linking results from a steady-state model to a multi-generational modeling component intended to model year-specific changes in streamflow characteristics. We also conclude that impacts of the Proposed Project on the affected salmonid populations are likely under-reported due to the errors in modeling and a lack of full consideration of important population performance characteristics, such as productivity, diversity, and spatial structure. Moreover, a population viability analysis of the affected populations should have been done to adequately assess effects on long-term viability. Due to the likely severity and types of impacts on population viability and structure, we conclude that the impacts would be unmitigable.

Description of EIS Modeling for Salmon

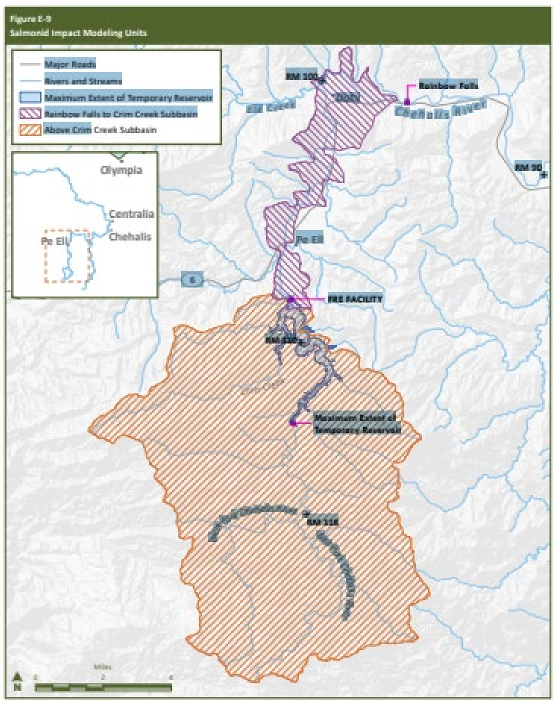
Purpose of modeling: The EIS relies upon projections produced by the models to quantify and characterize effects of two of the three alternatives described in the EIS, the proposed flood reduction projects and the "no action alternative". The third, the "local actions" alternative, was not evaluated by the models.

Alternatives Modeled:

Section 2 of the EIS describes three alternatives:

1) Proposed Project: The Applicant proposes to: (a) Construct a flood retention facility and associated temporary reservoir near Pe Ell on the Chehalis River to reduce peak flood levels during a major flood or larger, from floods originating in the Willapa Hills. A major flood is measured as 38,800 cubic feet per second (cfs) at the Grand Mound stream gage; and (b) Make changes to the Chehalis-Centralia Airport levee by raising the levee 4 to 7 feet, widening the levee, and raising a portion of NW Louisiana Avenue to reduce flood damage from a catastrophic flood. A catastrophic flood is measured as 75,100 cfs at the Grand Mound stream gage.
2) Local Actions: A local and non-structural approach to reduce flood damage in the Chehalis-Centralia area which considers a variety of local-scale options that local governments and agencies could choose to do in the future. These actions could achieve the Applicant's objective to reduce flooding from storms in the Willapa Hills through improving floodplain function, land use management actions, buying out or relocating at-risk properties or structures, improving flood emergency response actions, and increasing water storage from Pe Ell to Centralia.
3) No Action: The "most likely future conditions if the Proposed Project is not constructed". Large- and small-scale efforts would continue basin-wide as part of the Chehalis Basin Strategy work. Local flood damage reduction efforts would continue based on local planning and regulatory actions. The No Action Alternative includes the use of current state and local floodplain regulations and land use regulations. It also includes planned updates to Comprehensive Plans and Shoreline Master Programs (SMPs). It includes projects to reduce flood damage that are in progress, funded, or permitted as of June 2019. These projects include local floodproofing efforts, Chehalis River Basin Flood Authority projects, and Chehalis Basin Strategy and Aquatic Species Restoration Plan projects.

Spatial area encompassed by the EIS: EIS modeling is centered on the evaluation of impacts of alternatives on freshwater habitats and salmon. The models evaluate impacts to spawning aggregations that occur within two spatial areas (mainstem Chehalis River between Rainbow Falls and the proposed dam site and then for all reaches upstream of the dam site) and within mainstem areas (including associated floodplain areas) below Rainbow Falls downstream to the area of tidal influence near Montesano. Effects of delta-bay and marine environments are known to be substantial, but not considered.



Species and populations modeled: Limited to four species of salmon (Spring Chinook, Fall Chinook, Coho, and Steelhead) for populations that originate in two spatial areas (1) Above Crim Creek Subbasin (all areas upstream of the proposed dam site); and (2) Rainbow Falls to Crim Creek Subbasin as depicted in Exhibit 5.3-1 p72, and Figure E-9. The models are not used to evaluate impacts on populations originating outside of these two spatial areas.

<u>Modeling of Alternative 1 - Proposed Project:</u> The proposed Project is described in Section 2 of the EIS. Modeling evaluated impacts of: (1) raising the Chehalis-Centralia Airport levee by raising the levee 4 to 7 feet and widening the levee; and (2) a Flood Retention Expandable (FRE) facility, located on the mainstem Chehalis River about 1 mile south (upstream) of the Town of Pe Ell, Washington, that would store up to 65,000 acres of floodwater in a temporary reservoir during major or larger floods, then slowly release it over a period of time. In normal conditions or for smaller floods, the Chehalis River would flow through the structure at its normal rate. FRE facility would be built with a foundation and hydraulic structure extents capable of supporting the future construction of a larger facility that could expand the water storage from 65,000 acre-feet to up to 130,000 acre-feet (FRE). Because expansion is uncertain and would be subject to a separate environmental review/permitting process, modeling did not evaluate the impacts of an FRO.

<u>Alternative 2 – Local Actions</u>: Not modeled.

<u>Alternative 3 – No Action</u>: The EDT modeling was employed to quantify impacts. Impacts attributed to climate change are emphasized by extensive reference to impacts of climate change in Section 5 of the EIS (Impact Analysis) in results for the No Action alternative and virtual lack of references regarding climate change in results of the Proposed Project. The purpose for this noticeable imbalance in presentation is not disclosed. Although the description of this alternative states that restoration actions are included, the EIS does not provide information on modeling of specific restoration actions or assessment of their impacts, though we have been told that only ASRP early actions were meant to be incorporated.[5]

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[5] February 10, 2020 meeting between Diane Butorac of the Washington State Department of Ecology and representatives of the Quinault Indian Nation, ICF, and NOAA. Early actions are four or five relatively small projects

Models and Methods. Use of the models in the EIS is described in Sections 3.4 (p34) and 5.3.1 (p70) and Attachment E-2 to Appendix E. These portions of the EIS provide a generic description of the models and methods employed to inform the EIS, but do not include necessary and sufficient detail for understanding and interpreting model results. Data limitations and gaps are not disclosed, assumptions, algorithms and relationships between fish populations and habitat conditions are not fully described, and procedures for parameterization and reach-specific parameter values are not provided or referenced. The EIS does not provide an adequate description of methodologies employed by the EDT and Hybrid models, particularly with respect to the evaluation of climate change and the mismatch between EDT steady state assumptions and the population dynamics involved when attempting to model population changes under effects of environmental variability on life stages.

The EDT and Hybrid models are intended to produce estimates of salmonid population performance characteristics, as described earlier in this report, notably for productivity and equilibrium abundance in relation to different environmental conditions or scenarios.

EDT:

EDT is the primary model that was employed to quantify mid (2040) and late (2080) century projections of impacts of the Proposed Project. EDT produces results using a sampling of potential life history trajectories that represent interactions between habitat conditions by species life-stages under steady state conditions. EDT is not designed to evaluate variability in recruitment or environmental conditions on a time scale finer that complete life-cycle for a given species. Information provided in the EIS does not constitute an adequate basis for understanding the strengths and limitations of EDT or interpreting results. Other sources of information would need to be considered. EDT has been extensively peer reviewed and documentation is readily available (e.g., Blair, G. et.al. 2009). However specific information regarding model parameterization and methods employed in the EIS are still needed.

Model Descriptions & Reviews

EDT Model

Background

The EDT analytical model is a habitat model that assesses environmental constraints on a salmonid population (Blair et al. 2009). It predicts the ways in which salmonid populations respond to changes in habitat conditions, habitat restoration actions, and other types of changes that can result from land and water uses and climate change. The model has been used extensively for assessing the effects of habitat conditions on salmonid populations and for recovery planning over the past 25 years.

The EDT model is constructed of four major components: (1) a spatial structure based on the network of connected stream reaches within the river basin; (2) characterizations of the habitat conditions for all stream reaches using a set of defined habitat attributes; (3) a set of rules (called biological rules) that compute survival parameters by species life stage for each reach and each scenario being modeled; and (4) specification of the species biology consisting of life history information (e.g., life stage durations and timing) and spawning distribution.

The model evaluates habitat conditions for a species life stages for each stream reach along multiple life-history pathways (called trajectories) that represent variations in life history consistent with

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that are to be conducted as an initial part of the ASRP. None of those actions, however, would affect areas relevant to the SEPA EIS analysis.

published literature for the species. Life-stage performance is then aggregated across the species life history to compute population-level performance. Species performance is assessed in terms of the potential capacity, productivity, and abundance. The model also outputs information on life-history diversity. The results can also be used to assess spatial structure of the species under the modeled habitat conditions.

Habitat for each reach is characterized using a set of approximately 45 different attributes that describe conditions for temperature, water flow, stream channel width, wood load, streambed scour, physical habitat types (such as pools and riffles), and others. It is relevant to this review to recognize that most of these attributes are characterized for a given scenario using a rating scheme designed to work within the model's use of biological rules to estimate survival-related parameters. The scheme uses ratings of 0 to 4, whereby a rating of 0 generally means the effect of the attribute on life stage survival will be benign, whereas a rating of 4 often produces a severe drop in survival; intermediate values have intermediate effects. Ratings differ by month if conditions vary with season (such as temperature).

A key aspect of the EDT Model to understand some of our findings in this review is that the model assesses salmonid population performance under steady-state conditions. The model is not dynamic in that it does not assess the effect of year-to-year variation in conditions—it assumes that conditions are more or less constant from year to year consistent with the definition of the attributes. In effect, this can be thought of as what would the population performance be if environmental conditions fluctuated—but fluctuated as they often do over some short period of years such as a decade. The model estimates the average performance for the population over that period of time in which any directional trend in conditions can be assumed to not exist.

Application to the Chehalis Basin

EDT model inputs and parameters as they existed prior to about 2017 were described in McConnaha et al. (2017). Lestelle was involved in reviewing many of the inputs as the model was then configured as part of his participation with the Science Review Team (SRT) for the ASRP. It bears noting that he was the project manager and lead analyst in preparing the first two versions of the EDT model to be used in modeling the Chehalis Basin between 2001 and 2004 (Mobrand Biometrics 2003). Many of the attribute ratings applied in those versions of the model are still used in the current versions of the model, though many have been updated with improved information.

We have reviewed a subset of ratings for some attributes as part of our review of the EIS. We received database files for the model from ICF[6] in response to a request for the files. We have reviewed a subset of the files and attributes, focusing on those that we thought would be most relevant and insightful. The files are very large and are cumbersome and extremely time consuming to work with due to their size.

We focused our attention on stream reaches relevant to the spawning aggregations analyzed within the EIS, namely to all of the reaches of the mainstem Chehalis River, within the West and East forks of the river, and to tributaries that enter the river upstream of the proposed dam site. The reaches of the mainstem Chehalis River are numbered, beginning with Chehalis-1 at the river mouth in Aberdeen, and continuing consecutively to Chehalis-94, which ends where the West Fork and East Fork of the river join. The proposed dam site is located at the downstream end of Chehalis-86. The proposed reservoir when filled would continue to the top of Chehalis-90. Table 1 lists river miles associated with key landmarks and EDT stream reaches to aid the reader.

[6] Memo dated March 12, 2020 To: Diane Butorac, Ecology. From ICF (Laura McMullen, Karl Dickman, and Matt Yelin) and Chip McConnaha. Re: Response to Quinault Indian Nation questions on EDT-LCM modeling.

The modeling assessed impacts by looking at two "populations" for each species, where a population in this sense is simply the fish production that would result from spawning aggregations within two geographic areas. These two areas are defined as (1) the mainstem Chehalis River between Rainbow Falls (about RM 97) and the proposed dam site (RM 108.2) and (2) all stream reaches upstream of the dam site to the assumed upper limits of spawning for each species. Spawning upstream of the dam site would occur both within the mainstem Chehalis River, as well as in the West and East forks and tributaries to these reaches.

Review of EDT Attribute Ratings

We focused our review on the following attributes: Fine Sediment, Bed Scour, Wetted Channel Width, and three flow attributes, Flow High, Flow Low, and Flow Intra-annual Variability. These attributes are of particular importance in affecting salmon population performance due to how the Proposed Project would be expected to alter patterns and rates of sediment supply and transport, habitat quantity related to streamflow, and other habitat characteristics related to flow patterns.

Fine sediment

The EDT attribute "Fine Sediment" is used to characterize the amount of fine sediment (< 0.083 mm grain size) contained within stream habitats used by salmonids for spawning and egg deposition. An attribute rating of 0 or 1 would indicate that the gravel is especially clean of fine sediment and there would be no adverse effect on incubating eggs. A rating of 2 would indicate a small to moderate adverse effect. A rating of 3 would produce a strong adverse effect on egg survival. A rating of 3.5 to 4 would kill all incubating eggs and embryos within the gravel.

Table 1. Landmarks and river miles associated with a subset of EDT stream reaches.

EDT reach	Adjacent landmark	River mile at lower end of reach
Chehalis-1	Chehalis R mouth	0.0
Chehalis-18	Satsop R mouth	20.2
Chehalis-38	Black R mouth	47.0
Chehalis-49	Skookumchuck R mouth	67.0
Chehalis-54	Newaukum R mouth	75.4
Chehalis-63	South Fork mouth	88.3
Chehalis-72	Rainbow Falls	97.0
Chehalis-86	proposed dam site	108.2
Chehalis-91	end of proposed reservoir	114.6
WF Chehalis-1	confluence of WF and EF	118.9

Figure 1 displays the EDT ratings for the mainstem Chehalis River beginning at reach Chehalis-1 (at the mouth) and extending upstream to the confluence of the West and East forks, and then into the forks as well as tributaries that enter the river upstream of the dam site. Vertical lines on the charts show the locations of Rainbow Falls, the proposed dam site, and the upstream end of the proposed reservoir when filled.

