Assessment of the White Salmon Watershed Using the Ecosystem Diagnosis and Treatment Model

Final Report

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Introduction

Salmon habitat models provide managers the ability to identify habitat limitations and prioritize restoration activities. Ecosystem Diagnosis and Treatment (EDT) has become a widely used tool for salmonid habitat analysis in the Pacific Northwest. The EDT model is a rule-based habitat rating system that provides reach-level diagnosis of habitat conditions for the major salmonid species of the Pacific Northwest. The EDT process itself is a complex modeling program with defined data needs. The program is a product developed by Mobrand Biometrics Incorporated (MBI) largely through funding by the Northwest Power and Conservation Council (NPCC). The NPCC had provided a free version of the program accessible through a website that required user registration.

The EDT model allows the user to rate the quality, quantity, and diversity of fish habitat along a waterway. The model uses diagnostic species such as steelhead and Chinook salmon to identify the most significant limiting factors in a river and to help identify reaches for protection and restoration. The model includes a set of tools to help organize environmental information and rate the habitat elements that pertain to specific life stages of the diagnostic species. A major benefit of EDT is that it can show the potential of a river under current conditions and possible future conditions. The result is a scientifically-based assessment of fish habitat and a prioritization of restoration needs.

The model helps to rate the quality of river habitat based on salmonid life histories. It uses rating curves to relate habitat conditions to life stage survival and capacity. These life stages are then connected to form life history trajectories (i.e., the tracing of a fish throughout its migratory course). Because habitat is described by reach (homogeneous sections of the river) and as it changes through a one-year cycle (several attributes such as flow and temperature are rated monthly), many potential trajectories can be formed. All successful trajectories are combined to estimate capacity and productivity at a population level. The range of successful trajectories is a measure of life history diversity.

Each reach of a stream has an estimated number of fish or capacity that can be supported for each life stage depending on the quantity of key habitat. For example, a certain amount of food or spawning area is available in the riffles, and pools provide rearing space for a quantifiable number of juveniles. Each habitat type, such as a pool or riffle, has characteristics that affect the survival of a life stage in that habitat. The quantity of habitat is thus measured as capacity. When capacity and survival over the course of a fish's life history is integrated, an overall capacity for the diagnostic species can be estimated as a measure of the quantity of habitat. The number of adult fish that return for each fish that spawns is a gauge of overall survival, which is directly linked with productivity and habitat quality.

The model outputs are designed to identify the potential for a river under historical conditions (prior to 1850), current conditions, and scenarios that might occur in the future. The result is a method for prioritization of restoration needs based on current conditions and inherent historic potential. Since each reach is rated separately, conditions can be critically examined along a river from the perspective of the diagnostic species. By comparing the current conditions in each reach with historic conditions, the model identifies the "restoration potential" and the "protection value" for each reach. The model output should help prioritize actions that are focused on areas with identified problems where the potential for benefit is highest.

The model incorporated 46 environmental attributes (termed Level 2 attributes) reported to affect fish survival (Table 1). A wide variety of information sources (termed Level 1 data) were used to rate the Level 2 attributes. Guidelines for rating the Level 2 attributes were available from the MBI website (http://www.mobrand.com/MBI/pdfs/AttributeRatings-Sept2004.pdf). Each attribute was rated for each reach using current (termed "patient") and historic (termed "template") conditions. Level 2 attribute scores were then combined by MBI through a set of rules, based on extensive literature reviews, into relative survivals for 16 attributes for Level 3. The rules used to combine Level 2 environmental attributes into Level 3 relative survival attributes vary by life stage of the fish.

Table 1. Organization of Level 2 Environmental Attributes by categories of major stream corridor features. Salmonid Survival Factors (Level 3) are shown associated with groups of Level 2 attributes. Associations can differ by species and life stage. (Lestelle et al. 2004).

Environmental Correlates (Level 2)		**Related Survival Factors (Level 3)**
1 Hydrologic characteristics		
1.1 Flow variation	Flow - change in interannual variability in high flows	Flow Withdrawals (entrainment)
	Flow - change in interannual variability in low flows	
	Flow - intra daily (diel) variation	
	Flow - intra-annual flow pattern	
	Water withdrawals	
1.2 Hydrologic regime	Hydrologic regime – natural	
	Hydrologic regime – regulated	
2 Stream corridor structure		
2.1 Channel morphometry	Channel length	Channel length Channel stability Channel width Habitat diversity Key habitat Obstructions Sediment load
	Channel width - month maximum width	
	Channel width - month minimum width	
	Gradient	
2.2 Confinement	Confinement – hydromodifications	
	Confinement – natural	
2.3 Habitat type	Habitat type - backwater pools	
	Habitat type - beaver ponds	
	Habitat type – glides	
	Habitat type - large cobble/boulder riffles	
	Habitat type - off-channel habitat factor	
	Habitat type - pool tailouts	
	Habitat type - primary pools	
	Habitat type - small cobble/gravel riffles	
2.4 Obstruction	Obstructions to fish migration	
2.5 Riparian and channel integrity	Bed scour	
	Icing	
	Riparian function	
	Wood	
2.6 Sediment type	Embeddedness	
	Fine sediment (intragravel)	
	Turbidity (suspended sediment)	
3 Water quality		
3.1 Chemistry	Alkalinity	Chemicals (toxic substances) Oxygen Temperature
	Dissolved oxygen	
	Metals - in water column	
	Metals/Pollutants - in sediments/soils	
	Miscellaneous toxic pollutants - water column	
	Nutrient enrichment	
3.2 Temperature variation	Temperature - daily maximum (by month)	
	Temperature - daily minimum (by month)	
	Temperature - spatial variation	

Continued.

Table 1. Continued.

4 Biological community		
4.1 Community effects	Fish community richness	Competition with hatchery fish Competition with other fish Food Harassment Pathogens Predation
	Fish pathogens	
	Fish species introductions	
	Harassment	
	Hatchery fish outplants	
	Predation risk	
	Salmonid carcasses	
4.2 Macroinvertebrates	Benthos diversity and production	

The tasks undertaken by U.S. Geological Survey's Columbia River Research Laboratory (USGS-CRRL) were designed to implement an EDT modeling process for the White Salmon River Subbasin in southeastern Washington (Columbia River Basin). This report details the resources used and steps taken to populate the EDT model for the White Salmon River up to the uppermost estimated historic distribution of the diagnostic species (steelhead trout, spring and fall Chinook salmon, and coho salmon). The outputs of the model vary depending on the data set or scenario used to generate them. A model run for a single scenario generates a large number of output graphs for each diagnostic species. Therefore, example outputs are presented in this document but not the full set of outputs. The Big White Salmon River Subbasin Plan (NPCC 2004) also analyzes and explains the results, and the entire set of outputs are available for download on the MBI website (http://www.mobrand.com/edt/home.jsp?subbasinID=2).

The success of this endeavor depended largely on a simultaneous effort, through partnership, with the Yakama Nation's Fisheries Department (YN) staff, and the Washington Department of Fish and Wildlife (WDFW). This collaboration to complete an EDT model for the White Salmon River was associated with the subbasin planning effort that occurred throughout the Columbia River basin in 2004. Although a training session and access for technical consultations with MBI were considered mandatory to the success of this task, the partnership with WDFW personnel (who had considerable experience with the model and access with MBI) made the training and access for USGS-CRRL's personnel less essential. While the principal "product" of USGS-CRRL's effort was a dataset populated with the best available information to be used for subbasin planning and future restoration scenarios, the task also enabled us to gather and condense information known about the watershed into a standardized format, which was used to populate the EDT attributes. Included in this report is a summary of the biological data used for each diagnostic species and the rationale and data sources used for each attribute (Appendix A), a list of information gathered for each attribute (Appendix B), and a list of documents reviewed for information that could be applied to the model (Appendix C).

Model inputs

Many types of information, from many sources, were identified, gathered, and organized that had potential to be used to characterize the White Salmon River watershed. Written resources with Level 1 information that could potentially be useful to rate the EDT attributes were collected, and a reference list was created (Appendix C). On December 31, 2003, this reference list was distributed via e-mail to the White Salmon River Subbasin Plan technical working group along with a request for any other potential sources of Level 1 data (Table 2). This technical working group was comprised of representatives from USGS-CRRL, Klickitat County (KC), NPCC, WDFW, YN, and consulting firms. The reference materials were then reviewed by USGS-CRRL and WDFW personnel for information to be used to rate the Level 2 attributes (Appendix B). Unprinted sources of information such as unpublished temperature data or USGS-CRRL flow data were not included in the reference materials list.

Table 2. Timeline of meetings, actions, and products completed for the White Salmon River EDT model.

Action or product	Date completed
River survey by raft from BZ Falls to Northwestern Lake with YN and USGS-CRRL- river overview and reach break discussions.	9/18/03
Meeting at CRRL with WDFW and USGS-CRRL to establish reach breaks and potential spawning distributions.	12/11/03
References of existing EDT attribute information largely collected.	12/30/03
Field data collected by USGS-CRRL and WDFW such as: habitat types, reach breaks, large woody debris counts, minimum and maximum widths, etc.	12/18/04 and 12/23/04
Reach breaks defined and distributed via e-mail to the Subbasin Plan technical working group (YN, WDFW, KC, and NPCC).	12/14/03
Reference list compiled and distributed for review and comment to the Subbasin Plan technical working group.	12/31/03

Table 2. Timeline of meetings, actions, and products completed for the White Salmon River EDT model.

Action or product	**Date completed**
Meeting at CRRL discussing EDT attribute information sources and values to be entered with YN, KC, WDFW, and USGS-CRRL.	1/20/04
GIS coverage of reach breaks distributed via e-mail to the Subbasin Plan working group.	2/20/04
References reviewed and EDT attribute ratings entered into the model based on existing information and field data collected by USGS-CRRL and WDFW.	1/04 through 3/04
EDT rankings discussed with USGS-CRRL, YN, WDFW, KC, and NPCC.	3/22/04
Stream Reach Editor with data entered and a document describing rationale for ranking distributed to the Subbasin Plan working group for review and comment.	3/27/04
GIS coverage of White Salmon watershed compiled and distributed to YN and WDFW.	4/1/04
Preliminary model runs completed by WDFW.	4/12/04
Preliminary EDT outputs presented and discussed with USGS-CRRL, YN, WDFW, KC, and NPCC.	4/13/04
Presentation made by USGS-CRRL to the White Salmon River Watershed Management Council discussing the EDT model, its parameters and progress.	4/26/04
Documentation of data sources and rationales used for EDT attribute ratings completed and incorporated into the White Salmon Subbasin Plan, Appendix F.	5/10/04
Two public meeting held with local watershed groups, community councils, county and state representatives invited by USGS-CRRL to provide feedback to attribute ratings and request additional refinement of the ratings.	11/17/04 and 11/22/04

Although the original intent of gathering information for the EDT attributes was to apply pre-existing data, some data gaps were filled with a small field effort. To accomplish this, WDFW and USGS-CRRL collaborated to collect field data on the mainstem of the White Salmon River from BZ Falls to Northwestern Lake and from representative sections of the tributaries Mill, Spring, and Buck creeks. This occurred during low flow conditions on December 18 and December 23, 2003. The information that was collected filled data gaps for attributes such as habitat type, low-flow stream width, bankfull width, woody-debris counts, confinement, hydroconfinement, and riparian function. Extensive field data concerning those attributes had already been collected from 2001 through 2003 by USGS-CRRL on Rattlesnake and Indian creeks as part of a separate Bonneville Power Administration-funded project titled "Assess current and potential salmonid production in Rattlesnake Creek associated with restoration efforts" (Connolly 2003).

An important part of the USGS-CRRL's duties was to assemble and query technical experts and knowledgeable watershed stakeholders. Several meetings with the White Salmon River Subbasin Plan technical working group occurred to ensure that available information and that the best expert evaluations were represented in the data to be used in the model (Table 2). Washington Department of Fish and Wildlife (WDFW) and USGS-CRRL collaborated extensively to populate the model with the available information and make model runs in time to be incorporated into the White Salmon River Subbasin Plan. Diagnostic fish species were selected from the limited array of anadromous salmonids that would have historically inhabited the White Salmon River. These species were: steelhead, coho salmon, fall Chinook and spring Chinook salmon. For more information on the diagnostic species population definitions and spawning distributions, see the Big White Salmon Subbasin Plan (NPCC 2004) and Appendix A of this report. Meetings at CRRL with WDFW and USGS established reach breaks (to separate the river into "environmentally homogenous" sections) and spawning distributions for the diagnostic fish species on December 11, 2003 (Table 3). A geographic information system (GIS) map layer of the reach breaks was distributed for review via e-mail to the White Salmon River Subbasin Plan technical working group. This information was also discussed in a meeting at CRRL on January 20, 2004. (See Appendix A for a more detailed description of the determination of reaches and spawning distributions of the diagnostic species used in the model.)

After USGS-CRRL and WDFW collaborated to develop the attribute ratings for each reach, a meeting with the Subbasin Plan technical working group was held on March 22, 2004 to present and review the data and rationale used to rate the model attributes, as well as the life history patterns for life stages of the diagnostic species. During the meeting, some clarifications and small adjustments to the ratings and rationales were discussed. A draft document describing rationale for ranking, similar to Appendix A, and a completed Stream Reach Editor (MBI's Microsoft Access database, which is used to input "patient" and "template" attribute values and reach specific comments) was distributed to the Subbasin Plan technical working group for review and comment on March 27, 2004.

Several meetings were held with watershed stakeholders to discuss the EDT model and attribute ratings. An introductory presentation was given by USGS-CRRL on April 26, 2004 in

Trout Lake, WA to the White Salmon River Watershed Management Council discussing the EDT model, parameters, and process. Additionally, local watershed groups, community councils, and county and state representatives were invited, by USGS-CRRL, to provide feedback to attribute ratings and request additional refinement of the ratings during two public meetings held on November 17, 2004 and November 22, 2004 in White Salmon, WA.

Current status

As of January 2005, the EDT model attributes have been researched, documented, entered into the stream reach editor, a GIS layer defining the reaches for the model has been created, and several EDT datasets for the White Salmon River have been produced (Figure 1, Table 2). The dataset that USGS-CRRL collaborated with WDFW and YN to produce, titled “Current without Harvest”, describes Condit Dam and its reservoir in the “patient” dataset as it currently exists. The dataset registered by WDFW on the MBI website, titled “BigWhite Removal4_21_04”, contains changes to attributes in the reservoir and downstream reaches that describe the White Salmon River with Condit Dam removed and given time for those reaches to adjust to an equilibrium (about 20 years post-removal). This dataset is readily available for download from the MBI website (http://www.mobrand.com/edt/home.jsp?subbasinID=2), and the attributes that have been changed in each reach were largely evident and noted in the comments portion of the stream reach editor. Appendix A of this report does not describe the changes made to the dataset that is registered. However, all of the “template” attributes and rationales remained the same, and the majority of “patient” attributes remained the same when comparing the two datasets. Appendix A describes the rationales and information used to populate the model, which was the primary task for USGS-CRRL. The “BigWhite Removal4_21_04” dataset was produced by WDFW to aid in the analysis used for the subbasin planning process. We will present and discuss the results of the registered dataset below, because these were the results available to the public.

Any alterations in the dataset to describe the White Salmon River with Condit Dam removed were done by WDFW. While many of the changes to describe the removal scenario were straightforward and reasonable, the changes, and the rationale for those changes, will not be described here, because USGS-CRRL was not involved in that effort. However, in general, the

WS11 reach was used as a guideline for altering the relevant attributes in the reservoir reaches. The WS11 reach is a lower mainstem reach that is confined in a basalt canyon; much like the pre-reservoir reaches appear to have been. To describe the removal scenario, changes in the reaches below Condit Dam took into account changes in flow and sediment, among others, that would occur after dam removal and an equilibrium has been re-established. Because of the unknown status of historic fish access into Little Buck and Mill creeks, WDFW assumed they would be inaccessible and removed these creeks in the model runs described here.

Another dataset was created with the habitat attributes rated in a way that would be considered “properly functioning conditions” (PFC) using the MBI scenario builder. Created originally by the Bureau of Land Management, PFC is a concept designed to assess the natural habitat-forming processes of riparian and wetland areas (Pritchard et al. 1998). Although less favorable than the template conditions when these habitat-forming processes are functioning properly, it can be assumed that environmental conditions are suitable to support productive populations of native anadromous and resident fish species. The MBI scenario builder translates the PFC concept into a set of EDT Level 3 attribute ratings that define a PFC environmental condition relevant to anadromous salmonids within Pacific Northwest streams. This scenario was not available on the MBI website at the time of this writing.

Preliminary runs of the model by WDFW, including some alternate scenarios such as dam removal, were completed on April 12, 2004. The outputs from those runs were discussed with the technical working group on April 13, 2004. Results from the preliminary runs of the model and some alternate scenarios were used to help guide portions of the White Salmon River Subbasin Plan prepared for the NPCC in 2004. These outputs were well described in the White Salmon River Subbasin Plan, which is currently available on the internet as a draft document (http://www.nwppc.org/fw/subbasinplanning/bigwhitesalmon/).

During the subbasin planning process, the EDT program was accessible largely because of funding by the NPCC. Prior to this, MBI required a fee for each model run, and the model was not available on the internet. However, subbasin planning support has ended and MBI now requires an annual fee to maintain the dataset on their website. As of this writing, the “BigWhite Removal4_21_04” dataset is registered on the MBI website and any changes to the model have to go through the watershed administrator (Dan Rawding, WDFW). Access to the model for updating attributes or evaluating scenarios is restricted until funding to MBI for support, backup, and upkeep of the model is available (~ $3000/year).

Because access to the model has been restricted and the model is not available for updating, USGS-CRRL was not able to correct typographical errors (all of those detected were minor), was not able to update the model (attribute-specific suggestions are included in Appendix A), was not able to conduct initial diagnostic model runs, and was not able to conduct additional alternative scenario runs. This situation limited our ability to collaboratively interpret output with technical staff at Yakama Nation's Fisheries Department, and did not allow conducting model runs to provide information on sensitivity of the output and potential alternative management scenarios. However, some initial diagnostic model runs and additional alternative scenario runs were done by WDFW for the subbasin planning process. A discussion of these results is available in this document and in the Big White Salmon River Subbasin Plan (NPCC 2004).

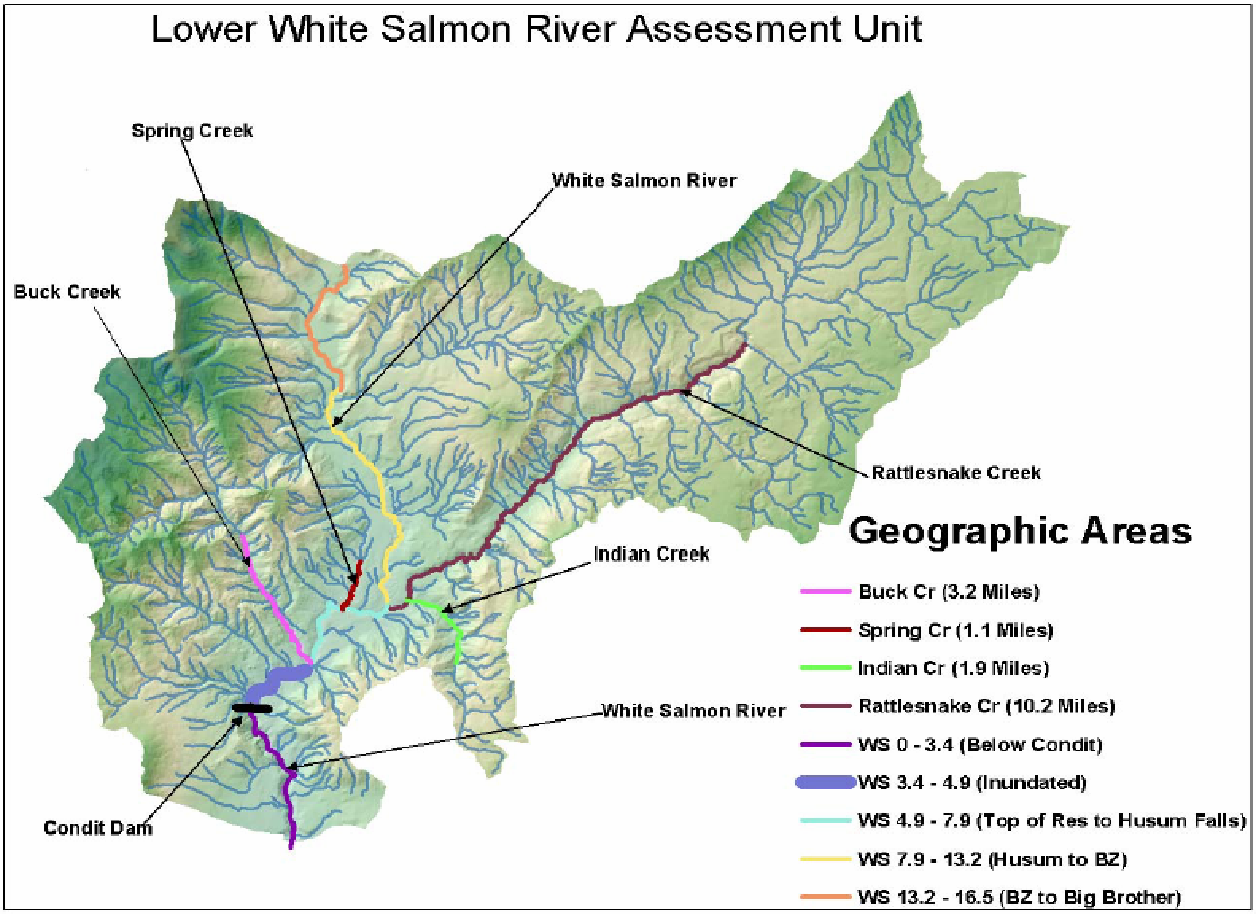


Figure 1. Map of geographic areas used in the EDT analysis of the White Salmon River, WA. From the White Salmon River Subbasin Plan (NPCC 2004).

Table 3. White Salmon River EDT reach breaks, descriptions, and lengths.

Reach name	Description	River miles	Length (mi)	Geographic area (river miles)
B1	Buck Creek mouth to diversion intake	(0.0 – 2.0)	2.0	Buck Creek
B2	Diversion intake to Buck Creek Falls 1	(2.0 - 3.2)	1.2	(0.0 - 3.2)
B3	Buck Creek Falls 1 to Buck Creek Falls 2	(3.2 – 4.0)	0.9	
B4	Buck Creek Falls 2 to end of anadromous distribution	(4.0 - 4.2)	0.2	
I1	Indian Creek mouth to Indian Creek culvert 1	(0.0 - 0.1)	0.1	Indian Creek
I2	Indian Creek culvert 1 to Indian Creek culvert 2	(0.1 - 0.8)	0.8	(0.0 - 1.9)
I3	Indian Creek culvert 2 to Indian Creek culvert 3	(0.8 - 1.1)	0.3	
I4	Indian Creek culvert 3 to Indian Creek culvert 4	(1.1 - 1.2)	0.1	
I5	Indian Creek culvert 4 to end of anadromous distribution	(1.2 - 1.9)	0.8	
LB1	Historic Little Buck Creek mouth to top of reservoir	(0.0 - 0.1)	0.1	Little Buck Creek
LB2	Top of reservoir to reach break	(0.1 – 1.0)	0.8	(0.0-2.2)
LB3	Reach break to end of anadromous distribution	(1.0 - 2.2)	1.2	
M1	Historic Mill Creek mouth to top of reservoir	(0.0 - 0.2)	0.2	Mill Creek
M2	Top of reservoir to Mill Creek culvert 1	(0.2 - 0.4)	0.2	(0.0-1.9)
M3	Mill Creek culvert 1to Mill Creek culvert 2	(0.4 - 1.1)	0.7	
M4	Mill Creek culvert 2 to end of anadromous distribution	(1.1 - 1.9)	0.9	
R1	Rattlesnake Creek mouth to Indian Creek confluence	(0.0 - 0.5)	0.5	Rattlesnake Creek
R2	Indian Creek confluence to Rattlesnake Creek Falls 1	(0.5 - 1.6)	1.2	(0-10.2)
R3	Rattlesnake Creek Falls 1 to end of confinement	(1.6 - 3.3)	1.6	
R4	End of confinement to upper confinement	(3.3 - 6.6)	3.3	
R5	Upper confinement to Rattlesnake Creek Falls 2	(6.6 - 10.2)	3.6	
R6	Rattlesnake Creek Falls 2 to end of anadromous distribution	(10.2 - 10.5)	0.4	
S1	Spring Creek mouth to dam	(0.0 - 0.7)	0.7	Spring Creek
S2	Pond behind Spring Creek dam	(0.7 - 0.8)	0.1	(0-1.1)
S3	Top of Spring Creek Pond to forks	(0.8 - 1.1)	0.3	
WS1	Mouth to first riffle-end of Bonneville Dam pool influence	(0.0 - 1.2)	1.2	Below Condit Dam
WS2	End of Bonneville Dam pool influence to Condit Powerhouse	(1.2 - 2.1)	0.9	(0 - 3.4)
WS3	Condit Powerhouse to Steelhead Falls	(2.1 - 2.7)	0.6	
WS4	Steelhead Falls to Condit Dam	(2.7 - 3.4)	0.7	
WS5	Condit Dam to Little Buck Ck.	(3.4 - 3.6)	0.2	Inundated
WS6	Little Buck Creek to Mill Creek	(3.6 - 4.1)	0.5	(3.4 - 4.9)
WS7	Mill Creek to end of deep reservoir	(4.1 - 4.9)	0.8	
WS8	End of deep reservoir to Buck Creek	(4.9 - 5.1)	0.2	Top of Reservoir
WS9	Buck Creek to Sandy Beach (first riffle)	(5.1 - 5.6)	0.5	to Husum Falls
WS10	Sandy Beach (first riffle) to Spring Creek	(5.6 - 6.8)	1.2	(4.9 - 7.9)
WS11	Spring Creek to Deadman's Corner	(6.8 - 7.5)	0.7	
WS12	Deadman's Corner to Rattlesnake Creek	(7.5 - 7.8)	0.3	
WS13	Rattlesnake Creek to Husum Falls	(7.8 - 7.9)	0.2	
WS14	Husum Falls to Sunshine (Big) Eddy	(7.9 - 9.9)	2.0	Husum to BZ
WS15	Sunshine (Big) Eddy to Diversion Hole	(9.9 - 10.3)	0.4	(7.9 - 13.2)
WS16	Diversion Hole to BZ Falls	(10.3 - 13.2)	2.9	
WS17	BZ Falls to Double Drop Falls	(13.2 - 14.4)	1.2	BZ to Big Brother
WS18	Double Drop Falls to Big Brother Falls	(14.4 - 16.5)	2.1	(13.2 - 16.5)

Representative outputs

A description of representative outputs are presented and explained below. For a complete set of outputs, the reader can download the full output report from http://www.mobrand.com/edt/home.jsp?subbasinID=2. For additional discussion of the results of the EDT modeling process and additional discussion of the diagnostic fish species used in the model the reader can refer to Big White Salmon Subbasin Plan (NPCC2004).