The four charts (A-D) contained in Figure 1 clearly show that errors were made in rating the reaches for this attribute beginning at Chehalis-56 (near Newaukum R. confluence) and extending upstream to

Chehalis-90, a distance of about 39 miles. The rating values vary somewhat by scenario and it is important to recognize how and where they differ.

Figure 1-A shows rating values under current conditions with only 2-year flood flows occurring and with no other actions. We note that downstream of Chehalis-56, ratings generally approach or exceed a value of 3, meaning that gravels there have high levels of fine sediment. Beginning at Chehalis-56 and extending to Chehalis-62, the rating drops to a value of 1 (meaning exceptionally clean gravel), and then from Chehalis-63 through Chehalis-90, the rating is 0 (meaning no fine sediment), which is almost never applied to represent any natural condition in EDT. It is notable that these reaches are affected by intensive land use practices that are known to generate large amounts of fine sediment and the condition is considered a limiting factor to salmon production in this area (Smith and Wenger 2001).

Figure 1-B displays the rating values for the reaches under current conditions with only 2-year flood flows and with the FRE dam in place and operating. Notice that all rating values are the same as in chart A, except for the reaches that are delineated as being within the footprint of the proposed reservoir. The ratings in those reaches are increased to a value of 0.4, which means in effect that fine sediments are essentially absent.

Fine Sediment ratings in EDT

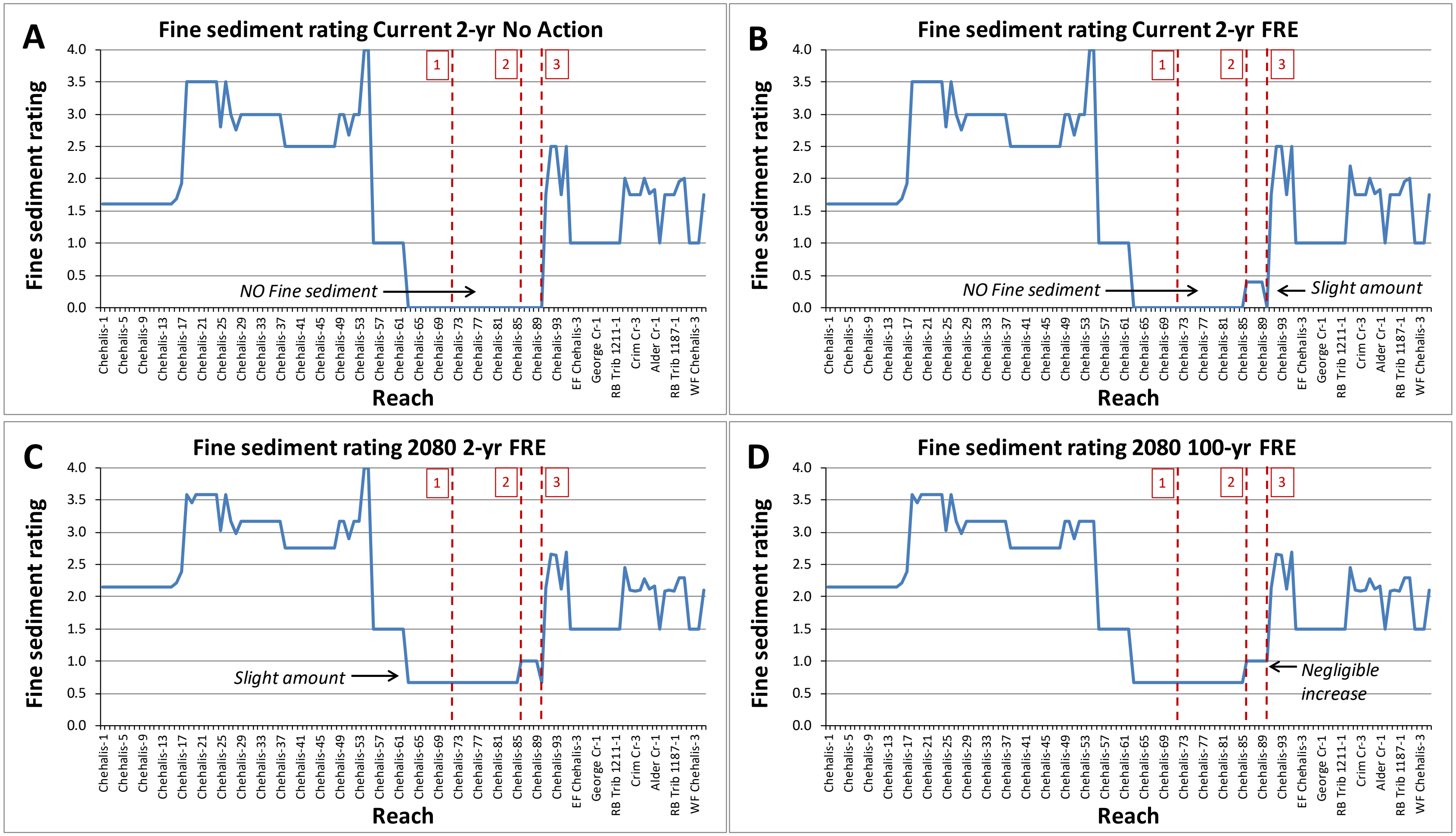

Figure 1. EDT ratings for the attribute Fine Sediment for all reaches in the mainstem Chehalis River from Chehalis-1 (at the river mouth) to Chehalis-94 (below confluence of forks) and other tributary reaches upstream of the proposed dam site. Ratings for four different modeling scenarios (A-D) are shown. Dashed vertical lines indicate location of Rainbow Falls (1), proposed dam site (2), and the upper end of the proposed reservoir when filled (3).

Figure 1-C shows rating values for all reaches under conditions expected to exist in late century with only 2-year flood flows and with the FRE dam in place and operating. The figure shows that all ratings for all reaches have been increased (they cannot exceed a rating of 4)—presumably because the modelers assumed that increased peak winter flows due to climate change would generate increased supply of fine sediment, such as by more landslides and erosion. This is a reasonable assumption and is consistent with projections for Western Washington by Mauger et al. (2015, 2016). We note that rating values for the reservoir reaches are 1.0, meaning that they would have exceptionally clean gravels.

Figure 1-D shows rating values for all reaches under conditions expected to exist in late century with 100-year flood flows (catastrophic level) and with the FRE dam operating. It bears highlighting that this means that a 100-year flood flow would be occurring every year because it is assumed that conditions are at steady state conditions for the model. Notice that only one very slight change in Fine Sediment ratings was incorporated into this scenario from that in Figure 1-C—this change being a slight increase in the upper end of the reservoir section of river. In effect, despite the FRE reservoir being filled every year continually under catastrophic flood floods (due to steady state conditions assumed), the entirety of the substrate within the reservoir is rated as being exceptionally clean, which would not be the case. The opposite would occur—fine sediments being carried along during the flood would rapidly cover the substrate as the reservoir was filled due to the high sediment load being generated and transported during flood flows. All salmon eggs deposited in gravels within the footprint of the reservoir prior to the reservoir being filled would be killed through suffocation by fine sediment and lack of oxygenation. Salmon eggs deposited in streambed gravels require relatively clean gravels and flowing water to maintain a continual oxygen supply to the eggs and embryos. The ratings shown for these stream reaches are clearly in error.

We note that within reservoirs, EDT typically assigns Fine Sediment ratings of 3.5 or higher. For example, in the Wynoochee Reservoir in the Wynoochee River subbasin, EDT modeling uses a Fine Sediment rating of 3.5. This high rating is intended to result in no survival of incubating salmon eggs as would be expected if spawning were to occur for example in the upper end of the reservoir before it filled during the winter.

Given how the upper Chehalis reservoir section was rated for Fine Sediment under this scenario (Figure 1-D), the model would result in exceptionally high salmon egg survival throughout this section of river, even in late century with increased peak flows, catastrophic floods, and dam closure.

It is troubling that the modeling results were apparently not reviewed in a manner to catch this error, which is problematic for an EIS that aims to assess the impacts of a proposed dam.

What conditions would we expect to be in the upper river, including downstream of an FRE dam, under 100-year flood flow conditions and dam operations? The supply of fine sediment delivered to the Chehalis River is expected to increase with flow magnitude (Table F-9, Earth Appendix EIS), so more fine sediment would be expected to enter spawning gravels for the 100-year event compared to the 10-year event, which would be expected to be more than the 2-year event. With dam operations and reservoir filling, landslides in the vicinity of the reservoir are also expected to increase, delivering still greater quantities of sediment to the river (see NSD, April 2020, White Paper – Review of Earth Discipline Report). This expected pattern is not reflected in Figure 1-A-D, and most glaringly within the reservoir reaches.

At least some of the errors evident in Figure 1 apparently became known to the modelers at some point. Page E-70 states:

> *"During the process of running the EDT model for the integrated approach, quality assurance and control measures were conducted. For example, corrections were made to sediment*

ratings in the EDT model for mainstem Chehalis River reaches upstream of the Newaukum River due to an error found in the ratings. In this case, updated EDT model outputs were reviewed but were not incorporated into the LCM because the LCM modeling had been completed and differences between the EDT model runs were judged to be small and did not change the results in any meaningful way." (emphasis added)

This statement is alarming because it implies that the modelers were aware that the modeling was being done with conditions set within the reservoir reaches to reflect exceptionally clean gravel, even with catastrophic flooding occurring and reservoir filling. We suspect, however, that the statement on page E-70 was meant to recognize that reaches upstream of the Newaukum River but downstream of the dam contained the error in Fine Sediment ratings, which might have been seen to not affect overall results in any meaningful way (though we would still disagree). It is hard for us to reconcile that the modelers came to realize that the ratings within the reservoir reaches were so badly in error without doing something about it. But regardless, the ratings that were applied, together with the troubling statement on page E-70, are indicative of flawed QA/QC of the modeling process.

Because of these obvious errors in Fine Sediment ratings, we conclude that the adverse impacts projected from modeling to the salmonid populations, particularly to Spring and Fall Chinook, are grossly underestimated.

Bed Scour

The EDT attribute "Bed Scour" is used to characterize the amount of streambed scour that would be expected to occur on average during the annual peak flow over an approximately 10-year time period. Hence, in some years there would be little or no bed scour (at flows much less than bankfull level), while scour would occur during a typical 2-year flood level, and even greater scour would be expected on a 10-year flood level. Scour of substrate materials during high flows can adversely affect the survival of incubating salmonid eggs (Kinsel et al. 2007) and overwintering juveniles located there.

The EDT ratings for this attribute at values of 0 and 1 would reflect benign conditions for both incubating eggs and overwintering juveniles. A rating of 2 would reflect moderately harsher conditions with respect to scour, and ratings of 3 or 4 would reflect much harsher conditions (resulting in high or total mortality). The ratings are defined by the average depth of scour that could be expected on representative riffles within a reach on average over a 10-year period.

Figure 2 shows the percentage change in the attribute rating from the current 2-year flood level to the 100-year flood level under No Action scenarios. From the 2-year to the 100-year flood level, the EDT ratings reflect a substantial increase in bed scour for reaches beginning several miles upstream of Rainbow Falls and continuing upstream to near the forks. The largest percentage increase is seen near the middle of that river section where the reservoir would occur under the proposed FRE alternative. We note that no other changes to bed scour were assumed to occur in any other reaches (which is unreasonable, given the lack of large wood and exposed gravels in those upper reaches, Weyerhaeuser 1994; ASRP Steering Committee 2019).

Change in Bed Scour ratings

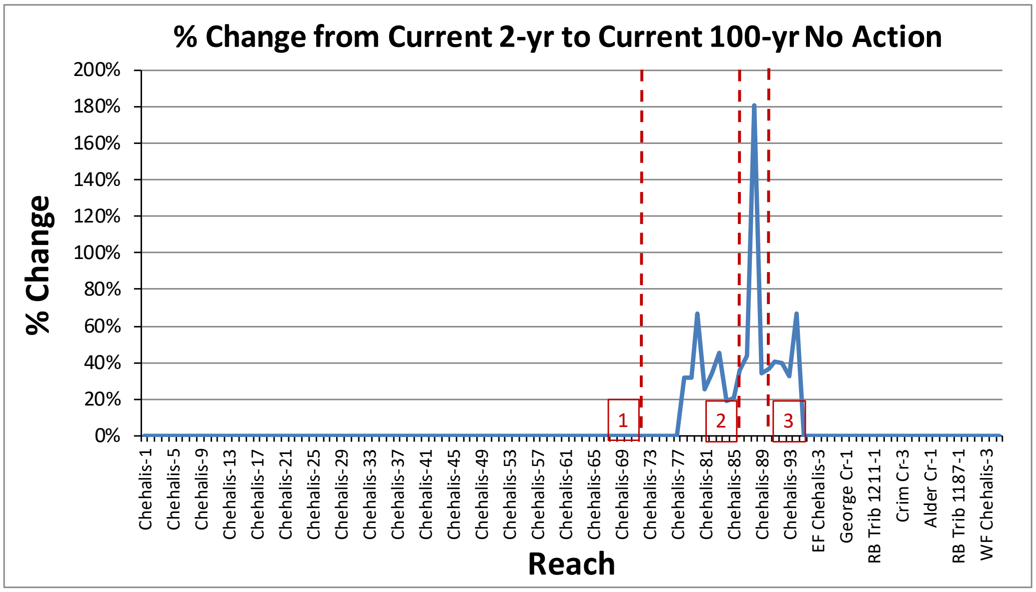

Figure 2. Percentage changes in the Bed Scour ratings from the current 2-year flood scenario to the current 100-year flood scenarios for all reaches in the mainstem Chehalis River from Chehalis-1 (at the river mouth) to Chehalis-94 (below confluence of forks) and other reaches upstream of the proposed dam site. Dashed vertical lines indicate location of Rainbow Falls (1), proposed dam site (2), and the upper end of the proposed reservoir when filled (3). Increases in Bed Scour ratings (seen with increased percentage change) indicated higher Bed Scour ratings.