Baseline Outputs

After the reaches for the White Salmon Subbasin had been established and portrayed in terms of Level 2 attributes, preliminary model runs of each dataset were made. These runs were made for each scenario and diagnostic fish species. There were several reports (i.e., outputs) generated from a model run. One of the coarse scale or baseline outputs, termed “report 1”, generates results for both smolts and adults. The “report 1” output displays population performance parameters, which were described in the introduction (productivity, capacity, equilibrium abundance, and life history diversity). Separate outputs were generated for the “patient”, and the “template” conditions of the scenario describing the watershed.

Outputs in “report 1” were generated for adult coho, fall Chinook, spring Chinook, and steelhead (Figure 2). The historic potential (“template”) condition and the “patient” conditions were titled “current without harvest” (Condit Dam in place, without accounting for harvest of any of the species), “dam removal” scenario, and “dam removal with PFC” scenario, which are described above. Essentially, the population performance parameters improved as the modeled conditions changed from the “current without harvest”, to “dam removal”, to “dam removal with PFC”, and then to “historic potential”.

The anomalous model results indicating that fall Chinook would have higher abundance with any of the other conditions compared to the “historic potential” condition can be attributed to several factors. As described in Appendix A, the model did not allow spring and fall Chinook to have overlapping spawning distributions. For the historic condition, the uppermost spawning reach of fall Chinook was set at WS5, which is 0.2 miles upstream of Condit Dam at the confluence with Little Buck Creek. Therefore, the historic and dam-removal scenarios only add 0.2 miles more potential spawning habitat than the “current without harvest” condition. In reality the spawning distribution of the two races of Chinook would likely overlap, with fall Chinook most likely spawning up to Husum Falls (an additional 4.4 miles of mainstem habitat). This additional spawning area would increase the fall Chinook abundance for the "dam removal" and "dam removal with PFC" scenarios.

In all but the "historic potential" scenario, Bonneville Dam inundates the lowest reaches of the White Salmon River, creating a pool that adds additional juvenile rearing habitat when compared with historic conditions. With Condit dam in place, the rating for bed scour was reduced in the bypass reaches (WS3 and WS4) where fall Chinook could spawn (NPCC 2004). The modeling suggests that these factors combine to increase fall Chinook abundance when Bonneville Dam and Condit Dam were in place compared to the historic condition. However, the model may not have adequately accounted for the reduced amount of appropriate spawning substrate in the reaches below Condit Dam, therefore over estimating the "current without harvest" condition.

While these estimates have some meaning, their main value was in troubleshooting by determining the reasonableness of the outcome and therefore appropriateness of the way the populations and their habitat have been described. It should be recognized that EDT outputs represent an equilibrium state, representing average habitat and climate conditions. The EDT productivity parameter is an estimated maximum productivity for average environmental conditions, therefore observed productivity may be notably less. This is also true for the capacity parameter. Therefore, abundance is the most appropriate performance parameter for assessing output accuracy, because it integrates productivity and capacity (Mobrand 2002). The lack of long-term assessment of anadromous salmonid abundance in the White Salmon River, and the lack of access for anadromous fish above Condit Dam makes it difficult to assess the "reasonableness" of the outcome. However, in other basins within the Lower Columbia River and the Columbia River Gorge Provinces, the EDT estimates of smolt and/or adult performance have been reasonably close to empirical estimates from WDFW population estimates (NPCC 2004). Since a similar approach was used in the White Salmon River, this suggests that the predicted performance of salmon and steelhead in the basin should be reasonable.

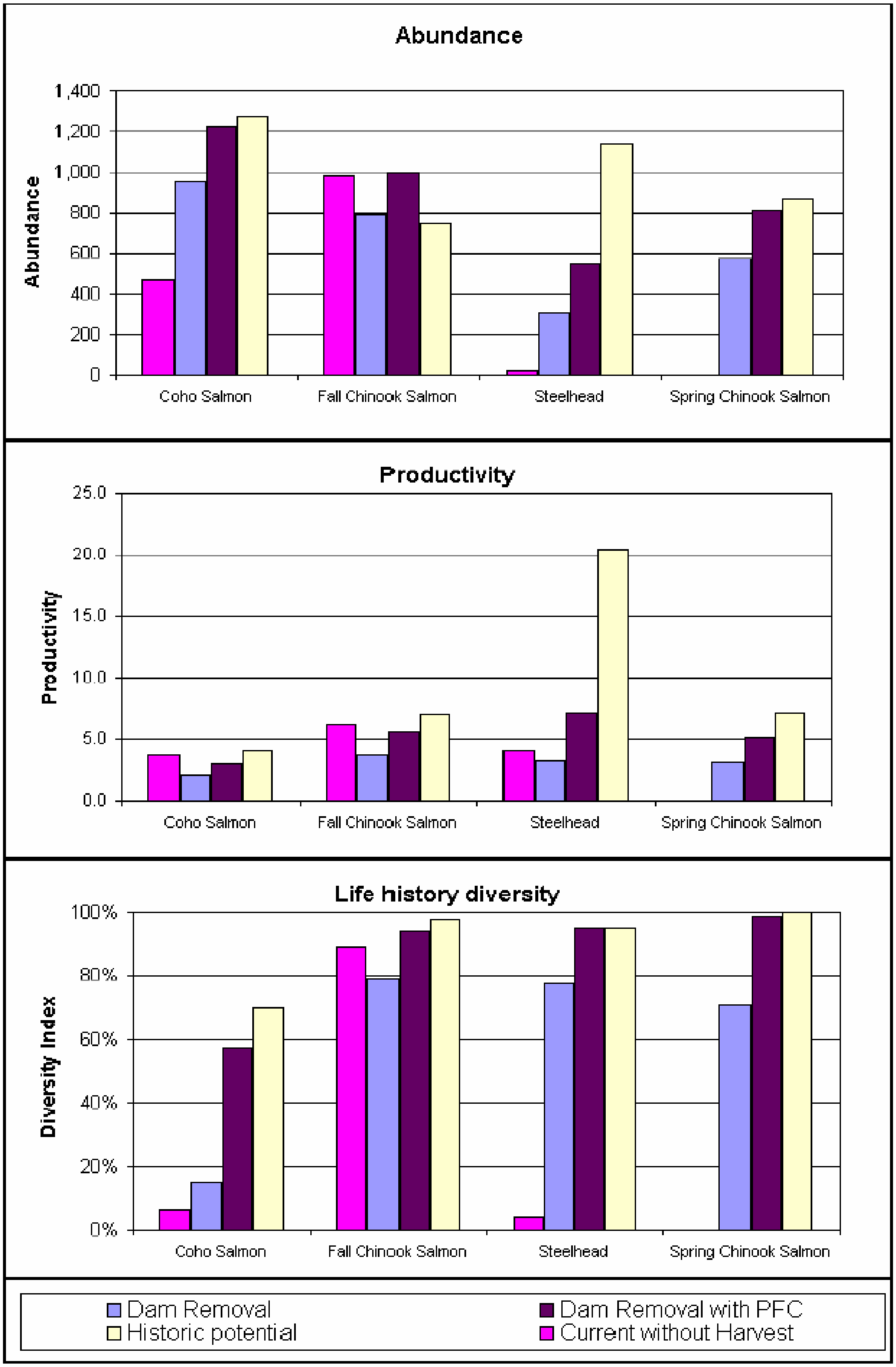


Figure 2. A summary of EDT performance parameters for each diagnostic species from report 1 outputs for historic potential, current conditions and possible future scenarios in the White Salmon River, WA. PFC = properly functioning condition. Figure from White Salmon River Subbasin Plan (NPCC 2004).

Diagnostic outputs

Geographic area priorities

An EDT model run produces outputs with information specific to each diagnostic fish species for each reach. These outputs are generated for the reach scale and/or geographic-area scale, and are labeled “report 2”. The geographic-area scale essentially lumps individual reaches into a user-specified geographic area for ease of presentation. In the White Salmon River, each tributary was designated as a separate geographic area, and adjacent mainstem sections with similar characteristics were also separate geographic areas (Table 3, Figure 1, and Figure 3). Reach-scale analysis takes into account the same performance parameters for salmonid populations as the baseline output, but it provides a greater level of detail by identifying reaches based on their relative protection and restoration value. Because the habitat requirements are different for each fish species, the results of reach analyses are specific to each fish species.

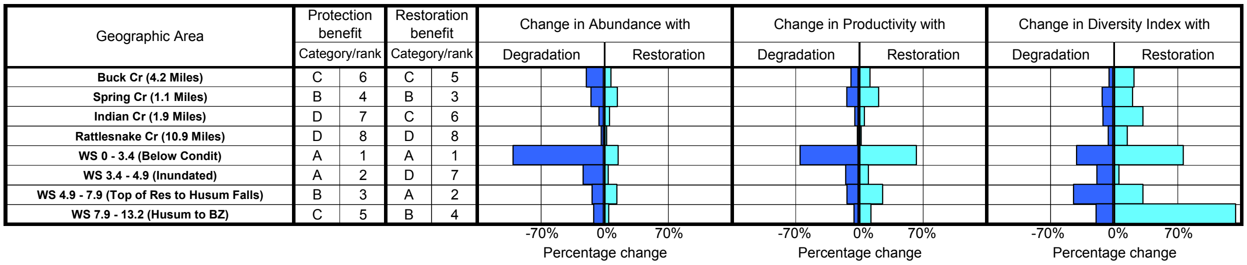
One of the outputs from the “report 2” is called the “tornado” or “ladder” diagram (Figures 3-8). The tornado diagram lists reaches that can be prioritized by “protection benefit” and “restoration benefit”. Protection benefit is the degree to which the performance parameters of a population are supported by a specific reach or geographic area. In other words, protection benefit indicates the estimated reduction in population performance if that reach or geographic area’s habitat conditions were degraded. Restoration potential is the increase in performance a population would experience if a single reach or geographic area were restored to historical conditions (Mobrand 2004).

The model can sort the reaches in the tornado diagrams by ranking the reaches’ importance to the diagnostic species averaged across all performance parameters (Figures 5-8). This report displays where protection and restoration efforts would benefit the diagnostic species the most. Some reaches can have high restoration and high preservation potential. Although this may seem contradictory, it actually indicates that these reaches are highly productive and have a larger effect on population performance than reaches with less restoration or preservation benefit. The diagrams shown in this report include reach length with the ranking, so consideration should be taken that longer reaches may inherently be ranked higher. Working with MBI, these results can be normalized by 1000 m of reach length (not currently available). It should also be noted that areas lower in the watershed have the most life history trajectories, and are therefore inherently ranked higher for both restoration and preservation benefit.

With the exception of the dam on Spring Creek (Sdam) between reaches S1 and S2, the culverts, falls, diversions, and dams were shown to have no restoration or protection benefit in the ladder diagrams. This was an artifact of the modeling effort for several reasons. One was because the model considers culverts and other possible barriers to be reaches with no length. Another reason was that the level of blockage at the potential fish barriers was unknown; so they were rated as 100% passable by all species and life stages. The exception was the Sdam reach, which was rated as 100% impassable. In Figures 4, 5, and 8 the S2 and S3 reaches also are shown to have no protection or restoration benefit. This was because the Sdam barrier was rated as not passable, so coho or steelhead can not inhabit those reaches. This gave those reaches no protection or restoration benefit for the fish that could potentially inhabit them. Obtaining and entering barrier passage information into the model would increase the accuracy of these outputs. Until then, the ranking of culverts and barriers, and reaches upstream of impassable culverts and barriers, should be viewed with caution.

Big White Salmon Coho

Relative Importance Of Geographic Areas For Protection and Restoration Measures



Geographic Area	Protection benefit		Restoration benefit	
	Category/rank		Category/rank	
Buck Cr (4.2 Miles)	C	6	C	5
Spring Cr (1.1 Miles)	B	4	B	3
Indian Cr (1.9 Miles)	D	7	C	6
Rattlesnake Cr (10.9 Miles)	D	8	D	8
WS 0 - 3.4 (Below Condit)	A	1	A	1
WS 3.4 - 4.9 (Inundated)	A	2	D	7
WS 4.9 - 7.9 (Top of Res to Husum Falls)	B	3	A	2
WS 7.9 - 13.2 (Husum to BZ)	C	5	B	4

Figure 3. The relative restoration and preservation value of geographic areas in the White Salmon River subbasin based on EDT population performance parameters for coho salmon. The registered dataset (BigWhite Removal4_21_04) was used to generate this output. All culverts and barriers were rated with 100% passage, except for the dam on Spring Creek between reaches S1 and S2.

The ladder diagrams for coho salmon indicate that protection and restoration of habitat, particularly in the mainstem reaches below Condit Dam, but also in the reaches from the top of the reservoir to Husum Falls, would have a high benefit to the species (Figures 3–5). This is most likely due to the large pools in these areas. All trajectories for coho life history pass through the reaches below Condit Dam, which increases the preservation benefit of those reaches. The protection and restoration of lower reaches of Buck and Spring creeks was also indicated to be a high priority to benefit the species. In general, the model output suggests that opportunities to enhance habitat quality (productivity) and life history trajectories through restoration are greater than opportunities for enhancing abundance through restoration.

The WS2 reach was found to have the highest protection and restoration benefit to fall Chinook (Figure 6). This reach was shown to have substantial opportunity for increased productivity through restoration. It is important to remember that we modeled the uppermost fall Chinook spawning distribution only up through WS5, because the model does not allow overlap between fall and spring Chinook. Most likely there would be overlap up to Husum Falls, therefore the reaches upstream of Condit Dam are likely more important than the model indicated.

The ladder diagrams for Spring Chinook showed that many of the mainstem reaches from the top of the reservoir up to BZ Falls have high protection values (Figure 7). The model indicated that tributaries tend to have more restoration benefit, with the lowermost reach in Buck Creek having the highest restoration benefit for the species. The results were similar for steelhead: the mainstem reaches below BZ Falls were shown to have high protection benefits, and the tributaries (particularly Rattlesnake Creek and lower Buck Creek) were shown to have high restoration benefits (Figure 8).

Big White Salmon Coho

Relative Importance Of Geographic Areas For Protection and Restoration Measures

Geographic Area	Protection benefit		Restoration benefit	
	Category/rank		Category/rank	
WS1_A	A	4	A	1
WS1_B	C	11	B	8
WS2	A	1	A	2
WS3	A	3	B	7
Steelhead_Falls	E	23	E	26
WS4	A	2	B	10
Condit_Dam	E	23	E	26
WS5	D	14	E	22
WS6	B	7	C	16
WS7	B	5	D	18
WS8	E	18	D	19
WS9	D	12	B	5
WS10	A	3	A	3
WS11	D	13	D	20
WS12	D	13	B	9
WS13	E	17	C	13
Husum_Falls	E	23	E	26
WS14	B	6	B	4
WS15	E	19	E	23
WS16	C	10	B	6
B1	C	9	B	11
Bdiv	E	23	E	26
B2	D	16	D	18
S1	C	8	C	15
Sdam	E	23	B	11
S2	E	23	E	26
S3	E	23	E	26
R1	E	18	C	12
R2	D	16	E	21
I1	E	21	E	25
ICulv1	E	23	E	26
I2	D	15	C	14
ICulv2	E	23	E	26
I3	E	22	E	23
ICulv3	E	23	E	26
I4	E	20	E	24
ICulv4	E	23	E	26
I5	E	18	D	17

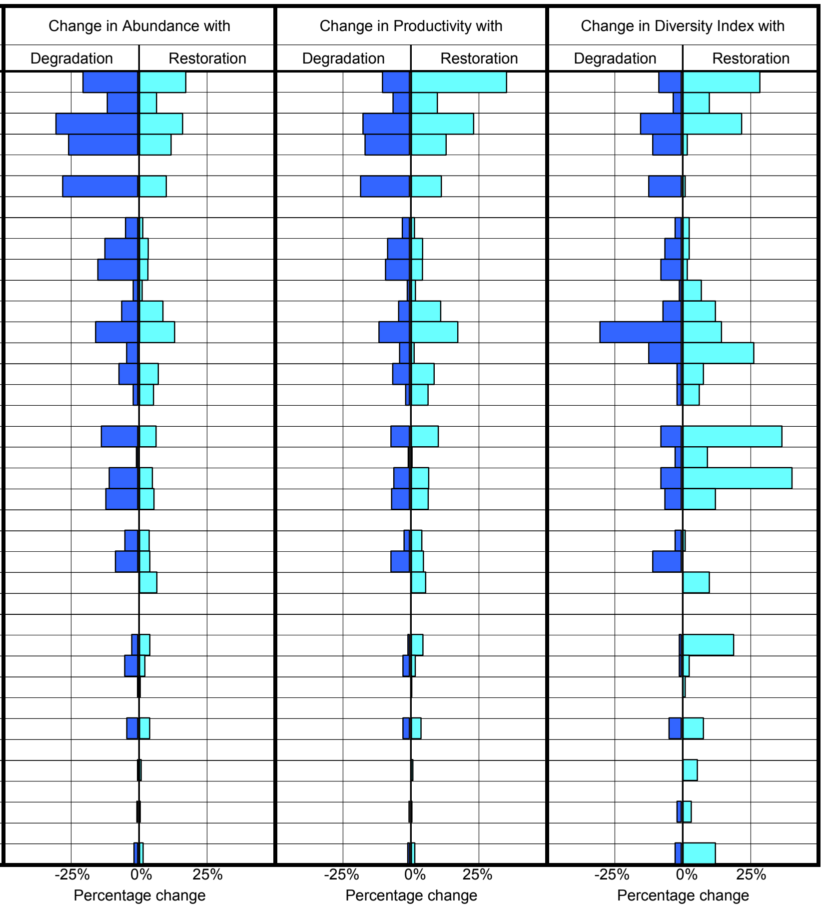


Figure 4. The relative restoration and preservation value of each reach in the White Salmon River subbasin based on EDT population performance parameters for coho salmon. The registered dataset (BigWhite Removal4_21_04) was used. All culverts and barriers were rated with 100% passage, with the exception of the dam on Spring Creek between reaches S1 and S2.

Big White Salmon Coho

Relative Importance Of Geographic Areas For Protection and Restoration Measures

Geographic Area	Protection benefit		Restoration benefit	
	Category/rank		Category/rank	
WS2	A	1	A	2
WS1_A	A	4	A	1
WS10	A	3	A	3
WS14	B	6	B	4
WS3	A	3	B	7
WS4	A	2	B	10
WS16	C	10	B	6
WS9	D	12	B	5
WS1_B	C	11	B	8
B1	C	9	B	11
WS12	D	13	B	9
S1	C	8	C	15
WS6	B	7	C	16
WS7	B	5	D	18
I2	D	15	C	14
R1	E	18	C	12
WS13	E	17	C	13
WS11	D	13	D	20
B2	D	16	D	18
Sdam	E	23	B	11
I5	E	18	D	17
WS5	D	14	E	22
R2	D	16	E	21
WS8	E	18	D	19
WS15	E	19	E	23
I4	E	20	E	24
I3	E	22	E	23
I1	E	21	E	25
Bdiv	E	23	E	26
Condit_Dam	E	23	E	26
Husum_Falls	E	23	E	26
ICulv1	E	23	E	26
ICulv2	E	23	E	26
ICulv3	E	23	E	26
ICulv4	E	23	E	26
S2	E	23	E	26
S3	E	23	E	26
Steelhead_Falls	E	23	E	26

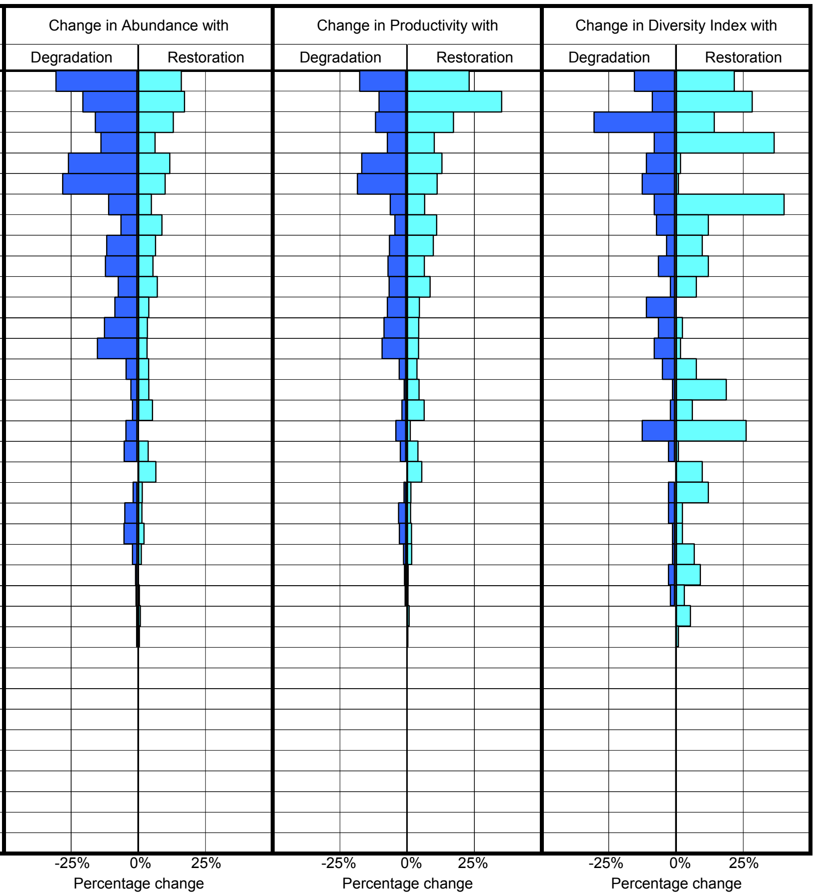
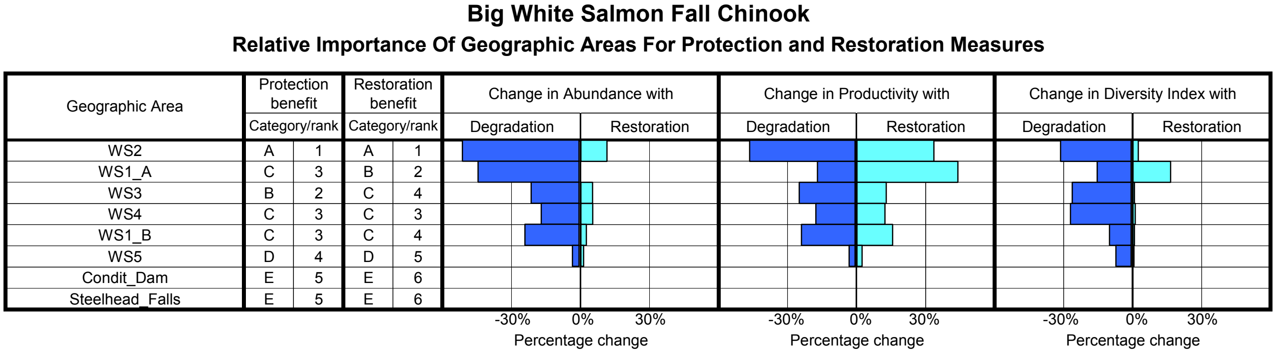
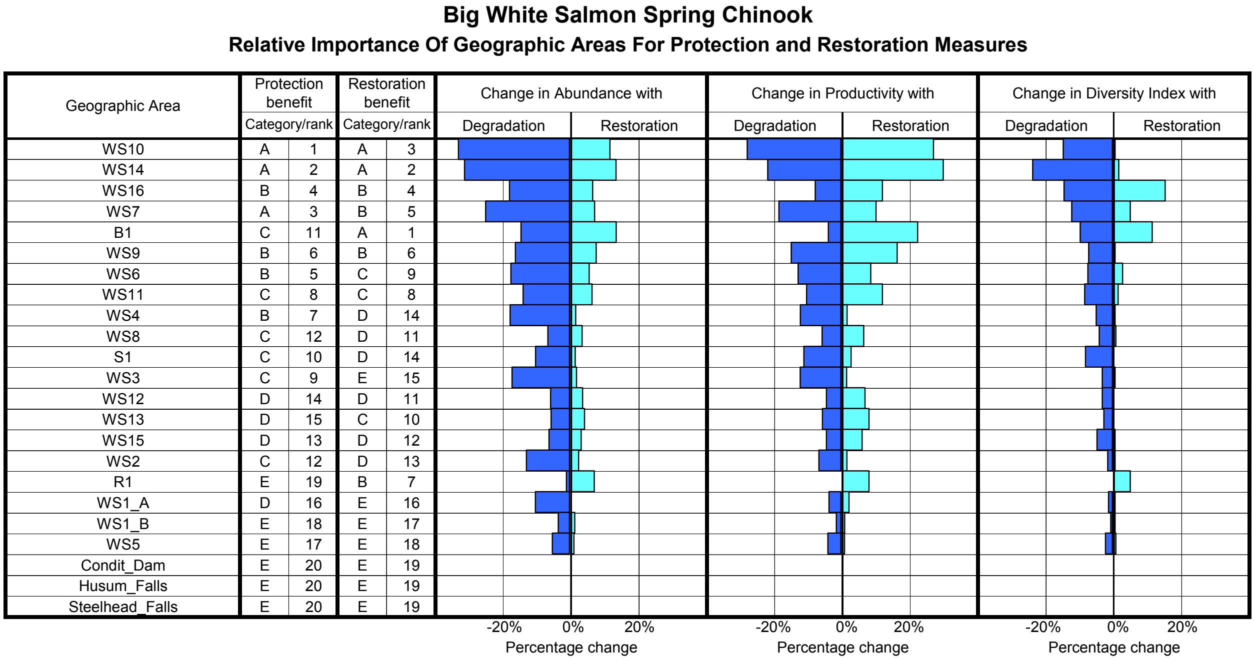


Figure 5. The relative restoration and preservation value of each reach, sorted by the average rank of the protection and restoration benefit combined, in the White Salmon River subbasin based on EDT population performance parameters for coho salmon. The registered dataset (BigWhite Removal4_21_04) was used. All culverts and barriers were rated with 100% passage, with the exception of 0% passage for the dam on Spring Creek between reaches S1 and S2.



Geographic Area	Protection benefit		Restoration benefit	
	Category/rank		Category/rank	
WS2	A	1	A	1
WS1_A	C	3	B	2
WS3	B	2	C	4
WS4	C	3	C	3
WS1_B	C	3	C	4
WS5	D	4	D	5
Condit_Dam	E	5	E	6
Steelhead_Falls	E	5	E	6

Figure 6. The relative restoration and preservation value of each reach, sorted by the average rank of the protection and restoration benefit combined, in the White Salmon River subbasin based on EDT population performance parameters for fall Chinook salmon. The registered dataset (BigWhite Removal4_21_04) was used. All culverts and barriers were rated with 100% passage.