Figure 3 shows the percentage change in the Bed Scour attribute rating from the current 100-year flood level (catastrophic flood) to the expected 100-year flood level at late century (2080) with climate change and under No Action scenarios. We would expect the Bed Scour rating to be further increased over the 100-year flood under current conditions due to the increased magnitude of peak flow in late century. The EIS assumes that peak flood flows will increase by 26% in late-century based on analysis by University of Washington's Climate Impact Group (page 41 in the EIS main report).

While the percentage increases in EDT ratings from current conditions to 2080 are shown to be increased in most reaches, the ratings were instead reduced for a set of reaches downstream of the proposed dam site, which does not make sense. We can only conclude that the Bed Scour ratings for these reaches showing reduced scour are in error. The error for these reaches appears to be substantial. This seems to further indicate a lack of an adequate QA/QC procedure for the EDT modeling.

Change in Bed Scour ratings

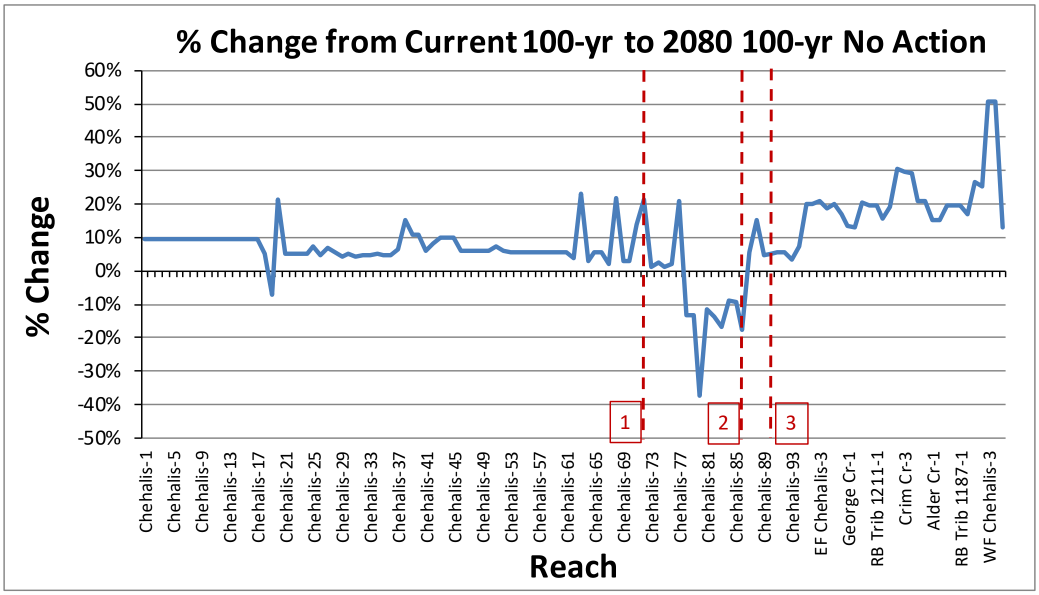

Figure 3. Percentage changes in the Bed Scour ratings from the current 100-year flood scenario to the 2080 100-year flood scenario for all reaches in the mainstem Chehalis River from Chehalis-1 (at the river mouth) to Chehalis-94 (below confluence of forks) and other reaches upstream of the proposed dam site. Dashed vertical lines indicate location of Rainbow Falls (1), proposed dam site (2), and the upper end of the proposed reservoir when filled (3). Percentage reductions in Bed Scour ratings in reaches downstream of the proposed dam site appear to indicate errors in ratings.

Wetted Stream Channel Width

The EDT model applies estimates of wetted stream channel width to calculate the quantities of available fish habitat for different habitat types. Each stream reach delineated in the model is assigned a wetted channel width for each month of the year, assuming steady-state conditions over some period of years. The channel width values represent the average widths over that period of years. Estimates of channel width are assigned for each scenario being modeled. Channel width values strongly affect the overall quantity of habitat under each scenario, and therefore are a key determinate of the model's estimates of salmon abundance for each life stage and the number of spawners at the end of the life cycle.

We compared the estimates of channel widths for each reach being modeled under different scenarios, focusing particularly on the months of highest average flow (January) and lowest average flow (August).

For the high flow month (January), Figure 4 compares wetted channel widths for the relevant Chehalis River stream reaches among three scenarios modeled: (1) current 2-year flood scenarios without the FRE, (2) current 100-year flood scenario with the FRE having been built, and (3) the 2080 100-year flood scenario with the FRE. As expected, comparing the top two panels in the figure shows some increases in wetted channel for many Chehalis River reaches and very large increases in width within reaches encompassed by the FRE reservoir under the current 100-year flood scenario with the FRE.

Figure 4 (bottom panel) shows another significant error in the modeling inputs. The figure shows that modeling was done for the 2080 100-year flood with the FRE using channel widths without the reservoir being filled. Other relevant months in the year when a reservoir might have been filled were modeled in the same way for this scenario. We are uncertain how this error would affect the modeling results. This is another example of an inadequate QA/QC procedure being followed.

For the low flow month (August), Appendix E of the EIS is not clear as to whether low flow channel width values were changed in the model to reflect expected climate change effects. Some text suggests that the modeling was done to reflect expected changes in low flow (see page E2-19), while other text suggests it was not (see page E2-27). Regardless, some changes in wetted channel width are evident in the model during August among the scenarios. Mauger et al. (2015, 2016) concludes that low flow channel widths will decline in most Western Washington streams due to climate change as a result of reduced precipitation during summer months.

Figure 5 top panel shows the percentage change in August wetted channel width from the current 2-year flood level to the 100-year flood level scenario at late century (2080) with climate change and without the FRE in place. Some reductions in wetted channel width are evident for this period though overall the changes are small. Figure 5 bottom panel shows the same information comparing the current 2-year flood level to the current 10-year flood level, i.e., without considering climate change. It is surprising that a larger reduction in wetted channel width is evident without climate change than shown in the top panel with climate change. We note that the average reduction in August channel width for the two scenarios in the bottom panel between the Satsop River and Newaukum River, a distance of 55 miles, is 5.0%. The concerning aspect of this is the inconsistency among the scenarios without any clear rationale for the differences. These anomalies indicated further problems with the QA/QC procedure.

It is not clear to us how these apparent anomalies in the data input for this attribute would alter the results if the ratings were done consistently and tracked logically with how the different scenarios should have been characterized in our view for this attribute. Our concern is over what appears to be a troubling inconsistency in attribute ratings among the scenarios and a lack of adequate QA/QC procedures.

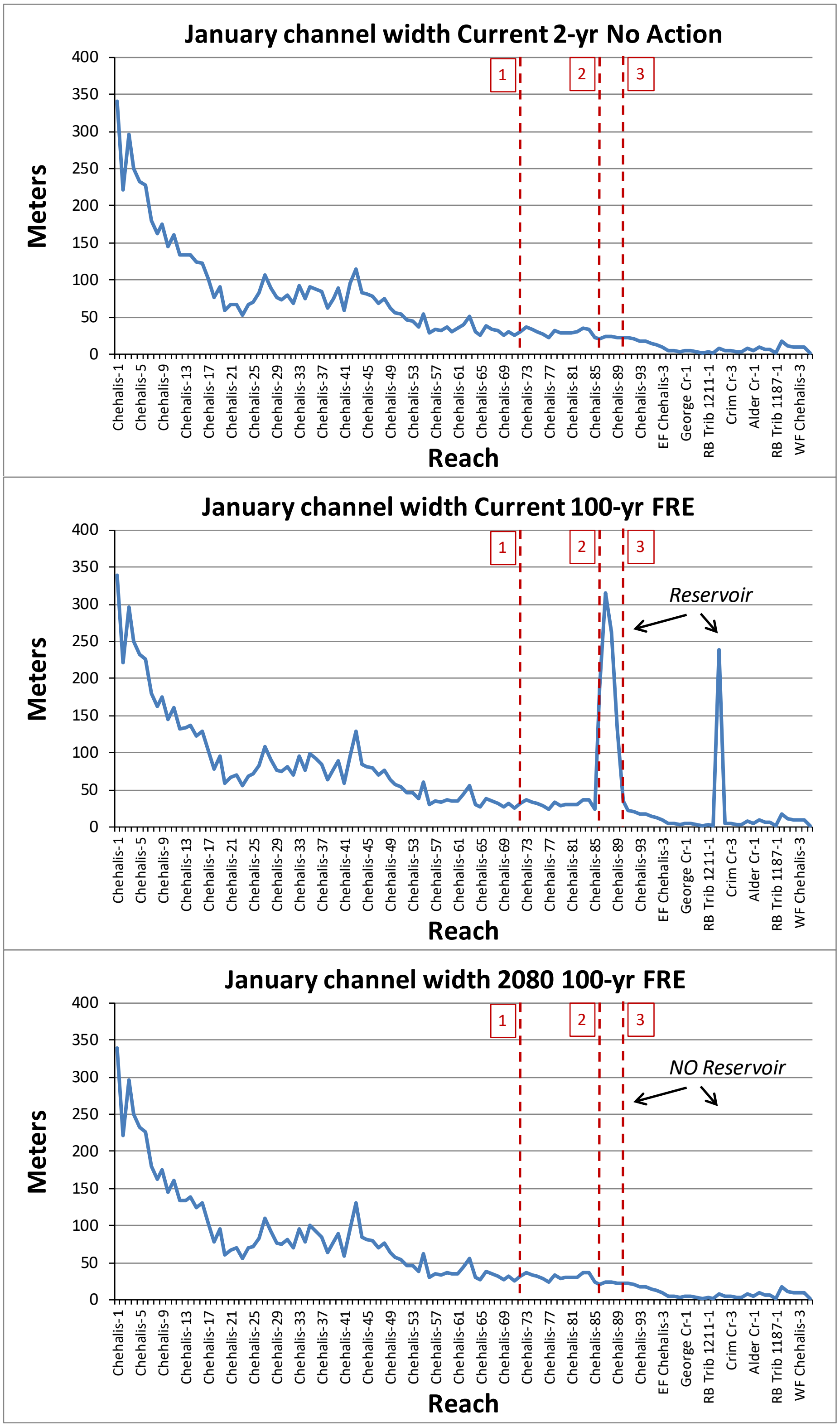

Figure 4. January wetted channel widths applied in EDT under the current 2-year flood scenarios (top), current 100-year flood scenario with the FRE (middle), and the 2080 100-year flood scenario with the FRE (bottom). Notice that the 2080 100-year FRE scenario shows no reservoir. Dashed vertical lines indicate location of Rainbow Falls (1), proposed dam site (2), and the upper end of the proposed reservoir when filled (3).

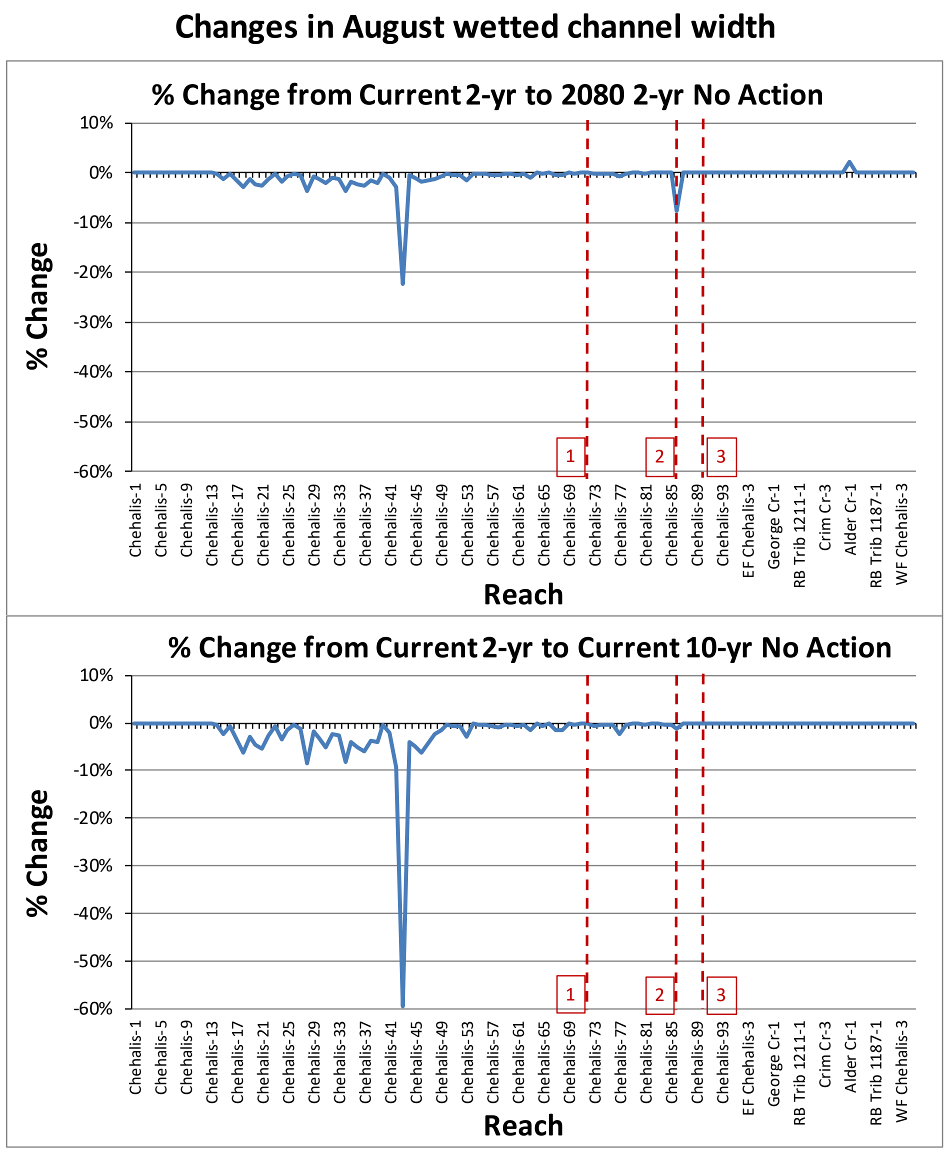

Figure 5. Top - Percentage changes in wetted channel width in August from the current -year flood scenario to the 2080 100-year flood scenario; Bottom – Percentage changes in wetted channel width in August from the current 2-year flood scenario to the current 10-year flood scenario. Notice that reductions in channel width with the current 10-year flood level are much greater than those under climate change for 2080.