Geographic Area	Protection benefit		Restoration benefit	
	Category/rank		Category/rank	
WS10	A	1	A	3
WS14	A	2	A	2
WS16	B	4	B	4
WS7	A	3	B	5
B1	C	11	A	1
WS9	B	6	B	6
WS6	B	5	C	9
WS11	C	8	C	8
WS4	B	7	D	14
WS8	C	12	D	11
S1	C	10	D	14
WS3	C	9	E	15
WS12	D	14	D	11
WS13	D	15	C	10
WS15	D	13	D	12
WS2	C	12	D	13
R1	E	19	B	7
WS1_A	D	16	E	16
WS1_B	E	18	E	17
WS5	E	17	E	18
Condit_Dam	E	20	E	19
Husum_Falls	E	20	E	19
Steelhead_Falls	E	20	E	19

Figure 7. The relative restoration and preservation value of each reach, sorted by the average rank of the protection and restoration benefit combined, in the White Salmon River subbasin based on EDT population performance parameters for spring Chinook salmon. The registered dataset (BigWhite Removal4_21_04) was used. All culverts and barriers were rated with 100% passage.

Big White Salmon Steelhead

Relative Importance Of Geographic Areas For Protection and Restoration Measures

Geographic Area	Protection benefit		Restoration benefit	
	Category/rank		Category/rank	
WS16	A	2	A	4
B1	B	6	A	2
WS14	A	3	A	5
WS10	A	1	B	9
R5	C	11	A	1
WS7	B	4	B	8
R4	C	10	A	3
WS4	B	5	C	13
WS9	B	7	C	13
WS18	C	13	B	8
WS3	C	9	C	12
WS11	C	8	C	14
R3	D	17	B	6
WS17	C	12	C	11
R2	D	16	B	8
WS15	C	14	C	14
WS6	C	13	D	16
B2	E	23	B	7
WS2	C	15	D	16
WS1_A	D	22	C	10
R1	E	24	B	9
WS8	D	19	D	17
WS12	D	18	D	19
I2	E	25	D	15
WS5	D	21	D	21
S1	D	20	E	23
I5	E	26	D	18
WS13	E	25	D	20
WS1_B	E	28	D	20
I3	E	28	E	23
I1	E	27	E	25
Sdam	E	30	E	22
I4	E	29	E	24
Bdiv	E	30	E	26
BZFalls	E	30	E	26
Condit_Dam	E	30	E	26
Double_Drop	E	30	E	26
Husum_Falls	E	30	E	26
ICulv1	E	30	E	26
ICulv2	E	30	E	26
ICulv3	E	30	E	26
ICulv4	E	30	E	26
RFalls1	E	30	E	26
S2	E	30	E	26
S3	E	30	E	26
Steelhead_Falls	E	30	E	26

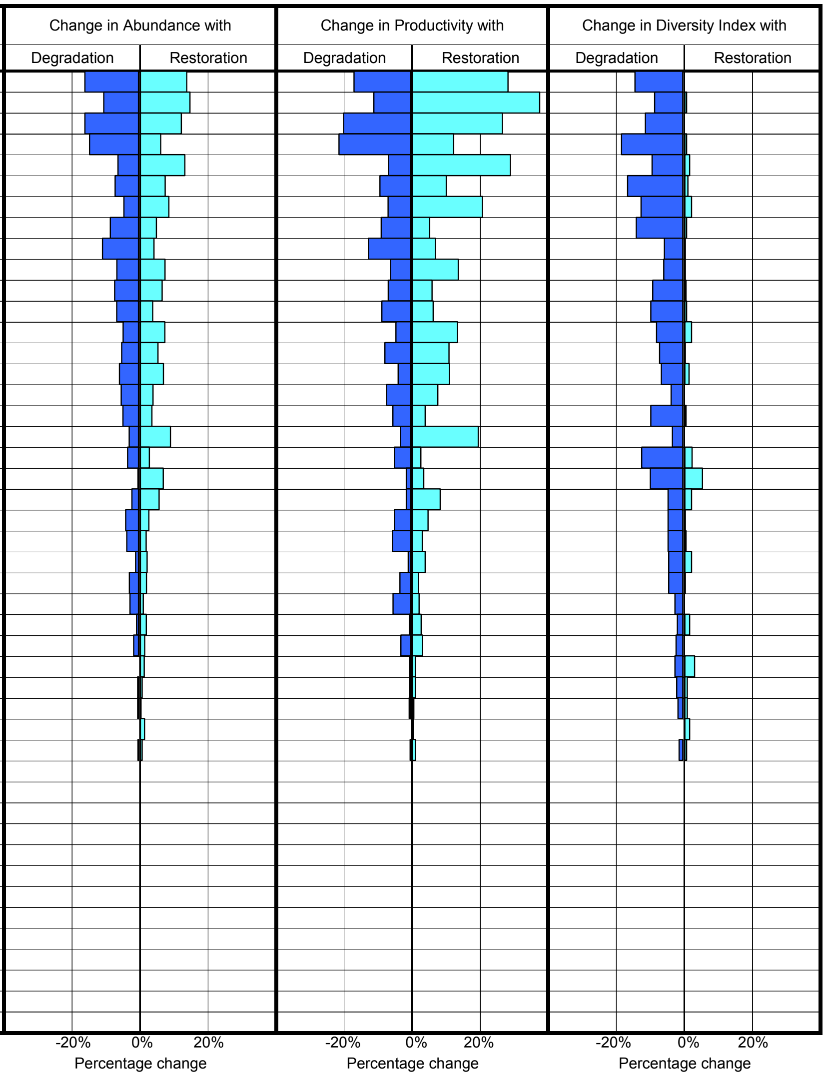


Figure 8. The relative restoration and preservation value of each reach, sorted by the average rank of the protection and restoration benefit combined, in the White Salmon River subbasin, based on EDT population performance parameters for steelhead. The registered dataset (BigWhite Removal4_21_04) was used. All culverts and barriers were rated with 100% passage, with the exception of 0% passage for the dam on Spring Creek between reaches S1 and S2.

Geographic area summary - Habitat factor analysis

The habitat factors or Level 3 survival factors that affect production potential are displayed in two types of "consumer report diagrams". The level 2 attributes that were used to rate the Level 3 survival factors are listed in Table 1, and Table 4 provides definitions for each survival factor. One report, titled "Protection and restoration strategic priority summary", shows the level of reduced productivity summarized by the habitat factors across the same set of reaches or geographic areas as the tornado diagrams presented above (Figure 9). This output condenses the most influential habitat factors across all life stages, and in the case of a geographic area analysis, across a number of reaches. This report is a display of the habitat factors that most reduce the diagnostic species population performance. Although often similar, the most important habitat factors may differ depending on the diagnostic species being analyzed.

The other type of consumer report diagram, titled "Reach analysis", shows more detail by describing the influence of Level 3 survival factors on the survival of each life stage for each diagnostic species, the relevant months for each life stage, percent of life history trajectories affected, the percent change in productivity, and several other statistics for each reach. For both styles of consumer report diagrams, increasing size of black dots indicates the relative magnitude of the negative impacts.

For the dam removal scenario, the habitat factor that was found to be the highest-ranked priority for restoration of coho salmon was habitat diversity (Figure 9). This was true for nearly every reach in the mainstem and tributaries. Other habitat factors that were shown to have affected potential productivity of coho salmon include reduced channel stability, increased sediment load, and flow. The model output suggested that an increase in harassment and poaching was a limiting factor in some of the reaches. Increased temperature was found to be a limiting habitat factor in the tributaries (Figure 9).

Because fall Chinook salmon leave the White Salmon River shortly after emergence, incubation is thought to be the most critical stage to their production. This explains why the most detrimental habitat factor was found to be the increased sediment load (Figure 10). Reduced key habitat quantity, reduced channel stability, and increased peak flow were also shown to be limiting factors for the productivity of fall Chinook salmon. In the lowermost reaches, increased harassment/poaching by anglers was found to limit productivity. The model output suggested that pathogens from fish stocking and straying, and predation from introduced species was also a factor in the downstream reaches (Figure 10).

The model output suggests that greatest potential limiting factors for spring Chinook salmon productivity were a loss of habitat diversity throughout the river, and increased sediment load in their spawning reaches (Figure 11). Decreased channel stability, increased peak flow, and reduced key habitat quantity were found to be limiting factors in many reaches. Higher than historic temperatures in the tributaries was also found to be a factor reducing productivity (Figure 11).

The potential steelhead productivity would likely be decreased due to the same factors listed for the other diagnostic species (Figure 12). The model output suggests that the most important limiting factors were a loss of key habitat quantity, decreased channel stability, increased sediment load, and increased peak flow, which decreases potential productivity in nearly all reaches. Harassment/poaching due to rafters and anglers was shown to be a limiting factor in the mainstem. Competition with hatchery fish, pathogens and predation were found to be habitat factors affecting productivity in the lowermost reaches. The model suggests that reduced summer low flows, increased temperatures, and susceptibility to pathogens due to increased temperatures, were concerns for steelhead production in Rattlesnake Creek (Figure 12).

Table 4. Definitions for the habitat factors also known as Level 3 survival factors (Lestelle et al. 2004).

Factor	Definition
Channel stability	The effect of stream channel stability (within reach) on the relative survival or performance of the focus species; the extent of channel stability is with respect to its streambed, banks, and its channel shape and location.
Chemicals	The effect of toxic substances or toxic conditions on the relative survival or performance of the focus species. Substances include chemicals and heavy metals. Toxic conditions include low pH.
Competition (with hatchery fish)	The effect of competition with hatchery produced animals on the relative survival or performance of the focus species; competition might be for food or space within the stream reach.
Competition (with other species)	The effect of competition with other species on the relative survival or performance of the focus species; competition might be for food or space.
Flow	The effect of the amount of stream flow, or the pattern and extent of flow fluctuations, within the stream reach on the relative survival or performance of the focus species. Effects of flow reductions or dewatering due to water withdrawals are to be included as part of this attribute.
Food	The effect of the amount, diversity, and availability of food that can support the focus species on the its relative survival or performance.
Habitat diversity	The effect of the extent of habitat complexity within a stream reach on the relative survival or performance of the focus species.
Harassment	The effect of harassment, poaching, or non-directed harvest (i.e., as can occur through hook and release) on the relative survival or performance of the focus species.
Key habitat	The relative quantity of the primary habitat type(s) utilized by the focus species during a life stage; quantity is expressed as percent of wetted surface area of the stream channel.
Obstructions	The effect of physical structures impeding movement of the focus species on its relative survival or performance within a stream reach; structures include dams and waterfalls.
Oxygen	The effect of the concentration of dissolved oxygen within the stream reach on the relative survival or performance of the focus species.
Pathogens	The effect of pathogens within the stream reach on the relative survival or performance of the focus species. The life stage when infection occurs is when this effect is accounted for.
Predation	The effect of the relative abundance of predator species on the relative survival or performance of the focus species.
Sediment load	The effect of the amount of the amount of fine sediment present in, or passing through, the stream reach on the relative survival or performance of the focus species.
Temperature	The effect of water temperature with the stream reach on the relative survival or performance of the focus species.
Withdrawals (or entrainment)	The effect of entrainment (or injury by screens) at water withdrawal structures within the stream reach on the relative survival or performance of the focus species. This effect does not include dewatering due to water withdrawals, which is covered by the flow attribute.

Big White Salmon Coho
Protection and Restoration Strategic Priority Summary

Geographic area priority			Attribute class priority for restoration																	
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
WS1_A	◯	◯	•		•		•		⬤	•			•	•	⬤			
WS1_B	◦	○			•		•		⬤	●			•	•	●			●
WS2	◯	◯	●		•		•		⬤	•					●			●
WS3	◯	○	●				•		⬤						●			●
Steelhead_Falls																		
WS4	◯	○	●				•		⬤						●			●
Condit_Dam																		
WS5			●				•		⬤						●			
WS6	○	◦	●				•		⬤						●			
WS7	○		●				•		⬤						●			
WS8			●				•		⬤	•					●			
WS9		○	●				•		●	•					●			
WS10	◯	◯	●				•		●	•					●			
WS11			●				•		⬤	•					●			
WS12		○	●				•		⬤	•					●			
WS13		◦	●				•		⬤	•					●			
Husum_Falls																		
WS14	○	○	●				•		⬤	•					●			
WS15			●				•		⬤	•					●			
WS16	◦	○	●				•		⬤	•					●			•
B1	◦	○	•				•		⬤						●			●
Bdiv																		
B2			●				•		⬤						●			●
S1	◦	◦							●						•			•
Sdam		○									⬤							
S2									●						●			⬤
S3									•						•			●
R1		◦	●				•		⬤	•					●	●		⬤
R2			•				•		●						●	●		●
I1			•				•		●						●	●		●
ICulv1																		
I2		◦	•				•		●						●	●		●
ICulv2																		
I3			•				•		⬤						●	●		●
ICulv3																		
I4			•				•		●						●	●		●
ICulv4																		
I5			•				•		⬤						●	●		●

1/ "Channel stability" applies to freshwater areas only.

Key to strategic priority (corresponding Benefit Category letter also shown)

A		B		C		D & E	
◯ ⬤	High	○ ●	Medium	◦ •	Low		Indirect or General

Figure 9. Habitat factor diagram for the White Salmon River averaged across all life stages of coho salmon. The registered dataset (BigWhite Removal4_21_04) was used. All culverts and barriers were rated with 100% passage, with the exception of 0% passage for the dam on Spring Creek between reaches S1 and S2.

Big White Salmon Fall Chinook
Protection and Restoration Strategic Priority Summary

Geographic area priority			Attribute class priority for restoration															
Geographic area	**Protection benefit**	**Restoration benefit**	***Channel stability***	***Chemicals***	***Competition (w/ hatch)***	***Competition (other sp)***	***Flow***	***Food***	***Habitat diversity***	***Harassment/poaching***	***Obstructions***	***Oxygen***	***Pathogens***	***Predation***	***Sediment load***	***Temperature***	***Withdrawals***	***Key habitat quantity***
WS1_A	◦	○	•				•		•	•			•	•	⬤			
WS1_B	◦	◦					•		•	●			•	•	●			●
WS2	◯	◯	•				•		●	•					●			●
WS3	○	◦	•				•		●						●			●
Steelhead_Falls																		
WS4	◦	◦	•				•		●						●			●
Condit_Dam																		
WS5			•				•		●	•					●			•

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

A		B		C		D & E	
◯	High	○	Medium	◦	Low		Indirect or General
⬤		●		•			

Figure 10. Habitat factor diagram for the White Salmon River averaged across all life stages of fall Chinook salmon. The registered dataset (BigWhite Removal4_21_04) was used. All culverts and barriers were rated with 100% passage, with the exception of 0% passage for the dam on Spring Creek between reaches S1 and S2.

Big White Salmon Spring Chinook
Protection and Restoration Strategic Priority Summary

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
WS1_A			•				•		•					•				
WS1_B							•		•					•				●
WS2	∘		•				•		●									●
WS3	∘						•		●									
Steelhead_Falls																		
WS4	○		•				•		●									
Condit_Dam																		
WS5			•				•		●									
WS6	○	∘	•				•		●						●			•
WS7	◯	○	•				•		●						●			•
WS8	∘		•				•		●	•					●			•
WS9	○	○	•				•		•	•					●			
WS10	◯	◯	•				•		•	•					●			
WS11	∘	∘	•				•		●	•					●			•
WS12			•				•		•	•					●			
WS13		∘	•				•		●	•					●			●
Husum_Falls																		
WS14	◯	◯	•				•		●	•					●			•
WS15			•				•		●	•					●			
WS16	○	○	•				•		●	•					●			•
B1	∘	◯	•				•		●						●	●		●
S1	∘								●						•			•
R1		○	•				•		⬤	•					●	⬤		⬤

1/ "Channel stability" applies to freshwater areas only.

Key to strategic priority (corresponding Benefit Category letter also shown)

A	◯ ⬤	High
B	○ ●	Medium
C	∘ •	Low
D & E	☐ ☐	Indirect or General

Figure 11. Habitat factor diagram for the White Salmon River averaged across all life stages of spring Chinook salmon. The registered dataset (BigWhite Removal4_21_04) was used. All culverts and barriers were rated with 100% passage, with the exception of 0% passage for the dam on Spring Creek between reaches S1 and S2.

Big White Salmon Steelhead
Protection and Restoration Strategic Priority Summary

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
WS1_A		◦			•		•		●	•			•	●	⬤	•		●
WS1_B					•		•		●	●			•	●	●			●
WS2	◦		•		•		•		●	•				•	●			●
WS3	◦	◦	•				•		•						●			●
Steelhead_Falls																		
WS4	○	◦	•				•		•						●			●
Condit_Dam																		
WS5			•				•		●	•					●			•
WS6	◦		•				•		●	•					●			•
WS7	○	○	•				•		●	•					●			•
WS8			•				•		•	●					●			
WS9	○	◦					•		•	•					●			
WS10	◯	○					•		•	•					●			
WS11	◦	◦	•				•		•	•					●			•
WS12			•				•		•	●					●			•
WS13			•				•		•	•					●			●
Husum_Falls																		
WS14	◯	◯					•		•	•					●			
WS15	◦	◦	•				•		•	●					●			
WS16	◯	◯	•				•		•	●					●			•
BZFalls																		
WS17	◦	◦	•				•		•						●			•
Double_Drop																		
WS18	◦	○	•				•		•						●			•
B1	○	◯					•		•						●	●		●
Bdiv																		
B2		○	•				•		•	•					●			●
S1									•						•			•
Sdam											●							
S2									⬤						●			⬤
S3									•						•			●
R1		○	•				•		•	•			•		●	●		⬤
R2		○					•		•				•		●	●		●
RFalls1																		
R3		○					•		•				•		●	●		●
R4	◦	◯					•		•				•		●	●		●
R5	◦	◯					•		•						●	●		●
I1							•		•				•		●	●		●
ICulv1																		
I2							•		•				•		●	●		●
ICulv2																		
I3							•		•				•		●	●		●
ICulv3																		
I4							•		•				•		●	●		●
ICulv4																		
I5							•		•				•		●	●		●

1/ "Channel stability" applies to freshwater areas only.

Key to strategic priority (corresponding Benefit Category letter also shown)

A		B		C		D & E	
◯ ⬤	High	○ ●	Medium	◦ •	Low		Indirect or General

Figure 12. Habitat factor diagram for the White Salmon River averaged across all life stages of steelhead. The registered dataset (BigWhite Removal4_21_04) was used. All culverts and barriers were rated with 100% passage, with the exception of 0% passage for the dam on Spring Creek between reaches S1 and S2.

Reach analysis

The reach analysis level of detail is available for each diagnostic species in each reach and can be useful for specific recovery measures in specific reaches. This reach-specific “consumer report” output provides additional detail by quantifying the reduction in productivity of each life stage as affected by changes in habitat relative to historic conditions (Figure 13). In this output, the relevant times of year for the life stage, and percent of life history trajectories affected for each life stage is displayed, along with some overall reach statistics. As with the diagrams above, the size of the black dots in the reach analysis diagrams indicate the relative influence that the habitat attribute has on the survival of each life stage of the diagnostic species. Each life stage is also ranked, with “1” representing the most severe reduction in survival. Ranking is based on the percent of time a given life stage resides in the reach, as well as the degree to which survival is reduced relative to historical conditions. The definition for each life stage of coho salmon, Chinook salmon, and steelhead are presented in Tables 5, 6, and 7, respectively. Reach analysis diagrams of two mainstem reaches (WS2 and WS11, Table 3) and two tributary reaches (B1 and R1, Table 3) are presented for each diagnostic species (Figures 13-25). However, because the reach analysis diagrams were reach- and species-specific, they may be too detailed to compare habitat problems across the watershed. The Big White Salmon Subbasin Plan (NPCC 2004) provides additional species-specific discussion and conclusions regarding these outputs.

The model output suggests that the life stages of coho salmon most affected by changes in habitat were the egg incubation, age-0 active rearing, and age-0 inactive life stages (Figures 13-17). This was true in the tributaries and mainstem. Changes in sediment and channel stability were shown to have the greatest influence on the egg incubation life stage. Reductions in habitat diversity and key habitat quantity were found to be the main habitat factors reducing survival in the age-0 active rearing, and age-0 inactive life stages (Figures 13-16)

The most probable reaches for fall Chinook salmon spawning were modeled entirely in the lower mainstem of the White Salmon River. Therefore, for fall Chinook, only the WS2 reach analysis was presented (Figure 17). Compared to historic conditions, survival in the egg incubation and fry colonization life stages were found to be the most altered in this reach. Similar to the egg incubation life stage of coho salmon, the habitat factors implicated in reduced survival of that life stage are increased sediment load, decreased channel stability, and loss of key habitat quantity (Figure 17).

Spring Chinook salmon are not expected to spawn in the lower reaches of the White Salmon River, therefore only a few of the life stages would inhabit the WS 2 reach (Figure 18). The model output suggested that in the mainstem reach of WS11 and the lowermost reach in Buck Creek (B1), the egg incubation and fry colonization life stages were most affected by changes in habitat. The habitat factors that were found to be the most influential in those changes were increased sediment load, reduced channel stability and reduced key habitat quantity (Figures 19 and 20). In the lowest reaches of Buck and Rattlesnake creeks, increased temperatures also influenced some of the life stages (Figures 20 and 21). In Rattlesnake Creek, the greatest productivity change was shown to be in the spawning life stage, and reduced habitat diversity, reduced key habitat quantity, and increased summer temperatures were the habitat factors that influenced this change the most.

The model output suggests that the same habitat changes that altered survival of the other diagnostic species will likely also alter steelhead survival in the White Salmon River. The egg incubation stage was found to be one of the most affected life stages, with increased sediment load a primary habitat factor in this change in survival compared to historic conditions (Figures 22-25). Because steelhead spawn in the spring, and their eggs incubate into the early summer, increased temperature in the tributaries will affect steelhead egg incubation more than the other diagnostic fish species, which spawn in the fall (Figures 24 and 25). This is because the offspring from fish that spawn in the fall emerge in the spring when temperatures are lower, and the fry can out-migrate or find cold water refuge. Survival rates for the age-0 active rearing and age-0 inactive life stages have also changed substantially when compared to historic conditions. As with the other species, loss of habitat diversity, reduced channel stability, decreased flow in the tributaries in the summer, and increased peak flow associated with storm events were found to be some of the habitat factors that reduced survival by life stage.

Table 5. Description of coho salmon life stages within the freshwater environment. (Lestelle et al. 2004)

Life stage	**Description**
Spawning	Period of active spawning, beginning when fish move on to spawning beds and initiate redd digging and ending when gametes are released. Note: For computational purposes, the reproductive potential associated with a spawning female is incorporated at the beginning of this stage; this potential includes sex ratio (average females per total spawners) and average fecundity per female
Egg incubation	Egg incubation and alevin development; stage begins at the moment of the release of gametes by spawners and ends at fry emergence (losses to egg viability that occur in the instant prior to fertilization are included here).
Fry colonization	Fry emergence and initial dispersal; time period is typically very short, beginning at fry emergence and ending when fry begin active feeding associated with a key habitat.
0-age resident rearing	Rearing by age-0 fish that is largely associated with a small "home range"; these fish are generally territorial.
0-age migrant	Directional migration by age-0 fish that tends to be rapid and not strongly associated with feeding/rearing. This type of movement typically occurs when fish redistribute within the stream system prior to, or during, winter.
0-age inactive	Largely inactive or semi-dormant fish age fish; this behavior is associated with overwintering, when feeding is reduced; fish exhibiting this behavior need to be largely sustained by lipid reserves.
1-age resident rearing	Feeding/rearing by age-1 fish that is associated with a home range; these fish are often territorial.
1-age migrant	Directional migration by age-1 fish that tends to be rapid and not strongly associated with feeding/rearing. Such migrations will typically occur during either spring or fall/early winter by fish migrating seaward or as a redistribution to a different freshwater habitat (such as occurs following winter or in preparation for winter).
Migrant prespawner	Adult fish approaching sexual maturity that are migrating to their natal stream; in the ocean this stage occurs in the final year of marine life, in freshwater feeding has generally ceased.
Holding prespawner	Adult fish approaching sexual maturity that are largely stationary and holding, while en-route to their spawning grounds; distance to the spawning grounds from holding sites may be short or long.

Table 6. Description of Chinook salmon life stages within the freshwater environment (Lestelle et al. 2004).

Life stage	**Description**
Spawning	Period of active spawning, beginning when fish move on to spawning beds and initiate redd digging and ending when gametes are released. Note: For computational purposes, the reproductive potential associated with a spawning female is incorporated at the beginning of this stage; this potential includes sex ratio (average females per total spawners) and average fecundity per female.
Egg incubation	Egg incubation and alevin development; stage begins at the moment of the release of gametes by spawners and ends at fry emergence (losses to egg viability that occur in the instant prior to fertilization are included here).
Fry colonization	Fry emergence and initial dispersal; time period is typically very short, beginning at fry emergence and ending when fry begin active feeding associated with a key habitat.
0-age resident rearing	Rearing by age-0 fish that is largely associated with a small "home range"; these fish are generally territorial.
0-age transient rearing	Rearing by age-0 fish accompanied by directional movement (i.e., these fish do not have home ranges); these fish are non-territorial, though agonistic behavior may still be exhibited (note: this pattern typifies a 0-age fall Chinook rearing pattern).
0-age migrant	Directional migration by age- 0 fish that tends to be rapid and not strongly associated with feeding/rearing. This type of movement typically occurs when fish redistribute within the stream system prior to, or during, winter.
0-age inactive	Largely inactive or semi-dormant fish age fish; this behavior is associated with overwintering, when feeding is reduced; fish exhibiting this behavior need to be largely sustained by lipid reserves.
1-age resident rearing	Feeding/rearing by age-1 fish that is associated with a home range; these fish are often territorial.
1-age migrant	Directional migration by age-1 fish that tends to be rapid and not strongly associated with feeding/rearing. Such migrations will typically occur during either spring or fall/early winter by fish migrating seaward or as a redistribution to a different freshwater habitat(such as occurs following winter or in preparation for winter).
Migrant prespawner	Adult fish approaching sexual maturity that are migrating to their natal stream; in the ocean this stage occurs in the final year of marine life, in freshwater feeding has generally ceased.
Holding prespawner	Adult fish approaching sexual maturity that are largely stationary and holding, while en-route to their spawning grounds; distance to the spawning grounds from holding sites may be short or long.