Flow attributes

The EDT Model uses three flow-related attributes of relevance to this discussion. These attributes characterize conditions of streamflow in the model with respect to changes in peak flow, low flow, and the amount of within-year flashiness in flow. Combined, these attributes, together with wetted channel width, are used to assess how streamflow affects the salmon performance parameters productivity and capacity. These attributes should be particularly important to the modeling application within the EIS when considering the effects of different flood flow magnitudes, how flow characteristics would be altered by climate change, and how these characteristics would be affected by the proposed FRE.

In simple terms, these three attributes are defined as:

Flow High	Describes how peak winter flows have been changed in the watershed relative to a comparable watershed in an unaltered condition; are peak flows and their frequencies comparable, greater than, or less than they were in the watershed's unaltered state? For example, peak flows typically increase as the amount of impervious surfaces increase. Climate change is expected to increase peak flow by 26% by late century (page 41 in the EIS).
Flow Low	Describes how low summer flows have been changed in the watershed relative to a comparable watershed in an unaltered condition; are low flows comparable, greater than, or less than they were in the watershed's unaltered state? For example, loss of groundwater sources will decrease summer low flows. Climate change is expected to decrease summer low flows in the region (Mauger et al. 2015, 2016).
Flow Intra-annual	Describes how the rate of runoff (flashiness) has been changed in the watershed relative to a comparable watershed in an unaltered condition; is flashiness comparable, greater than, or less than it was in the watershed's unaltered state? Increases in impervious surfaces will generally increase flow flashiness (Konrad 2000). Climate change will likely increase flashiness as a result of intensification of rate of rainfall (Mauger et al. 2015, 2016).

To understand how these attributes might affect salmon performance, it is important to recognize how the attributes and their definitions were originally developed and their intended application (Lestelle et al. 2004; Lestelle 2005). Because EDT is a steady-state model, the attributes were developed to characterize what can be thought of as the average of an environmental condition that would be expected over a relatively short period of years, like a decade, when we would not expect to see a strong directional trend in conditions—i.e., a steady state of conditions even though interannual variability in characteristics would occur over that period of years.

The attributes were not developed to be applied in the manner being used in the EIS application, that is, to reflect conditions associated with hypothetical 2-year, 10-year, and 100-year flood frequencies under steady-state conditions. The Flow High attribute, by its definition and as it is was meant to be applied in the model, means that there is an assumed amount of interannual variability in annual peak flow over some averaged period of years. The actual name of this attribute in EDT is "Flow – change in interannual variability in high flows", recognizing that it considers the amount of interannual variability in peak flows (Lestelle 2005), implying a certain frequency of flood flows of given magnitudes over a period of years.

But this begs the question: How would the attributes need to be applied for questions like those being addressed in the EIS if the attribute definitions and their associated biological rules integral to the model are not to be distorted? This author (Lestelle) is well aware of how the attributes and the associated modeling rules were developed because he was the principal developer of these modeling components.

This question is best answered by example. The Flow High attribute, like most other EDT attributes, are rated on a 0 to 4 scale, as follows for this attribute (notice especially the meaning for a rating of 2):

Rating	Meaning
0	Magnitude & frequency of peak flows much reduced from the unaltered watershed
1	Magnitude & frequency of peak flows reduced from the unaltered watershed
2	Magnitude & frequency of peak flows unchanged from the unaltered watershed
3	Magnitude & frequency of peak flows increased from the unaltered watershed
4	Magnitude & frequency of peak flows much increased from the unaltered watershed

Although the rating definitions seen above seem to be qualitative only, the rating is best accomplished using actual time series flow data and calculations described in Lestelle (2005), which was done for the Chehalis River as contained in Mobrand Biometrics (2003) for current conditions, as they existed at the time that report was done.

What then does it mean for rating this attribute if it is to be used in the model for a hypothetical condition for 100-year flood flows either under current conditions or projected in year 2080 under steady-state conditions? It necessarily would mean that the model would be projecting effects under a 100-year flood flow, meaning that since the model's calculations are all for steady-state conditions, that in effect the Flow High attribute would reflect a condition where the 100-year flood would occur <u>every</u> year over some averaged period of years. Given that the unaltered watershed would have a Flow High rating of 2 (by definition), then it should mean that the rating for the 2080 100-year flow scenario would be a value of 4. The rating for the current condition 100-year flood scenario would logically be somewhat less than 4 (to allow for a higher rating at the late century time period), though certainly higher than a value of 3.

Table 2 lists ratings for Flow High that were applied in the EDT model for the different flood frequencies being modeled. Note that all flood frequencies for current conditions were given a rating of 2.3, meaning that the rating is only modestly higher than the rating given to the unaltered watershed.

The Flow High rating was increased to 3 for the 2080 2-year flood scenario and was kept at the same value for the other 2080 flood frequencies, as well as for all of the FRE flood frequency scenarios. No rationale for assigning these scenarios these values for different flood frequencies was given. We conclude that the ratings are inconsistent with the attribute definition and the use of the attribute within the model as it was designed.

It bears noting for comparison that the Newaukum River ratings for this attribute for <u>current</u> conditions based on empirical flow data was calculated in 2003 to be a value of 3.2 (Lestelle 2005). This value was applied in the 2003 EDT analysis of the Chehalis Basin. That rating was still being used in the analyses for developing the ASRP until at least 2015 (based on files received from ICF at that time). This point is important because it shows a substantial inconsistency in how the ratings have been developed and applied in the various flood frequency scenarios within the EIS for the Chehalis Basin. It bears noting that the Newaukum rating was reduced to a value of 2.3 in the current model version but we are unaware of the rationale for doing so.

Why would the Flow High attribute for the Chehalis River in late century with a 26% in increase in peak flow due to climate change and under a 100-year steady-state flood scenario only be given a rating of 3?

We can only conclude that the EIS is substantially underestimating the effects of the 100-year flood scenarios due to how this attribute was rated for those scenarios, especially in late century.

We have concerns about the other flow attributes as well because we do not understand the rationale that has been applied in a steady-state model for the different flow scenarios. Our conclusions for these attributes are similar to our conclusions about the use of the Flow High attribute in the different flow scenarios.

Our overall conclusion about how these flow attributes were rated—without adequate attention to how the ratings would change with climate scenarios and for different flow frequencies, is that salmon performance would be worse than what has been projected for at least some scenarios. We are uncertain about other scenarios and the magnitude of change that would likely occur if the ratings were done to reflect our concerns.

Table 2. Ratings applied for the Flow High attribute in the EDT model as applied in the EIS.

Flood scenario	Flow High
Unaltered watershed state	2
Current 2-year flood	2.3
Current 10-year flood	2.3
Current 100-year flood	2.3
Current 2-year flood with FRE	2.3
Current 10-year flood with FRE	2.3
Current 100-year flood with FRE	2.3
2080 2-year flood	3
2080 10-year flood	3
2080 100-year flood	3
2080 2-year flood with FRE	3
2080 10-year flood with FRE	3
2080 100-year flood with FRE	3

<u>Hybrid Model:</u> The Hybrid Model was employed to provide information on how environmental variability in peak flow events might affect populations over time. The Hybrid Model couples EDT projections of productivities and capacities by species life-stages under conditions in three specific water years (Oct-1 Sept 30 as defined by USGS) with simulation of randomly chosen water years.

Three water years were modeled using EDT: (a) 2011 representing a normal water year flows (referred to as the 2-year flood flow) – no dam closures – open gates; (b) 2009 representing a major 10 year flood water year (referred to as the 10-year flood flow); and (c) 1996 representing a catastrophic flood water year (referred to as the 100-year flood flow).

Three flooding scenarios (flow rate is measured at the Grand Mound gage) were evaluated : (1) Major flood: Water flow rate of 38,800 cubic feet per second (cfs) or greater (2) Catastrophic flood: Water flow rate of 75,100 cfs; and (3) Recurring flood: A major flood or greater that occurs in each of 3 consecutive years. Modeling with the Hybrid Model involved running multiple 100 simulations of randomly selected water years. Arithmetic mean results were reported.

The Hybrid Model has not been peer reviewed and documentation provided in the DEIS is too limited to permit full evaluation of the Hybrid Model, its integration with life-cycle population projections produced by EDT and how streamflow events were stochastically modeled. Our evaluation of the parameterization of EDT presented previously in this report, whereby it is evident that many errors and inconsistencies exist, also raises concerns about the QA/QC procedures for the Hybrid Model.

The EDT Model estimates performance characteristics under steady-state conditions, i.e., it assumes that environmental conditions are virtually constant during a period of years encompassed by life cycles for the modeled species. The Hybrid Model, which incorporates a multi-generational component[7], then uses the results of the steady-state model to introduce interannual variability in flood flow effects and associated dam operations to evaluate the effects of this variability on salmon performance.

Page E-63 states:

> *"The integrated EDT-LCM modeling approach was used to identify the potential impacts on coho salmon, steelhead, and spring-run and fall-run Chinook salmon from the Proposed Action. The EDT model was used to compute the effect of the Proposed Action on the modeled species at points in time. Life-stage and reach-specific productivity and capacity outputs from EDT based on changes in habitat were then input into NOAA LCM for each species to evaluate stochastic effects of the alternatives on anadromous salmonid population dynamics over time. The integrated approach takes advantage of the strengths of both models, where EDT estimates the effects of an action on habitat, and the life-cycle models incorporate the effects of environmental variability and sequential flood retention events into the analyses."*

DEIS, App. E.

Page E-63 further states:

> *"Changes to salmon and steelhead population metrics are modeled by integrating the effect of changes in fish habitat function throughout the study area and fish passage through the FRE facility using the integrated EDT-LCM approach (Attachment E-2)."*

Three water flow year (WY spanning the period from Oct 1-Sept 30 according to USGS convention, not calendar years) regimes were selected: (1) 2011 Normal – no dam closures – open gates; (2)2009 Major flood ~ 10-year flood; (3) 1996 Catastrophic flood – 100-year flood.

The memo of January 31, 2014 To: H&H Technical Committee From: Larry Karpack, Watershed Science & Engineering (WSE) Cc: Bob Montgomery, Anchor QEA Re: Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species - Re-evaluation of Statistical Hydrology and Design Storm Selection for the Chehalis River Basin describes the catastrophic and major flood events as:

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[7] The EDT Model calculates end of life cycle productivity, capacity, and equilibrium values using a set of equations described in Moussalli and Hilborn (1985). In contrast, the Hybrid Model is initiated with an assumed number of spawners, and then advances the resulting eggs and progeny of those spawners through the entire life cycle of the species, ending with surviving progeny that spawn to begin the next generation. The model continues through a series of 100 generations to estimate run sizes at the end of that time.

- February 1996 Event – This was a large frontal storm with very broad rainfall distribution throughout the Chehalis River basin and beyond (from north of Seattle to southern Oregon). The 24-hour rainfall totals throughout the basin generally ranged from 10+ year to 100+ year recurrence. It was extremely cold in the month prior to the storm and there may have been some snow accumulations in mid elevations. The resulting flood was the second largest in the historic record at many basin streamflow gages including Grand Mound (84 year record), Porter (65 year record), and Doty (74 year record) and the 4th largest in the historic record on the South Fork Chehalis (74 years aggregate record). It is still the largest flood in the observed record on the Skookumchuck River (74 years aggregate record) and Newaukum River (74 year record).
- January 2009 Event – This event was focused primarily in the eastern and northern portions of the Chehalis River Basin although significant rain still fell in the upper watershed. Flooding, or near flooding, of Interstate 5 was caused by high flows on the Newaukum system which peaked well in advance (12 hours or more) of the arrival of the peak Chehalis River flow from the upper basin. The January 2009 event also caused very high flows in many lower basin tributaries (Satsop, Black, Wynoochee). The resulting flood was the 5th largest in the 84-year historic record at Grand Mound and the 7th largest in 74 years at Doty. The January 2009 event was the second largest observed flood on the South Fork Chehalis (after 2007) and Newaukum Rivers (after 1996) and the third largest on the Skookumchuck (after 1996 and 1953). At Porter on the Chehalis River, the 2009 flood was the 3rd largest in the 65-year record reflecting large contributions from lower basin tributaries. The January 2009 event was the third largest event in the historic record on the Wynoochee (in 40 years since the construction of the dam) and the 5th largest event on the Satsop (in 84 years). Considering the flow at Porter and on the lower basin tributaries the January 2009 event is estimated to be the second largest event in the historic record downstream of Montesano.

According to the explanation provided by ICF during the February 10, 2020 meeting at Ecology (fn 5), the approach employed to evaluate stochasticity in WY flow events was determined by the availability of time and resources. The reasoning and consequences of this limited approach were described in Appendix E:

> *"Because specific past year's water years were chosen to represent all 2-, 10-, and 100-year flood conditions, there is no variation in timing and duration of the flood events and no variation in flow Fish Species and Habitats Discipline Report Attachment E-2 Proposed Chehalis River Basin Flood Damage Reduction Project February 2020 SEPA Draft Environmental Impact Statement Appendix E E2-10 conditions at other times of the year. The lack of variation in timing and duration of the flow events means that there is not variation in the life stage of the salmon and steelhead being affected by the flood event. In reality, in the future, variation in the timing and during of the flood events are very likely, which would result in different life stages of the salmon and steelhead being affected by the floods, which could result in greater or lesser impact to salmon and steelhead."* p.E2-9.
>
> *"Modeled future climate conditions represent projected conditions in mid- and late-century, which correspond to projected climate conditions in years 2031 to 2063 and years 2064 to 2099 in the integrated model, respectively (Table E2-1; Figure E2-7). In the EDT model these periods correspond to around 2040 and 2080, respectively. The term 'around' and the ranges in years modeled for the future climate periods are used because future climate predictions represent general periods of time, not specific years. Future climate conditions assumptions developed by the University of Washington Climate Impacts Group were incorporated into flow and temperature models to project changes to conditions in the Chehalis Basin (e.g., Van Glubt et al. 2017). The assumptions used to characterize conditions in mid- and late-century under future climate conditions are described later in the No Action Alternative section."* p.E2-15-17.

Model structure

- A single set origin of life-stage trajectories (LST) is generated by EDT and used for all simulations. These trajectories are partitioned based on place of origin (i.e., above or below Rainbow Falls).
- EDT generates steady state estimates of productivities and capacities under the three selected WY conditions (normal, major, catastrophic floods). Under steady state conditions, EDT would generate the numbers of fish by life-stage and age along with associated productivities and capacities for rolled-up trajectories.
- Three 100 year scenarios are evaluated: (1) WYs selected via "Random draw" of normal, major and catastrophic WYs; (2 a-c) Random draw with 3 consecutive years of major WYs inserted into the sequence (what years based on modeler judgement) to evaluate early, mid-year, late year effects of uncertainty in WYs; (3 a-c) Random draw with 3 consecutive catastrophic WYs into the sequence to evaluate early, mid-period, and late-periods.
- With selection of WYs in the Hybrid Model, the life-stage EDT parameters associated with the WY type are applied to the fish modeled as being alive in that year.
- Fish are simulated to mature and spawn and the next generation is initiated.
- This cycle is repeated for 100 years and replicated 100 times.

These fundamental features of the Hybrid Model were described by representatives of ICF and NOAA during a technical meeting involving representatives of the Quinault Nation at the meeting with Department of Ecology on February 10, 2020. Questions regarding details of the Hybrid Model were raised and responses received from ICF in a March 12, 2020 memo accompanied by data provided by ICF.

Upon examination of the data that accompanied the memo provided by ICF, it was discovered that the description of the Hybrid Model provided during the February 10, 2020 meeting at the Department of Ecology was not accurate.

We learned that two issues occurred in creating the information that was passed on to NOAA from ICF for the Hybrid Model, neither of which is mentioned in the DEIS. Egg to smolt (juvenile) life stages for coho and steelhead encompass two or more WYs as opposed to the one WY involved in comparable life stages for Spring and Fall Chinook. All coho modeling was done assuming only one WY type encountered during the incubation to smolt life stages. For steelhead, ICF divided the steelhead incubation to smolt phase into distinct stanzas using a March to March delineation. So, in the first stanza, incubation, summer rearing and first winter would be included. The second stanza would be the second summer and the second winter, and so on for the third stanza. Since WYs do not line up with these time periods, one stanza in the model in reality would be essentially half and half across two different WYs. But the modeling was done assuming a single WY for each stanza.

We learned that the reason why this notable error occurred was due to NOAA not clearly specifying life stages associated with single WYs. The problem was not discovered until it was too late to make a correction in time for publication of the EIS. At that point, the decision was made to essentially look past the glitch. This raises an issue regarding oversight and communication between NOAA and ICF staff.

The Hybrid Model attempts to evaluate stochasticity in WY events to the pre-smolt life stages of Spring and Fall Chinook, coho, and steelhead. However, the pre-smolt life stages for coho and steelhead encompass more than a single WY. The end result of the communication failure between EDT and ICF modelers was that WYs are not tied to pre-smolt life stages for coho and steelhead is that the way in which hybrid modeling was done is incorrect for analyzing WY effects[8]

ICF described the algorithm for aggregating trajectory-specific productivity and capacity estimates into subbasin-level productivity and capacity as consisting of the following steps:

1. Define the spatial scale of aggregation. In the Chehalis analysis, the spatial scale is the Subbasin scale defined by the Scientific Review Team as the reporting structure for EDT. All trajectories that originate (spawn) in a specific Subbasin are aggregated together into an estimate of Subbasin-specific productivity and capacity.
2. Calculate average number of eggs per spawner in the Subbasin. This is the weighted average of the age-specific eggs per spawner of each trajectory weighted by the cumulative density-independent survival of each trajectory.
3. Exclude so-called “jack” trajectories. In the Chehalis, only Spring Chinook and Fall Chinook have “jack” trajectories. These are trajectories with life cycle models that begin with “0,1-age.”
4. Calculate trajectory productivity by multiplying each trajectory’s cumulative density-independent survival by the Subbasin-wide eggs per spawner value calculated in step 2.
5. Calculate subbasin productivity as the weighted average of trajectory productivity weighted by trajectory equilibrium abundance (fish/m) across all trajectories originating (spawning) in the Subbasin. This calculation is performed on trajectory productivity, juvenile productivity, and juvenile-to-adult productivity.
6. Calculate each spawning reach capacity in fish/m as the average of trajectory capacity in fish/m of all trajectories originating (spawning) in the reach. For Spring Chinook, Fall Chinook, and steelhead, spawning reach capacity in fish/m is the unweighted average of the trajectory capacities in fish/m. For Coho, spawning reach capacity in fish/m is the weighted average of trajectory capacity in fish/m weighted by trajectory capacity in fish/m. Total spawning reach capacity is the product of spawning reach capacity in fish/m by the spawning reach length in m. This calculation is performed on trajectory capacity, juvenile capacity, and juvenile-to-adult capacity.
7. Calculate Subbasin capacity by taking the sum of the capacities of all spawning reaches in the subbasin.

This procedure is important because aggregation of EDT-produced effects directly influences population performance metrics. Mobrand Biometrics (2005) documents the mathematical algorithms used by EDT to aggregate projections for life history trajectories at page 13, but the trajectory weighting factors have been modified since that time. The effect of the aggregation procedure on results produced by the Hybrid Model cannot be evaluated absent detailed information to understand and evaluate the procedure that was actually employed.

It is noteworthy that the EIS described the purpose of the Hybrid Model differently than that presented during the February 10, 2020 meeting. “The modeling approach was selected primarily to evaluate the effects of operating the FRE facility (outlets open versus closed) on salmonids and not the effects of various flood flows under the Proposed Action. “ p. E-187. In its memo of March 12, 2020, ICF described the scenarios examined with the Hybrid Model.

[8] Personal communication by Karl Dickman (ICF) toLarry Lestelle, March 19, 2020.

Table 3. Nineteen scenarios modeled for the SEPA EIS EDT analysis, as grouped by flow year, with or without proposed structure, and time period.

	Current- w/o structure	Construction	Current w/ structure	Mid- w/o structure	Mid- w/ structure	Late- w/o structure	Late – w/ structure
2- year flow	X	X	X	X	X	X	X
10-year flow	X		X	X	X	X	X
100-year flow	X		X	X	X	X	X

Results produced by the Hybrid Model are provided in the EIS, App. E at p. E-187-189.

> *"Differences in changes in estimated salmonid abundance among the typical seasonal flow and major and catastrophic flood scenarios modeled based on EDT are shown in Figures E-25, E-28, E-31, and E-34 for each species modeled. There was little variability in estimated salmonid abundance associated with the flood scenarios modeled under the No Action Alternative. The variation that did occur among the flood scenarios was due to increased bed scour. In the EDT model, current bed scour ratings were adjusted to reflect presumed conditions during major and catastrophic flood events.*
>
> *Adjustments were limited to mainstem Chehalis River reaches upstream of Elk Creek due to the low river gradient below Elk Creek. Because of this, differences among flood events were greater in the Above Crim Creek Subbasin than in the Rainbow Falls to Crim Creek Subbasin. Among all three species and two life-history strategies of Chinook salmon, two subbasins, and two time periods modeled, differences in decreased estimated abundance between floods modeled under the No Action Alternative ranged from 0% to 8%. The largest difference was between the typical seasonal flow and the catastrophic flood for spring-run Chinook salmon in the Above Crim Creek Subbasin, where estimated abundance decreased 24% and 32%, respectively (Figure E-25).*
>
> *The flow conditions modeled are the only stochastic aspect to the integrated modeling approach used in the analysis. Variability associated with ocean conditions and marine survival as well as other freshwater factors would be expected to increase the variability around median abundance estimates but were not incorporated into the modeling approach. These factors are discussed in Section 2.4.2.1.4. Also, evaluating effects of the No Action Alternative on salmon and steelhead quasi-extinction thresholds rather than zero as the lower bound was not a component of the SEPA EIS analysis."*

These results are not surprising given the structure and limitations of the Hybrid Model. The described method approaches stochasticity and uncertainty in a very superficial way that produces results dominated by WY effects. This could easily lead to misunderstanding and misrepresentation. As structured, differences in impacts between the proposed project and no action alternative could be interpreted as reflecting the effect of the proposed project alone, where a more complete analysis of uncertainty and interactions among factors that affect ecological functions could yield much different results.

In addition to the error in modeling coho and steelhead, there are several issues that are important, but not evaluated. The modeling procedure does not:

(1) incorporate expected changes in the frequency and magnitude of changes in flood and low flow events or temperatures. The EIS repeatedly mentions increases in the frequency of flood events, but the modeling methods are not consistent with the statement at p 5-3 of the EIS that major and catastrophic floods are expected to occur 1 in 4 years, and 1 in 27 years by late century, respectively. Changes in the magnitude of peak flows are not considered while the EIS states that peak flows are expected to increase on average by 12% by mid-century and 26% by late century (WSE 2019; EIS pE-56). Variability of changes in low flows – the EIS states that summer precipitation is projected to decrease in magnitude by as much as 30% (Mote et al. 2014; EIS pE-56) but it does not appear to have been considered. Changes in frequencies and magnitudes of changes in temperature and flows are prominently mentioned in the EIS (e.g., Discussion of impacts of the No Action Alternative at p54, p69, p105, p112, pp121, , p128, p133, p140, p.175, p162. It is curious that this expectation is mentioned only for the No Action alternative, with the exception of section 5.7.3).

(2) consider changes in timing of flows and their effects on phenology and survival of salmon;

(3) reflect possibilities of multiple closures of a dam in a single WY;

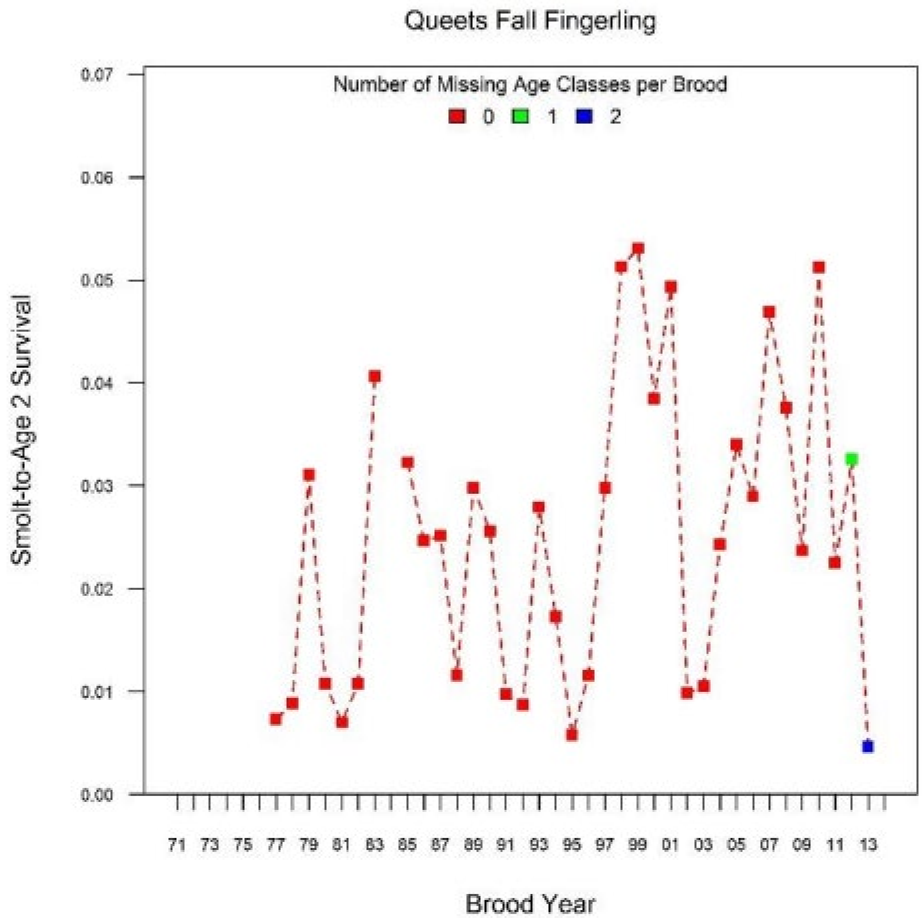
(4) incorporate effects of changes in development, groundwater (baseflows), temperatures, sediment transport;

(5) consider variability in estuarine or marine survival or harvest – extremely unlikely that WY events would be independent of estuarine or marine conditions due to the relationships between air and ocean currents and precipitation patterns;

(6) capture the environmental variability that would be expected in different parts of the Chehalis Basin at specific times because evaluation is based on a limited set of three a priori selected WYs;

(7) deal substantively with impacts of habitat restoration actions or various kinds of intra and inter species interactions.