Table 7. Description of steelhead life stages within the freshwater environment (Lestelle et al. 2004).

Life stage	**Description**
Spawning	Period of active spawning, beginning when fish move on to spawning beds and initiate redd digging and ending when gametes are released. Note: For computational purposes, the reproductive potential associated with a spawning female is incorporated at the beginning of this stage; this potential includes sex ratio (average females per total spawners) and average fecundity per female.
Egg incubation	Egg incubation and alevin development; stage begins at the moment of the release of gametes by spawners and ends at fry emergence (losses to egg viability that occur in the instant prior to fertilization are included here).
Fry colonization	Fry emergence and initial dispersal; time period is typically very short, beginning at fry emergence and ending when fry begin active feeding associated with a key habitat.
0-age resident rearing	Rearing by age-0 fish that is largely associated with a small "home range"; these fish are generally territorial.
0-age migrant	Directional migration by age-0 fish that tends to be rapid and not strongly associated with feeding/rearing. This type of movement typically occurs when fish redistribute within the stream system prior to, or during, winter.
0-age inactive	Largely inactive or semi-dormant age-0 fish; this behavior is associated with overwintering, when feeding is reduced; fish exhibiting this behavior need to be largely sustained by lipid reserves.
1-age resident rearing	Feeding/rearing by age-1 fish that is associated with a home range; these fish are often territorial.
1-age migrant	Directional migration by age-1 fish that tends to be rapid and not strongly associated with feeding/rearing. Such migrations will typically occur during either spring or fall/early winter by fish migrating seaward or as a redistribution to a different freshwater habitat (such as occurs following winter or in preparation for winter).
1-age inactive	Largely inactive or semi-dormant fish age-1fish; this behavior is associated with overwintering, when feeding is reduced; fish exhibiting this behavior need to be largely sustained by lipid reserves.
2+-age resident rearing	Feeding/rearing by age-2 and older fish that is associated with a home range; these fish are often territorial.
2+-age migrant	Directional migration by age-2 fish that tends to be rapid and not strongly associated with feeding/rearing. Such migrations will typically occur during either spring or fall/early winter by fish migrating seaward or as a redistribution to a different freshwater habitat (such as occurs following winter or in preparation for winter).
2+-age inactive	Largely inactive or semi-dormant fish age 2 and older fish; this behavior is associated with overwintering, when feeding is reduced; fish exhibiting this behavior need to be largely sustained by lipid reserves.
Migrant prespawner	Adult fish approaching sexual maturity that are migrating to their natal stream; in the ocean this stage occurs in the final year of marine life, in freshwater feeding has generally ceased.
Holding prespawner	Adult fish approaching sexual maturity that are largely stationary and holding, while en-route to their spawning grounds; distance to the spawning grounds from holding sites may be short or long.

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Coho

Geographic Area:	WS2	**Stream:**	Big White Salmon
Reach:	End of BON pool influence to Powerhouse	**Reach Length (mi):**	0.95
		Reach Code:	WS2

Restoration Benefit Category:1/	A	**Productivity Rank:1/**	2	**Potential % change in productivity:2/**	23.2%
Overall Restoration Potential Rank:1/	2	**Average Abundance (Neq) Rank:1/**	2	**Potential % change in Neq:2/**	16.0%
(lowest rank possible - with ties)1/	26	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	21.8%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	2	**loss in productivity with degradation:2/**	-17.2%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-30.3%
(lowest rank possible - with ties)1/	23	**Life History Diversity Rank:1/**	2	**% loss in diversity with degradation:2/**	-15.0%

					Change in attribute impact on survival															
Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	11.7%	-5.2%	8							●	●								●
Egg incubation	Oct-May	11.7%	-42.7%	3	⬤							•					⬤			●
Fry colonization	Mar-May	64.7%	-6.1%	4	●				●		⬤					•				●
0-age active rearing	Mar-Oct	10.1%	-37.7%	2	•		●				⬤				•	•				⬤
0-age migrant	Oct-Nov	12.7%	-2.9%	6							●					•				
0-age inactive	Oct-Mar	10.2%	-87.8%	1	•				●		**⬤**									⬤
1-age active rearing	Mar-May	10.2%	-16.5%	5	•		•		●		●				•	•				⬤
1-age migrant	Mar-Jun	30.0%	-0.3%	7							●					•				
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	87.1%	0.0%	10								•								
Prespawning holding	Oct-Dec	11.7%	-3.0%	9								●								⬤
All Stages Combined		87.1%																		

1/ Ranking based on effect over entire geographic area.

2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	◦
Moderate	●	○
High	⬤	◯
Extreme	**⬤**	**◯**

Figure 13. A coho salmon "consumer reports diagram", for Reach WS2 (RM 1.2-2.1) of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with “1” representing the most severe impact relative to historical conditions.

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed Reach Analysis - Coho

Geographic Area:	WS11	**Stream:**	Big White Salmon
Reach:	Spring Ck. to Deadman's Corner	**Reach Length (mi):**	0.70
		Reach Code:	WS11

Restoration Benefit Category:1/	D	**Productivity Rank:1/**	24	**Potential % change in productivity:2/**	1.0%
Overall Restoration Potential Rank:1/	20	**Average Abundance (Neq) Rank:1/**	28	**Potential % change in Neq:2/**	0.0%
(lowest rank possible - with ties)1/	26	**Life History Diversity Rank:1/**	4	**Potential % change in diversity:2/**	26.3%
Preservation Benefit Category:1/	D	**Productivity Rank:1/**	15	**loss in productivity with degradation:2/**	-3.6%
Overall Preservation Rank:1/	13	**Average Abundance (Neq) Rank:1/**	18	**% loss in Neq with degradation:2/**	-4.1%
(lowest rank possible - with ties)1/	23	**Life History Diversity Rank:1/**	3	**% loss in diversity with degradation:2/**	-12.0%

					Change in attribute impact on survival																
Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	2.3%	-4.4%	6							●	●								
Egg incubation	Oct-May	2.3%	-40.7%	3	⬤							•					⬤			
Fry colonization	Mar-May	21.0%	-5.2%	4	●				●		⬤									
0-age active rearing	Mar-Oct	3.0%	-37.9%	2	•						⬤									
0-age migrant	Oct-Nov	4.1%	-1.3%	8							●									
0-age inactive	Oct-Mar	2.7%	-89.6%	1	•				●		⚫									
1-age active rearing	Mar-May	2.7%	-14.1%	5	•				●		⬤									•
1-age migrant	Mar-Jun	9.9%	-0.2%	9							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	29.4%	0.0%	10								•								
Prespawning holding	Oct-Dec	2.3%	-3.1%	7								●								
All Stages Combined		29.4%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	◦
Moderate	●	○
High	⬤	◯
Extreme	⚫	⚪

Figure 14. A coho salmon "consumer reports diagram" for Reach WS11 (RM 6.8-7.5) of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Coho

Geographic Area:	B1	**Stream:**	Big White Salmon
Reach:	Buck Ck. mouth to diversion intake	**Reach Length (mi):**	2.01
		Reach Code:	B1

Restoration Benefit Category:1/	B	**Productivity Rank:1/**	11	**Potential % change in productivity:2/**	6.3%
Overall Restoration Potential Rank:1/	11	**Average Abundance (Neq) Rank:1/**	11	**Potential % change in Neq:2/**	5.4%
(lowest rank possible - with ties)1/	26	**Life History Diversity Rank:1/**	8	**Potential % change in diversity:2/**	12.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	10	**loss in productivity with degradation:2/**	-6.6%
Overall Preservation Rank:1/	9	**Average Abundance (Neq) Rank:1/**	9	**% loss in Neq with degradation:2/**	-11.8%
(lowest rank possible - with ties)1/	23	**Life History Diversity Rank:1/**	8	**% loss in diversity with degradation:2/**	-6.0%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**																
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	5.4%	-2.1%	6							●									●
Egg incubation	Oct-May	5.4%	-42.4%	1	●												⚫			●
Fry colonization	Mar-May	7.8%	-12.7%	4	●				●	•	⚫									⚫
0-age active rearing	Mar-Oct	0.3%	-41.6%	3	•				●		⚫							•		⚫
0-age migrant	Oct-Nov	0.3%	-3.0%	7							●									
0-age inactive	Oct-Mar	0.2%	-63.0%	2	•				●		⬤									⚫
1-age active rearing	Mar-May	0.2%	-17.6%	5	•				●		⚫									⚫
1-age migrant	Mar-Jun	0.2%	-0.7%	9							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	7.8%	0.0%	10							•									
Prespawning holding	Oct-Dec	5.4%	-1.2%	8							•									⚫
All Stages Combined		7.8%																		

1/ Ranking based on effect over entire geographic area.

2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	◦
Moderate	●	○
High	⚫	⚪
Extreme	⬤	◯

Figure 15. A coho salmon "consumer reports diagram" for reach B1 (RM 0.0-02.0) of Buck Creek, a tributary of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Coho

Geographic Area:	R1	**Stream:**	Big White Salmon
Reach:	Rattlesnake Ck. mouth to Indian Ck.	**Reach Length (mi):**	0.48
		Reach Code:	R1

Restoration Benefit Category:1/	C	**Productivity Rank:1/**	15	**Potential % change in productivity:2/**	4.3%
Overall Restoration Potential Rank:1/	12	**Average Abundance (Neq) Rank:1/**	14	**Potential % change in Neq:2/**	3.8%
(lowest rank possible - with ties)1/	26	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	18.8%
Preservation Benefit Category:1/	E	**Productivity Rank:1/**	23	**loss in productivity with degradation:2/**	-0.5%
Overall Preservation Rank:1/	18	**Average Abundance (Neq) Rank:1/**	20	**% loss in Neq with degradation:2/**	-2.2%
(lowest rank possible - with ties)1/	23	**Life History Diversity Rank:1/**	13	**% loss in diversity with degradation:2/**	-0.8%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	2.6%	-6.7%	6							⬤	●								⚫
Egg incubation	Oct-May	2.6%	-45.9%	3	⬤												⬤			⚫
Fry colonization	Mar-May	8.9%	-7.9%	4	●				●	•	⬤									⬤
0-age active rearing	Mar-Oct	2.1%	-72.4%	2	•		•		•	•	⬤							⬤		⬤
0-age migrant	Oct-Nov	2.3%	-4.4%	7							●									
0-age inactive	Oct-Mar	1.9%	-88.5%	1	●				●		⚫									●
1-age active rearing	Mar-May	1.9%	-20.7%	5	•				●		⬤									⬤
1-age migrant	Mar-Jun	2.8%	-0.4%	9							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	10.0%	0.0%	10							•	•								
Prespawning holding	Oct-Dec	2.6%	-4.5%	8							●	•								●
All Stages Combined		10.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⚫	❍

Figure 16. A coho salmon "consumer reports" diagram for reach R1 (RM 0.0-0.5) of Rattlesnake Creek, a tributary of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Fall Chinook
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Fall Chinook

Geographic Area:	WS2	**Stream:**	Big White Salmon
Reach:	End of BON pool influence to Powerhouse	**Reach Length (mi):**	0.95
		Reach Code:	WS2

Restoration Benefit Category:1/	A	**Productivity Rank:1/**	2	**Potential % change in productivity:2/**	33.8%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	11.5%
(lowest rank possible - with ties)1/	6	**Life History Diversity Rank:1/**	2	**Potential % change in diversity:2/**	2.3%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-46.0%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-51.1%
(lowest rank possible - with ties)1/	5	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-30.7%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**																	
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Nov	23.6%	-6.2%	3							●	●								●
Egg incubation	Nov-May	23.6%	-32.6%	1	●							•					⬤			●
Fry colonization	Apr-May	50.7%	-4.9%	2	●				●		⬤					•				○
0-age active rearing	Mar-Oct	3.4%	-5.9%	5	•		•				●				•	•				⬤
0-age migrant																				
0-age inactive																				
1-age active rearing																				
1-age migrant																				
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Oct	50.9%	0.0%	6							•	•								
Prespawning holding	Oct-Nov	23.6%	-4.9%	4					•		●	•								⬤
All Stages Combined		50.9%																		

1/ Ranking based on effect over entire geographic area.
2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	◦
Moderate	●	○
High	⚫	⚪
Extreme	⬤	◯

Figure 17. A fall Chinook salmon "consumer reports diagram" for Reach WS2 (RM 1.2-2.1) of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Spring Chinook
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Spring Chinook

Geographic Area:	WS2	**Stream:**	Big White Salmon
Reach:	End of BON pool influence to Powerhouse	**Reach Length (mi):**	0.95
		Reach Code:	WS2

Restoration Benefit Category:1/	D	**Productivity Rank:1/**	17	**Potential % change in productivity:2/**	1.2%
Overall Restoration Potential Rank:1/	13	**Average Abundance (Neq) Rank:1/**	14	**Potential % change in Neq:2/**	2.1%
(lowest rank possible - with ties)1/	19	**Life History Diversity Rank:1/**	8	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	11	**loss in productivity with degradation:2/**	-6.5%
Overall Preservation Rank:1/	12	**Average Abundance (Neq) Rank:1/**	11	**% loss in Neq with degradation:2/**	-12.8%
(lowest rank possible - with ties)1/	20	**Life History Diversity Rank:1/**	16	**% loss in diversity with degradation:2/**	-1.4%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	19.1%	-2.3%	2	●				●		⬤					•				○
0-age active rearing	Mar-Oct	67.0%	-1.4%	1							•									⬤
0-age migrant																				
0-age inactive																				
1-age active rearing																				
1-age migrant	Mar-Jun	19.1%	-0.2%	3							●					•				
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Apr-Aug	100.0%	0.0%	4							•	•								
Prespawning holding																				
All Stages Combined		100.0%																		

1/ Ranking based on effect over entire geographic area.