(8) clearly present results on important population performance metrics of productivity, diversity, spatial structure, instead focusing on the metric of abundance (Neq), or potentials for metapopulation structure. Failure to present and discuss the significance of these metrics fails to inform readers of the EIS of their importance for consideration of harvest potentials, resilience to stress, and ability to withstand change. Because of these structural limitations, the analysis is framed in way that can easily lead to misinterpretation. Since factors relating to climate change, development, and restoration are incorporated into evaluation of all alternatives, the EIS asserts that the effects of the Proposed Project can be determined by differences computed through subtraction. This is misleading in that the effects of other factors not included in the structural assumptions for impact analyses would very likely significantly affect the magnitude and uncertainty associated with that difference. Even one of these factors, for example, variability of estuarine and marine survivals, could have a large effect on model results. For example, the figure depicted below (p44 of TCCHINOOK 19-2 v1) illustrates the variability in early marine survivals for Queets Fall Chinook, the coded-wire-tag indicator stock used by the Pacific Salmon Commission's Chinook Technical Committee to represent Washington Coastal Fall Chinook.



Model Results

Metrics: Model projections are presented in three general metrics in the absence of harvest: (1) "Abundance" or spawners at equilibrium escapements; (2) "Productivity", reproductive rate at low spawner abundance; and (3) population "Spatial structure" and "diversity", the proportion of populations with productivities >1. Results are presented principally in terms of abundance, with only sparse mention of model results in terms of the other two metrics. The EIS provides only cursory treatment of projected impacts of the Proposed Project and No Action alternatives on productivity, diversity, and spatial structure, extremely important considerations for assessing resilience and long-term sustainability.

Because the modeling was limited to consideration of freshwater environmental effects of the Proposed Project within the limited study area, effects of environmental variability during periods of estuarine and ocean residence were not considered. The ability of salmon populations to sustain harvest, a consideration of critical importance to the ability of the Quinault Nation to exercise fishing, hunting, and gathering rights reserved under the January 6, 1856 Treaty of Olympia with the United States was not evaluated.

The EDT projects habitat relationships to salmon under results "steady state" conditions using deterministic computational algorithms without consideration of variability or uncertainty in population structure and environment.

DEIS p. 78-79: *"Operation of the FRE facility would have significant adverse impacts on salmon and steelhead in both the Above Crim Creek Subbasin and the Rainbow Falls to Crim Creek Subbasin. In addition to reduced abundance of salmon species, operation of the FRE facility is expected to reduce the species' productivity, diversity, and spatial structure. Spatial structure refers to the pattern of fish production among subbasins in the Chehalis Basin. The loss of production from one population in a subbasin could lead to a reduction in the resilience of the overall population and an increase in vulnerability to environmental variables. The Proposed Project would decrease the spatial structure of populations in the basin by eliminating spring-run Chinook salmon, coho salmon, and steelhead populations in the Rainbow Falls to Crim Creek Subbasin by late-century; significantly impacting spring-run Chinook salmon in the Above Crim Creek Subbasin in both the midcentury and late-century periods; and impacting fall-run Chinook salmon in the Above Crim Creek and Rainbow Falls to Crim Creek subbasins in both the mid-century and late-century periods. The reduction or loss of salmon or steelhead from one population (subbasin) would also result in a loss of genetic diversity within and among populations of each species across the Chehalis Basin.*

The combination of construction and operation of the Proposed Project is expected to have significant adverse impacts on salmon and steelhead in both subbasins. Integrated model results, summarized in Exhibits 5.3-3 and 5.3-4, show estimated impacts on salmon and steelhead in mid-century and late century, compared to the abundance prior to construction.

The model shows that the operation of the Proposed Project would have a significant adverse impact on spring-run Chinook salmon, fall-run Chinook salmon, coho salmon, and steelhead."

Sidebar p. 78: *"Chehalis Basin Perspective on Salmonid Impacts The subbasin upstream of Crim Creek supports genetically unique populations of salmon and steelhead. The Proposed Project would result in a loss of genetic diversity within and among populations of each species across the Chehalis Basin. Spring-run Chinook spawn in three primary areas within the Chehalis Basin. The Proposed Project would significantly affect one of these three important spawning areas. Salmon and steelhead in the Proposed Project footprint and subbasin upstream of Crim Creek that are evaluated in this report make up the following percentages of the Chehalis Basin population: • About 1.2% to 3.4% of spring-run Chinook salmon, fall-run Chinook salmon, and coho salmon • About 15.7% of steelhead Reductions in the number of salmon and steelhead from the Proposed Project are significant because they bring population abundances even further below 70% of historical abundance, which is the goal for other recovery plans. The Proposed Project could affect future restoration options in the subbasins above and below Crim Creek and within the larger basin for the fish species and habitats they rely on."*

Exhibit 5.3-3
Estimated Abundance of Salmon and Steelhead Above Crim Creek

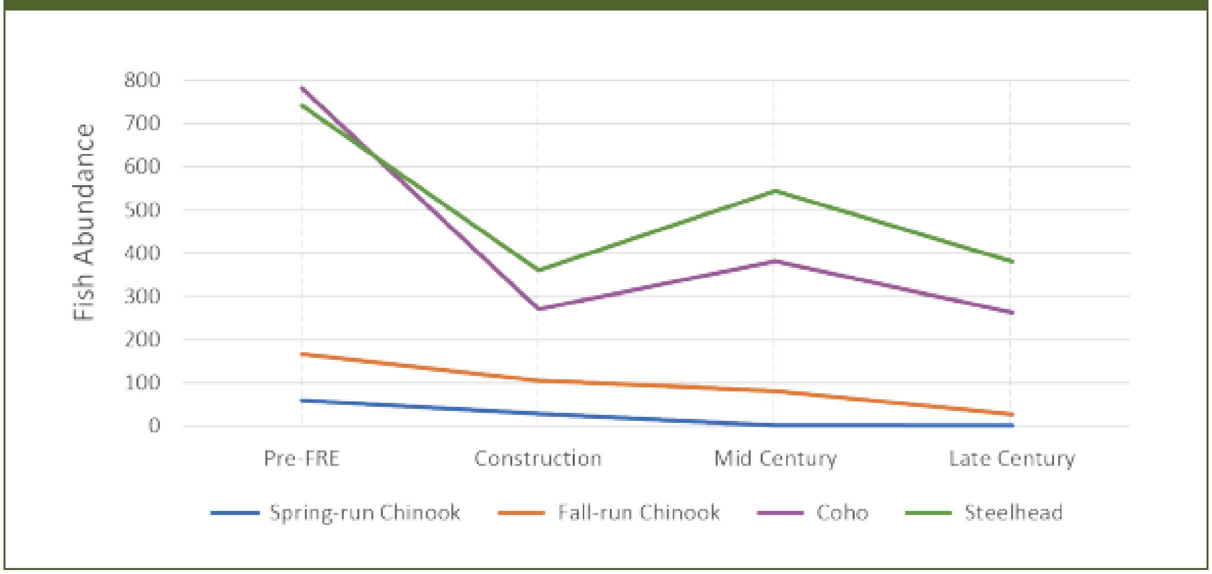
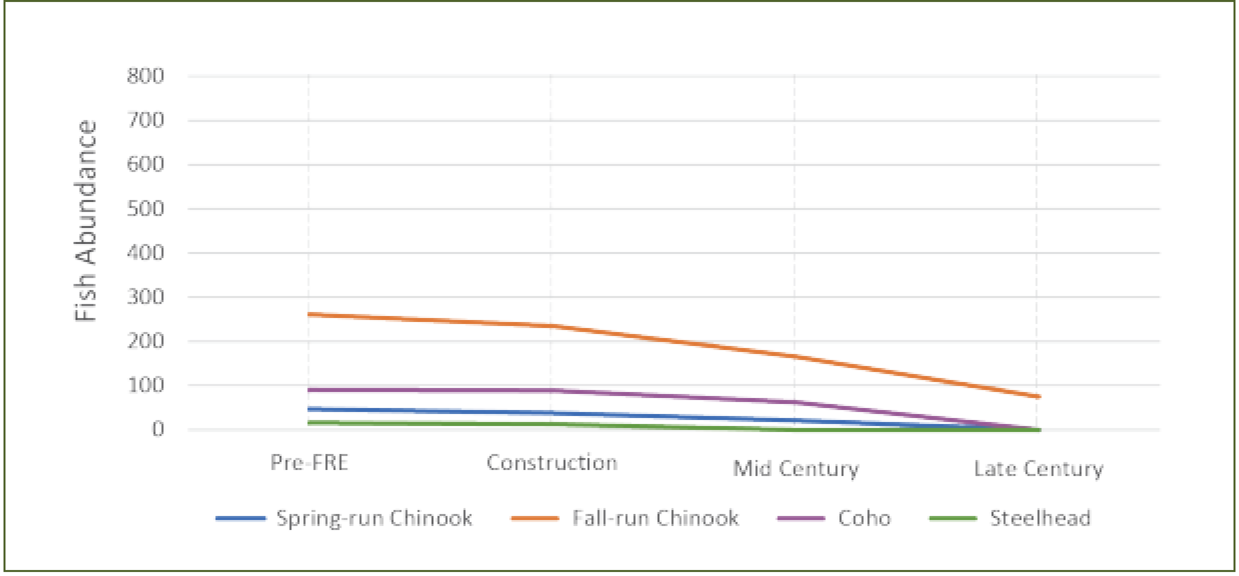


Exhibit 5.3-4
Estimated Abundance of Salmon and Steelhead in Crim Creek to Rainbow Falls Subbasin



A different set of figures is provided to depict projections under the No Action alternative.

Exhibit 5.3-6
Estimated Abundance of Salmon and Steelhead Above Crim Creek Under the No Action Alternative

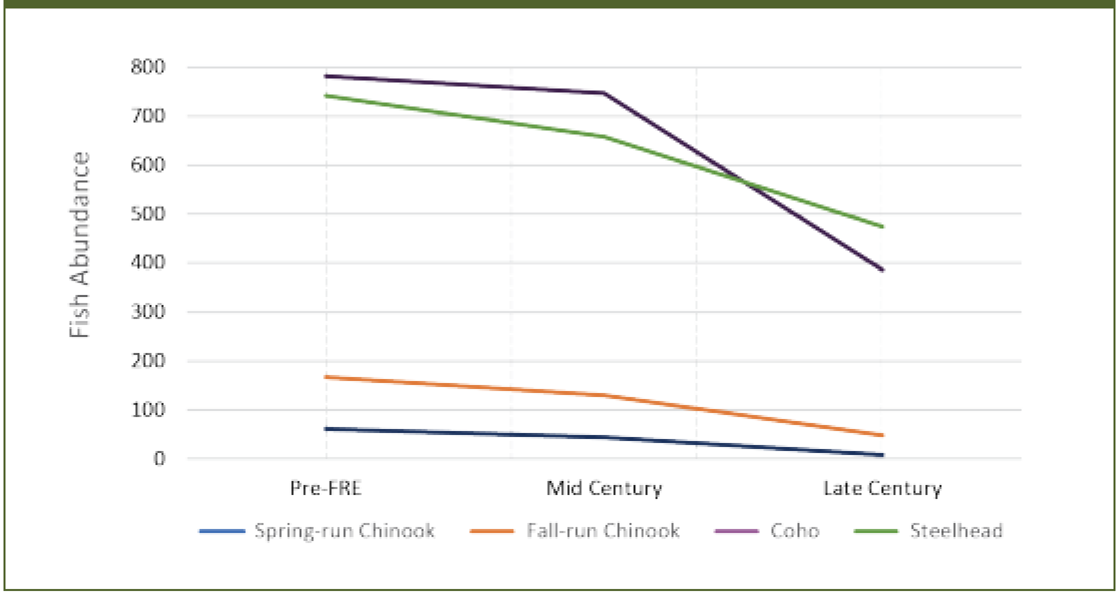
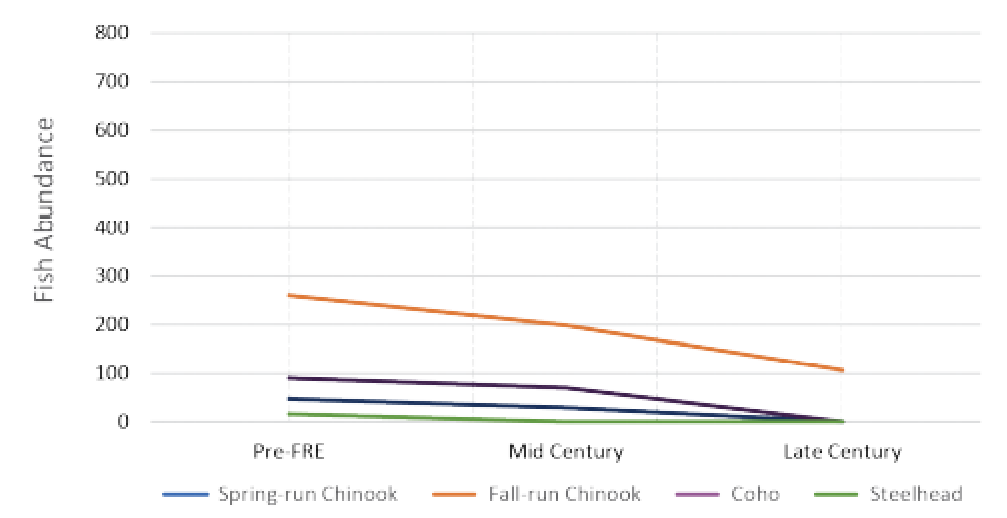


Exhibit 5.3-7

Estimated Abundance of Salmon and Steelhead in Crim Creek to Rainbow Falls Subbasin Under the No Action Alternative



EIS p. 83-84*: "Quantitative modeling was completed to determine impacts on salmon and steelhead under the No Action Alternative. Increases in water temperature and reductions in summer flows including the effects of climate change over the long term are expected to have a large impact on all three salmonid species (and two life-history strategies for Chinook salmon) modeled. Exhibit 5.3-5 shows the modeled decrease in abundance compared to the median abundance under current conditions for each species and subbasin.*

In addition to loss of abundance of salmon species, the No Action Alternative is also expected to reduce the species' productivity, diversity, and spatial structure due to the projected loss of spring-run Chinook salmon, coho salmon, and steelhead populations from the Rainbow Falls to Crim Creek Subbasin. This is expected to increase the vulnerability of these species to environmental variability. Habitat degradation associated with the No Action Alternative is also expected to reduce genetic diversity within and among populations due to reductions in abundance and the loss of populations in the Rainbow Falls to Crim Creek Subbasin. Exhibits 5.3-6 and 5.3-7 show estimated impacts on salmon and steelhead in midcentury and late-century, compared to the pre-FRE abundance."

Exhibit 5.3-5

Change in Late-Century Salmonid Abundance Compared to Existing Conditions for No Action Alternative Based on Integrated Model Results

	DECREASE IN ABUNDANCE IN LATE-CENTURY FOR NO ACTION ALTERNATIVE COMPARED TO EXISTING CONDITIONS	
FISH SPECIES	ABOVE CRIM CREEK SUBBASIN	RAINBOW FALLS TO CRIM CREEK SUBBASIN
Spring-run Chinook Salmon	-87%	Eliminated from Subbasin
Fall-run Chinook Salmon	-71%	-59%
Coho Salmon	-51%	Eliminated from Subbasin
Steelhead	-36%	Eliminated from Subbasin

The EIS' descriptions of modeling results are unbalanced. As illustrated above, text, figures and tables are presented in a way that increased the difficulty of comparing results of the Proposed Project and No Action alternatives.

Under the Proposed Project, declines in equilibrium escapements during construction range from 37% (Fall Chinook) to 65% (coho) for the area above Crim Creek and from 1% (coho) to 19% (Spring Chinook and steelhead) for the area from Rainbow Falls to Crim Creek (Exhibit 5.3-2, p74). Under the No Action alternative, declines in equilibrium escapements are projected to range from 36% (steelhead) to 87% (Spring Chinook) for the area above Crim Creek and from 59% (Fall Chinook) to 100% (Spring Chinook, coho, and steelhead) for the area from Rainbow Falls to Crim Creek (Exhibit 5.3-5). For the area from Rainbow Falls to Crim Creek, projected equilibrium escapements are similar for both the Proposed Project and No Action alternatives. Curiously, no comparable table to Exhibit 5.3-5 is provided for the Proposed Project in the EIS and the information in graphical presentations are cumbersome to compare.

Figures 1 and 2 (p. 16) and Table 2 (p.17) of a memo[9] to the Chehalis Board provide presentations that facilitate comparisons of projected equilibrium escapements under the Proposed Project and No Action alternatives.

Figure 1
Estimated Abundance Impacts Above Crim Creek from the Proposed Action and No Action Alternative

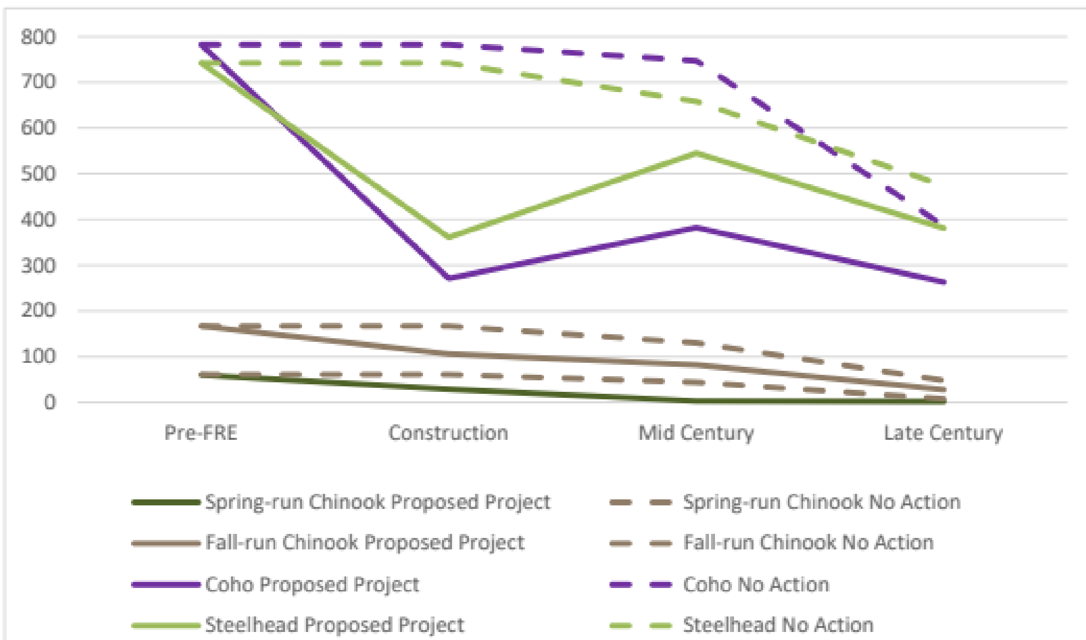


Figure 1 for the area above Crim Creek illustrates that projected declines under the No Action alternative are much more gradual than those of the Proposed Project which show pronounced declines due to dam construction activity. Because EDT provides steady state projections, the DEIS provides mid and late century information on salmon population impacts, but no more specific information as to timing. Under the Proposed Project, adverse impacts will occur during initial 2025-2030 period for construction and subsequent operation of the FRE facility. Some of these are discussed in DEIS Appendix

[9] Memo dated March 31, 2020. To: Chehalis Basin Board, From: Andrea McNamara Doyle, Office of Chehalis Basin Director Cc: Gordon White and Diane Butorac, Department of Ecology; Michael Garrity and Celina Abercrombie, Department of Fish and Wildlife; Stephen Bernath, Department of Natural Resources; Bart Gerhart, Washington State Department of Transportation Re: Response to Chehalis Basin Board Questions on the Chehalis River Basin Flood Damage Reduction Project.

E pE-79 et.seq. Accelerated adverse impacts and reduction of time available for potential mitigation or restoration actions to take effect are not considered. The timing of when adverse effects would be expected to occur and their duration is significant because earlier and more severe declines lessen the time available for restoration actions to take effect. The potential for the Proposed Project in limiting restoration actions is noted at p.S-8: "*The Proposed Project could reduce future restoration options in the subbasins above and below Crim Creek and within the larger basin for the fish species and habitats they rely on.*" Impacts of construction activity would be immediate and occur over an indeterminate period [10] while other impacts would accrue over time during operation of the dam and fish passage facilities.

Figure 2
Estimated Abundance Impacts Crim Creek to Rainbow Falls from the Proposed Action and No Action Alternative

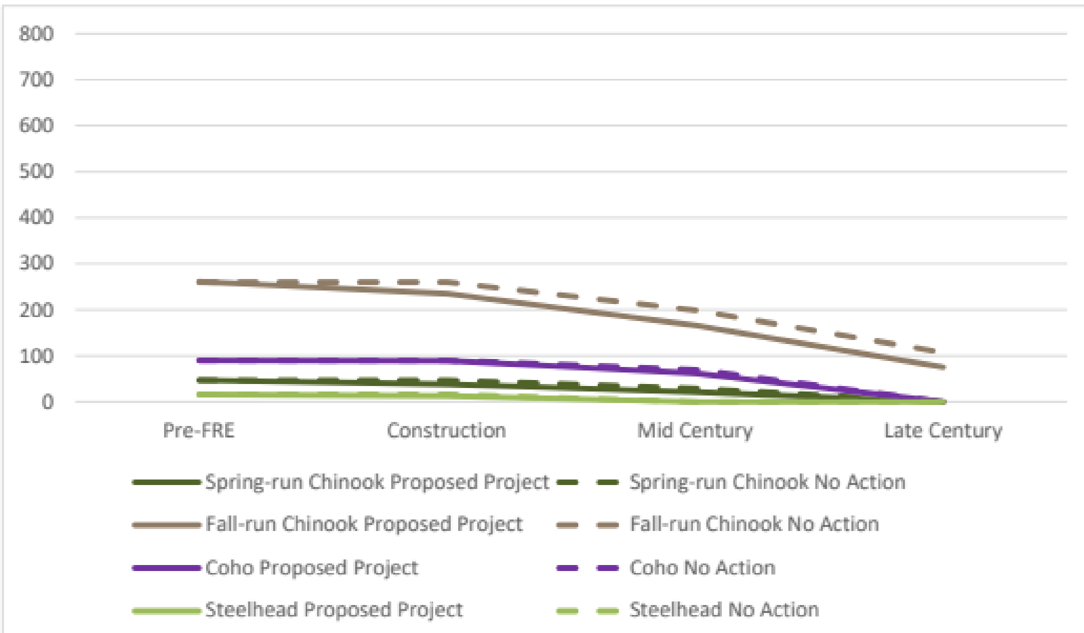


Figure 2 for the area from Rainbow Falls to Crim Creek area illustrates that equilibrium escapements are projected to decline at slightly lower rates for the No Action alternative, but similar results for both the Proposed Project and No Action alternatives by late century. The overall pattern of declining equilibrium escapements is due primarily to the effects of assumptions regarding climate change and, to a much lesser degree, development activity within the Chehalis Basin.[11]

[10] Construction is proposed to occur over five years and the applicant has requested that annual construction period be permitted to run from July through September, a time period encompassing active migration of salmon species. The EIS does not provide information on magnitude or duration of likely adverse impacts on salmon (particularly Chinook and coho) which may occur during construction.

[11] The EIS includes assumptions regarding climate change in evaluation of both the Proposed Project and No Action Alternatives. Information necessary to untangle confounded effects is not presented, nor is a separate assessment of climate change impacts included.

Table 2

Overall Change in Estimated Abundance of Salmon and Steelhead Between the Proposed Action and the No Action Alternatives in Mid-Century and Late-Century

SPECIES	ABOVE CRIM CREEK		RAINBOW FALLS TO CRIM CREEK	
	MID-CENTURY	LATE-CENTURY	MID-CENTURY	LATE-CENTURY
Spring-run Chinook salmon	-67%	-10%	-17%	0%
Fall-run Chinook salmon	-29%	-12%	-12%	-12%
Coho salmon	-47%	-15%	-9%	0%
Steelhead	-16%	-13%	0%	0%

Because the same assumptions are incorporated into the evaluation methods for both the Proposed Project and No Action alternatives, the March 31 memo (fn 10) asserts effects of the dam can be determined by subtraction of projected changes in equilibrium escapements under the No Action alternative from those of the Proposed Project. Results of this calculation are presented in Table 2. This subtraction is approximate because effects of components of the Proposed Project are confounded with other factors such as environmental change, development, and to an unknown extent restoration, some of which are described in section 5.3.3 of the EIS.

Comments & Evaluation

Although documentation of modeling for salmon is incomplete in the EIS and responses for additional information are still pending, our summary comments with respect to modeling using the EDT and Hybrid Models follow:

1. Numerous errors were identified in the salmon modeling process relied upon by the EIS, indicating lack of adequate QA/QC.
2. Despite many concerns with the EIS modeling, we concur with the fundamental conclusions of the modeling analyses that both the Proposed Project and No Action Alternative would have significant adverse impacts on Spring and Fall Chinook, Coho and Steelhead populations originating in the two spatial areas that were modeled, under the assumptions employed to perform the analyses
3. Results of modeling of the Proposed Project do not distinguish impacts of the project from those associated with climate change and stream/floodplain restoration actions.
4. We are concerned with the representation of impacts under the “No Action” Alternative. Particular concerns include: (a) inability to distinguish impacts of climate change effects, stream and floodplain restoration actions, and other assumptions that are intermixed within this alternative; (b) use of qualitative terms to compare results of the two alternatives (e.g., “similar to”); and (c) the representation that “ The No Action Alternative” represents the most likely future, including the effects of climate change, if the Proposed Project is not constructed. The implication is that the impacts under the “No Action” Alternative are inevitable or de minimis since the Proposed Project would only affect the timing of loss of salmon populations. However, this is due to the limited nature of the EIS modeling effort which does not substantively evaluate or explain:
   - The “Local Actions” Alternative.

- Effects of restoration actions that are already planned or might be taken under the ASRP.
- Impacts of potential listings under the Endangered Species Act which could substantively alter the assumptions employed for EIS modeling.
- The importance of spatial structure and diversity to the populations of the Chehalis Basin; these are extremely important concepts within the ASRP and the identification Ecological Diversity Regions within the ASRP (ASRP Steering Committee 2019).

Gaps and Omissions:

5. The failure to consider climate change effects related to alterations of atmospheric and ocean currents.
6. The analyses being centered on peak flows, which does not adequately address changes in the frequency of water flow (peak and low flows), interannual differences in temporal flow patterns, temperatures, and intensity of recurrent storm events.
7. Not accounting for increased variability and trends of precipitation patterns, changes in delta-bay (below RM 9) and marine environments.
8. A failure to quantify uncertainties and provide guidance for interpretation, including reliability of results.
9. The assumption of constant survivals in the delta-bay and marine environments when there is ample evidence of high variability.
10. Failure to consider substantively hatchery-wild or interspecies impacts
11. Impacts of alteration of biological processes that affect food webs (e.g., insects, molluscs, predation, algal blooms, etc.) on aquatic species are ignored.
12. The significance of effects of variability and uncertainty on productivity and diversity, major considerations on the ability to sustain populations or access fish for harvest (discussed in a separate white paper "Review of Evaluation of Impacts on Fish and Fisheries", complexities of freshwater or marine fisheries management, and the ability to exercise reserved treaty rights.
13. The lack of a formal population viability analyses.
14. Failure to substantively evaluate the local action alternative
15. Limitation of the population structure to populations above Crim Creek and between Rainbow Falls and Crim Creek does not account for changes in other populations originating in other subbasins.
16. The use of outdated climate science; EIS climate projections do not reflect the current state of knowledge regarding climate change
17. The impacts of the "Local Actions" alternative
18. Specific restoration or mitigation actions, even though the Cumulative Effects Discipline Report, Appendix 2, references several generic habitat improvement and restoration efforts, and development of the ASRP is well underway.
19. The effects of the extensive list of uncertainties acknowledged in the Cumulative Effect Appendix (starting at p3-2-33).

Conclusions

The information provided in the EIS does not provide a sufficient basis for thorough scientific review of the modeling procedures used to evaluate impacts on salmon. We found it necessary to request and examine additional data and information from the developers and users of the EDT and Hybrid Models, but are still left with substantial uncertainties regarding the models, methods, and parameters employed in EIS salmon modeling.

Numerous errors in modeling inputs and configuration were discovered indicating that QA/QC procedures did not provide adequate oversight. While we found the application of both the EDT Model and the Hybrid Model in the EIS to be flawed, we do not disagree that the genetic diversity and abundance of populations of Spring and Fall run Chinook, coho, and steelhead originating in the subbasins above Crim Creek and from Rainbow Falls to Crim Creek would be expected to be significantly and adversely affected by the Proposed Project in late century under the assumptions prescribed by the EIS, and particularly those occurring in conjunction with climate change and development. Also, the manner in which the EIS was framed in terms of the purpose, objective, and metrics for analysis largely predetermine results of the analyses and precludes consideration of other alternatives that could address the twin objectives of reducing flood damage and restoring aquatic species throughout Chehalis Basin.

The presentation of modeling results focuses on equilibrium spawner abundance levels and does not provide an adequate description of the significance of productivity, diversity and spatial structure, which are also of critical importance for evaluating resilience and sustainability of salmon populations. In addition, the peak-flow centric analysis of peak water flows resulted in inadequate treatment of low flows, water temperature, and effects on phenology (i.e., seasonally-related life history traits of species).

Omissions of other factors, such as consideration of variability in freshwater, estuarine, and marine environments, inter- and intra-species interactions, and lack of consideration for effects on harvest opportunities result in substantial information gaps.

Evaluation of climate change is overly simplistic and methods do not reflect current science. A more thorough evaluation of climate change is warranted because assumptions which affect model results are ingrained in the analyses of all alternatives.

We lack confidence in the validity and utility of results produced by the Hybrid Model developed to examine potential effects of stochasticity in streamflows. Numerous errors were identified in the model inputs used in the life stage projections produced by EDT and questions remain regarding how the stochasticity in streamflow years was actually modeled.

Therefore, while we agree with the EIS conclusions that there are significant impacts, we find that the modeling procedures were flawed owing to numerous errors and an apparent mismatch of linking results from a steady-state model to a multi-generational modeling component intended to model year-specific changes in streamflow characteristics. We also conclude that impacts of the Proposed Project on the affected salmonid populations are likely under-reported due to the errors in modeling and a lack of full consideration of important population performance characteristics, such as productivity, diversity, and spatial structure. Moreover, a population viability analysis of the affected populations should have been done to adequately assess effects on long-term viability. Due to the likely severity and types of impacts on population viability and structure, we conclude that the impacts would be unmitigable.

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Attachments

CVs

Gary S. Morishima
Summary Vitae

Education:

- o Ph.D. Quantitative Science & Environmental Management, University of Washington (major subjects include fisheries population dynamics, operations research, resource economics, numerical analysis, mathematical statistics)
- o B.S., Mathematics, University of Washington

Professional Experience:

- o Over forty years of experience in computer simulation modeling, natural resource management (forestry, fisheries, economics), legislative processes, policy analysis, mathematical statistics, workshop organization and conduct, conflict resolution, and meeting facilitation.
- o Technical Advisor, Natural Resources, Quinault Nation, since 1979.
- o CEO, MORI-ko L.L.C., Natural Resource Consulting Firm, since 1969
- o Affiliate Professor, University of Washington School of Environmental and Forest Sciences
- o Forest Manager, Quinault Nation, 1974-1979.
- o Ford Fellow, Center for Quantitative Science in Fisheries, Forestry, and Wildlife, University of Washington
- o Systems Analyst, Boeing Company

Current activities:

- o Pacific Salmon Commission Technical Committees (since 1985):
  - Coho (U.S. Section Chair)
  - Joint Interceptions (U.S. Section Chair, now disbanded)
  - Selective Fishery Evaluation
  - Chinook
  - Data Sharing
- o Other
  - Washington State Department of Natural Resources Carbon Sequestration Advisory Group
  - National Wildlife Health Center and the USGS Climate Adaptation Science Center Network Workgroup on Climate Change and Wildlife Health
  - National Congress of American Indians Climate Action Task Force
  - University of Oregon Landscape Carbon Sequestration for Atmospheric Recovery (LCSAR) Workgroup
  - Chehalis Basin Science Review Team
  - Intertribal Timber Council Operations Committee
  - Invited speaker at the 2020 Society for Applied Anthropology
  - Invited speaker at the 2020 North American Carbon Program Open Science Conference
  - Invited speaker at the 2020 Eighth Rising Voices Workshop (National Center for Atmospheric Research/University Corporation for Atmospheric Research)
  - Invited speaker at the 2020 University of Arizona School of Natural Resources Fall Seminar Series

Past Activities:

- o Author Team, NW Chapter Fourth National Climate Assessment, 2017.
- o Member National Academy of Sciences Review Team, State of the Carbon Cycle 2 Report, 2017.
- o Member, Washington State Governor's Chehalis Basin Task Force, 2017.
- o Member, Advisory Committee on Climate Change and Natural Resources Science, appointed by the U.S. Secretary of the Interior (2013-2016).
- o Member, Native American Policy Team, appointed by the U.S. Fish & Wildlife Service of the Department of the Interior (2013-2016).
- o Executive Board, Intertribal Timber Council (1977-2016)
- o Member, Washington State Climate Change Preparation and Adaptation Work Group.

- Member, Department of the Interior Climate Change Task Teams on Adaptation and Sequestration.
- Member, Coded Wire Tag Workgroup. Action Plan to Implement Recommendations of the CWT Expert Panel. Pacific Salmon Commission.
- Member, Expert Panel on the Future of the Coded Wire Tag Program for Pacific Salmon. Pacific Salmon Commission.
- Member, Expert Panel on Application of Genetic Stock Identification Methods to Ocean Salmon Fisheries. Pacific Salmon Commission.
- Participant, Independent Science Advisory Board, Harvest Management of Columbia Basin Salmon and Steelhead. Northwest Power and Conservation Council.
- Salmon Technical Team, Pacific Fishery Management Council (1981-2007, including past chair)
- Member, National Task Force on Tribal-Federal Relations, U.S. Forest Service (1999-2003)
- Technical Advisor, Tribal Leaders Task Force on Trust Reform (2002-2004)
- Intergovernmental Advisory Committee (appointed by the U.S. Secretary of Agriculture) to provide advice in implementing the Northwest Forest Plan (1993-2000)
- Member, Drafting Team on Secretarial Order on American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act (signed by the Secretaries of Interior and Commerce in 1999).
- Salmon & Steelhead Advisory Commission (appointed by the U.S. Secretary of Commerce), from 1982-1985.
- Various Task Forces on Indian Self-Determination and Education Assistance Act, Self-Governance, Fiscal Management systems of the Bureau of Indian Affairs, American Indian Policy Review Commission.
- Chair, Task Force for developing regulations to implement the National Indian Forest Resources Management Act.
- Policy Advisory Team for Natural Resources for former Washington State Governor Booth Gardner

Publications: List available upon request

Awards:

- National Earle Wilcox Award for Outstanding Contributions to Indian Forestry, Intertribal Timber Council
- Pride in Excellence Award, Boeing Company

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Lawrence C. Lestelle

Senior Fisheries and Aquatic Scientist

Education and Training

2006-2010
Enrolled in Ph.D. program, Fisheries Science, University of Washington

1988
Graduate, Washington Agriculture and Forestry Education Leadership Program

1978
M.S., Fisheries Science, University of Washington

1972
B.S., Fisheries Science, University of Washington

Employment History

Biostream Environmental, Principal and Sr. Scientist
2004 - Present

Mobrand Biometrics, Inc.
Sr. Biologist
1992 - 2004

MJM Research
Sr. Biologist
1991 - 1992

Quinault Indian Nation
Biologist and Program Manager
1974 - 1991

Fisheries Research Institute, University of Washington, Research Assistant
1972 – 1974

Professional Affiliations

American Fisheries Society
1976 - Present

Awards

Professional of the Year in 1989
Conservationist of the Year in 1989
Awards by the Grays Harbor Chapter of Trout Unlimited

Larry Lestelle has over 40 years of experience in salmon and aquatic resources research, management, and conservation in the Pacific Northwest. He has expertise in a wide variety of issues related to population dynamics and modeling, salmonid ecology, resource assessment and enhancement, fisheries management and environmental impacts. He was one of the lead architects of the Ecosystem Diagnosis and Treatment (EDT) Model, now widely used across the Pacific Northwest to assist managers and planners in salmon recovery and environmental impact assessment.

Habitat Modeling and EDT Design
Larry was one of the principal scientists in developing the EDT Model as part of the Mobrand Biometrics, both in regards to technical components and its application to salmon recovery planning. He formulated the biological rules that enable the model to assess species-specific responses to environmental change (species include Chinook, coho, chum, steelhead, cutthroat, and bull trout) in freshwater, estuarine, and marine environments. He has facilitated hundreds of hours of workshops and seminars on EDT applications. He has developed a variety of other fisheries and aquatic resources models, including water balance models, fisheries harvest models, and population assessment models.

Salmon Recovery Planning
Larry has had lead or supporting roles in salmon recovery planning and related population assessments aimed at numerous salmonid populations in the Pacific Northwest. These have been conducted on a wide variety of rivers throughout Washington, in Central and Eastern Oregon, and in Northern California. He has served as scientific advisor to several tribal agencies involved in recovery research and planning in their rivers (Klamath River in California and the Skokomish, Queets, Quinault, and Chehalis rivers in Washington).

Assessment of Environmental Impacts
Larry has provided key technical analysis of fisheries issues on relicensing projects on the Skokomish, Cowlitz, Deschutes (OR), and Lewis rivers, forest management and agricultural impacts in Washington, Oregon, and California, and mining impacts in Alaska and Montana. Has provided technical expertise on many other types of land use effects on fish populations, including urbanization, floodplain development, and dam operations.

Aquatic Ecology Research
Larry has planned and carried out extensive research aimed at improving understanding of salmonid ecology, effects of land uses and flow regulation on salmonid performance, and results of salmon supplementation.

Selected Projects

Review of NOAA Fisheries Life Cycle Model used in the Chehalis River Basin, WA
Principal role in a multi-year review of a new model (LCM) being built by NOAA Fisheries for the Washington Department of Fish and Wildlife for use in developing a basin-wide restoration plan for aquatic species in the Chehalis River Basin in Western Washington. As part of this review, smaller versions of the LCM were built to simulate the larger more complex model to serve in testing and evaluating modeling performance. The LCM is being developed to model the effects of various habitat scenarios on coho, spring and fall Chinook, and steelhead.

Analysis of Recovery Actions for Mid-Columbia Steelhead
Analyzed suites of recovery actions using the EDT model, including those associated with freshwater habitat, hydro, harvest, and hatcheries, for the recovery of steelhead populations in Fifteen Mile Creek, Deschutes River, John Day River, Umatilla River, and Walla Walla River. Prepared report materials to be incorporated into Oregon State's recovery plan for the affected populations.

Analysis of Recovery Actions for Grande Ronde Chinook and Steelhead
Analyzed suites of recovery actions using the EDT model, including those associated with freshwater habitat, hydro, harvest, and hatcheries, aimed at the recovery of spring chinook and steelhead populations in the Grande Ronde watershed, Oregon. Prepared summary report materials to be incorporated into NOAA's recovery plan for the affected populations.

Analysis of Effects of Changes in Regulated Flow Regimes on Salmonids in the Yakima River, WA
Developed updated biological rules for use in EDT modeling to assess effects of various alternatives for regulated flows in the mainstem Yakima River. Modifications to regulated flows were under consideration as part of potential new reservoirs (proposed Black Rock Project by U.S. Bureau of Reclamation).

Extension of EDT Rules to Estuarine and Marine Environments for Recovery Planning
Developed biological rules for analysis of ESA-listed summer chum salmon using the EDT model. The rules were developed to assess the effects of habitat conditions within estuarine and marine nearshore waters. Applied EDT modeling in developing recovery actions for summer chum in Hood Canal (part of the Puget Sound complex). Provided technical analysis to the Hood Canal Coordinating Council (lead author of the summer chum recovery plan) for updating the recovery plan.

Selected Publications and Reports

Lestelle, L.C., L.E. Mobrand, J.A. Lichatowich, and T.S. Vogel. 1996. Applied ecosystem analysis - a primer, EDT: the Ecosystem Diagnosis and Treatment Method. Project number 9404600, Bonneville Power Administration, Portland, Oregon.

Lichatowich, J., L.E. Mobrand, L. Lestelle, and T. Vogel. 1995. An approach to the diagnosis and treatment of depleted Pacific salmon populations in freshwater ecosystems. Fisheries 20(1): 10-18.

Mobrand, L.E., J.A. Lichatowich, L.C. Lestelle, and T.S. Vogel. 1997. An approach to describing ecosystem performance "through the eyes of salmon". Canadian Journal of Fisheries and Aquatic Sciences 54: 2964-2973.

Lestelle, L.C., L.E. Mobrand, and W.E. McConnaha. 2004. Information structure of Ecosystem Diagnosis and Treatment (EDT) and habitat rating rules for Chinook salmon, coho salmon, and steelhead trout. Report prepared for Northwest Power Planning Council. Mobrand Biometrics, Inc. Vashon, WA.

Lestelle, L.C., B. Watson, and G. Blair. 2006. Species-habitat rules: supporting documentation for updated flow rules for application in EDT—Supplemental report to information structure of Ecosystem Diagnosis and Treatment (EDT) and habitat rules for chinook salmon, coho salmon, and steelhead trout. Report prepared for U.S. Bureau of Reclamation. Mobrand-Jones and Stokes, Inc. Vashon, WA.

Blair, G.R., L.C. Lestelle, and L.E. Mobrand. 2009. The Ecosystem Diagnosis and Treatment model: a tool for evaluating habitat potential for salmonids. Pages 289-309 *in* E.E. Knudsen and J.H. Michael Jr. (eds.) Pacific Salmon Environment and Life History Models: Advancing Science for Sustainable Salmon in the Future. American Fisheries Society. Bethesda, MD.