2/ Value shown is for overall population performance.

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	◦
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

Figure 18. A spring Chinook salmon "consumer reports diagram" for Reach WS2 (RM 1.2-2.1) of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Spring Chinook
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed Reach Analysis - Spring Chinook

Geographic Area:	WS11	**Stream:**	Big White Salmon
Reach:	Spring Ck. to Deadman's Corner	**Reach Length (mi):**	0.70
		Reach Code:	WS11

Restoration Benefit Category:1/	C	**Productivity Rank:1/**	5	**Potential % change in productivity:2/**	11.8%
Overall Restoration Potential Rank:1/	8	**Average Abundance (Neq) Rank:1/**	8	**Potential % change in Neq:2/**	6.1%
(lowest rank possible - with ties)1/	19	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	1.1%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	9	**loss in productivity with degradation:2/**	-10.2%
Overall Preservation Rank:1/	8	**Average Abundance (Neq) Rank:1/**	10	**% loss in Neq with degradation:2/**	-13.8%
(lowest rank possible - with ties)1/	20	**Life History Diversity Rank:1/**	6	**% loss in diversity with degradation:2/**	-8.2%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Sep	6.3%	-5.3%	6							●	●					•			●
Egg incubation	Sep-Apr	6.3%	-42.5%	1	●							•					⬤			●
Fry colonization	Mar-May	23.8%	-5.8%	2	●				●		⬤									
0-age active rearing	Mar-Oct	21.6%	-2.9%	4							●									
0-age migrant	Oct-Nov	2.0%	-2.0%	8							●									
0-age inactive	Oct-Mar	2.0%	-28.0%	3	●				●		⬤									
1-age active rearing	Mar-May	2.0%	-3.3%	7					•		●									
1-age migrant	Mar-Jun	10.3%	-0.1%	9							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Apr-Aug	47.8%	0.0%	10							•	•								
Prespawning holding	May-Sep	6.3%	-5.4%	5					•		●	•								
All Stages Combined		47.8%																		

1/ Ranking based on effect over entire geographic area.

2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	◦
Moderate	●	○
High	⬤	◯
Extreme	⚫	◯

Figure 19. A spring Chinook salmon "consumer reports diagram" for Reach WS11 (RM 6.8-7.5) of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Spring Chinook
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Spring Chinook

Geographic Area:	B1	**Stream:**	Big White Salmon
Reach:	Buck Ck. mouth to diversion intake	**Reach Length (mi):**	2.01
		Reach Code:	B1

Restoration Benefit Category:1/	A	**Productivity Rank:1/**	3	**Potential % change in productivity:2/**	22.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	13.4%
(lowest rank possible - with ties)1/	19	**Life History Diversity Rank:1/**	2	**Potential % change in diversity:2/**	11.3%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	17	**loss in productivity with degradation:2/**	-3.7%
Overall Preservation Rank:1/	11	**Average Abundance (Neq) Rank:1/**	9	**% loss in Neq with degradation:2/**	-14.5%
(lowest rank possible - with ties)1/	20	**Life History Diversity Rank:1/**	5	**% loss in diversity with degradation:2/**	-9.5%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Sep	13.0%	-17.9%	3							●	•						⬤		●
Egg incubation	Sep-Apr	13.0%	-52.0%	1	●												⬤	●		●
Fry colonization	Mar-May	13.0%	-20.9%	2	●				●	•	⬤									●
0-age active rearing	Mar-Oct	3.8%	-18.2%	6					●		●							•		⬤
0-age migrant	Oct-Nov	2.1%	-3.0%	8							●									
0-age inactive	Oct-Mar	2.1%	-38.0%	4	•				●		⬤									⬤
1-age active rearing	Mar-May	2.1%	-3.7%	7					•		•									⬤
1-age migrant	Mar-Jun	2.1%	-0.4%	9							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Apr-Aug	13.0%	-0.2%	10					●		•							•		
Prespawning holding	May-Sep	13.0%	-15.6%	5					●		●							●		⬤
All Stages Combined		13.0%																		

1/ Ranking based on effect over entire geographic area.

2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	◦
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Figure 20. A spring Chinook salmon "consumer reports diagram" for reach B1 (RM 0.0-02.0) of Buck Creek, a tributary of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Spring Chinook
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Spring Chinook

Geographic Area:	R1	**Stream:**	Big White Salmon
Reach:	Rattlesnake Ck. mouth to Indian Ck.	**Reach Length (mi):**	0.48
		Reach Code:	R1

Restoration Benefit Category:1/	B	**Productivity Rank:1/**	9	**Potential % change in productivity:2/**	7.8%
Overall Restoration Potential Rank:1/	7	**Average Abundance (Neq) Rank:1/**	6	**Potential % change in Neq:2/**	6.8%
(lowest rank possible - with ties)1/	19	**Life History Diversity Rank:1/**	3	**Potential % change in diversity:2/**	4.8%
Preservation Benefit Category:1/	E	**Productivity Rank:1/**	20	**loss in productivity with degradation:2/**	0.0%
Overall Preservation Rank:1/	19	**Average Abundance (Neq) Rank:1/**	20	**% loss in Neq with degradation:2/**	-0.9%
(lowest rank possible - with ties)1/	20	**Life History Diversity Rank:1/**	19	**% loss in diversity with degradation:2/**	0.0%

					Change in attribute impact on survival															
Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Sep	4.0%	-76.5%	1							⬤	●					•	⚫		⚫
Egg incubation	Sep-Apr	4.0%	-68.1%	2	●												⬤	⬤		⚫
Fry colonization	Mar-May	4.0%	-22.9%	5	●				●	•	⬤									●
0-age active rearing	Mar-Oct	1.1%	-42.5%	4	•		•		•		●				•			⬤		●
0-age migrant	Oct-Nov	0.7%	-5.1%	8							●									
0-age inactive	Oct-Mar	0.7%	-42.3%	6	●				●		⬤									●
1-age active rearing	Mar-May	0.7%	-6.2%	7					•		●									●
1-age migrant	Mar-Jun	0.7%	-0.2%	10							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Apr-Aug	4.0%	-0.3%	9					•		●	•						⬤		
Prespawning holding	May-Sep	4.0%	-59.3%	3					●		⬤	•					•	⬤		●
All Stages Combined		4.0%																		

1/ Ranking based on effect over entire geographic area.

2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⚫	⭕

Figure 21. A spring Chinook salmon "consumer reports diagram" for reach R1 (RM 0.0-0.5) of Rattlesnake Creek, a tributary of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Winter Steelhead
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Steelhead

Geographic Area:	WS2	**Stream:**	Big White Salmon
Reach:	End of BON pool influence to Powerhouse	**Reach Length (mi):**	0.95
		Reach Code:	WS2

Restoration Benefit Category:1/	D	**Productivity Rank:1/**	26	**Potential % change in productivity:2/**	2.4%
Overall Restoration Potential Rank:1/	16	**Average Abundance (Neq) Rank:1/**	21	**Potential % change in Neq:2/**	2.6%
(lowest rank possible - with ties)1/	26	**Life History Diversity Rank:1/**	3	**Potential % change in diversity:2/**	2.2%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	19	**loss in productivity with degradation:2/**	-4.8%
Overall Preservation Rank:1/	15	**Average Abundance (Neq) Rank:1/**	20	**% loss in Neq with degradation:2/**	-3.2%
(lowest rank possible - with ties)1/	30	**Life History Diversity Rank:1/**	6	**% loss in diversity with degradation:2/**	-12.1%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**																
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Mar-Jun	0.9%	-5.8%	9							⬤	●								●
Egg incubation	Mar-Jul	0.9%	-31.5%	4	●							•					⬤			●
Fry colonization	May-Jul	2.1%	-8.4%	6	•				●		⬤				•	●				
0-age active rearing	May-Jul	2.0%	-21.4%	5			●				●				•	•				
0,1-age inactive	Oct-Mar	6.3%	-23.2%	2	•				●		●									
1-age migrant	Mar-Jun	35.5%	-0.7%	8							●					•				
1-age active rearing	Mar-Oct	6.7%	-15.5%	1			●		•		●				•	•				
2+-age active rearing	Mar-Oct	3.6%	-6.3%	7			•		•		●									
2+-age migrant	Mar-Jun	64.1%	-0.1%	13							●					•				
2+-age transient rearing																				
Prespawning migrant	Nov-Apr	99.0%	-0.1%	12								•								
Prespawning holding	Dec-May	0.9%	-1.0%	14								•								⬤
All Stages Combined		99.0%																		

1/ Ranking based on effect over entire geographic area.　2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⚫	⚪

Figure 22. A steelhead "consumer reports diagram" for Reach WS2 (RM 1.2-2.1) of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Winter Steelhead
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed Reach Analysis - Steelhead

Geographic Area:	WS11	**Stream:**	Big White Salmon
Reach:	Spring Ck. to Deadman's Corner	**Reach Length (mi):**	0.70
		Reach Code:	WS11

Restoration Benefit Category:1/	C	**Productivity Rank:1/**	16	**Potential % change in productivity:2/**	6.1%
Overall Restoration Potential Rank:1/	14	**Average Abundance (Neq) Rank:1/**	19	**Potential % change in Neq:2/**	3.7%
(lowest rank possible - with ties)1/	26	**Life History Diversity Rank:1/**	9	**Potential % change in diversity:2/**	0.5%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	8	**loss in productivity with degradation:2/**	-8.5%
Overall Preservation Rank:1/	8	**Average Abundance (Neq) Rank:1/**	9	**% loss in Neq with degradation:2/**	-6.5%
(lowest rank possible - with ties)1/	30	**Life History Diversity Rank:1/**	9	**% loss in diversity with degradation:2/**	-9.4%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Mar-Jun	1.9%	-5.2%	7							●	●								●
Egg incubation	Mar-Jul	1.9%	-31.6%	1	●							•					⬤			●
Fry colonization	May-Jul	6.5%	-4.8%	5	•				●		●									
0-age active rearing	May-Jul	3.8%	-11.5%	3							●									
0,1-age inactive	Oct-Mar	4.5%	-19.3%	3	•				●		●									
1-age migrant	Mar-Jun	24.6%	-0.4%	9							•									
1-age active rearing	Mar-Oct	4.7%	-9.1%	4					•		●									
2+-age active rearing	Mar-Oct	1.6%	-4.1%	10					•		●									
2+-age migrant	Mar-Jun	27.5%	0.0%	14							•									
2+-age transient rearing																				
Prespawning migrant	Nov-Apr	63.7%	-0.1%	12								•								
Prespawning holding	Dec-May	1.9%	-1.8%	11								•								
All Stages Combined		63.7%																		

1/ Ranking based on effect over entire geographic area.

2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⚫	⚪

Figure 23. A steelhead "consumer reports diagram" for Reach WS11 (RM 6.8-7.5) of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Winter Steelhead
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed
Reach Analysis - Steelhead

Geographic Area:	B1	**Stream:**	Big White Salmon
Reach:	Buck Ck. mouth to diversion intake	**Reach Length (mi):**	2.01
		Reach Code:	B1

Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	37.9%
Overall Restoration Potential Rank:1/	2	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	14.7%
(lowest rank possible - with ties)1/	26	**Life History Diversity Rank:1/**	9	**Potential % change in diversity:2/**	0.5%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	5	**loss in productivity with degradation:2/**	-10.9%
Overall Preservation Rank:1/	6	**Average Abundance (Neq) Rank:1/**	5	**% loss in Neq with degradation:2/**	-10.3%
(lowest rank possible - with ties)1/	30	**Life History Diversity Rank:1/**	12	**% loss in diversity with degradation:2/**	-8.3%

					Change in attribute impact on survival															
Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Mar-Jun	8.0%	-1.5%	7							●	•								●
Egg incubation	Mar-Jul	8.0%	-44.2%	1	•				•								⚫	⚫		●
Fry colonization	May-Jul	9.4%	-6.9%	4	•				●		●							●		
0-age active rearing	May-Jul	7.4%	-20.0%	2					●		●							•		
0,1-age inactive	Oct-Mar	10.0%	-12.6%	4	•				●		●									
1-age migrant	Mar-Jun	3.4%	-0.3%	11							•									
1-age active rearing	Mar-Oct	6.7%	-7.8%	5					●		•									
2+-age active rearing	Mar-Oct	3.3%	-2.3%	9					•		•									
2+-age migrant	Mar-Jun	5.0%	0.0%	13							•									
2+-age transient rearing																				
Prespawning migrant	Nov-Apr	12.3%	0.0%	12							•									
Prespawning holding	Dec-May	8.0%	-0.5%	10							•									⬤
All Stages Combined		12.3%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	◦
Moderate	●	○
High	⬤	◯
Extreme	⚫	⚪

Figure 24. A steelhead "consumer reports diagram" for reach B1 (RM 0.0-02.0) of Buck Creek, a tributary of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Species/Component:	Winter Steelhead
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Big White Salmon Watershed Reach Analysis - Steelhead

Geographic Area:	R1	**Stream:**	Big White Salmon
Reach:	Rattlesnake Ck. mouth to Indian Ck.	**Reach Length (mi):**	0.48
		Reach Code:	R1

Restoration Benefit Category:1/	B	**Productivity Rank:1/**	13	**Potential % change in productivity:2/**	8.2%
Overall Restoration Potential Rank:1/	9	**Average Abundance (Neq) Rank:1/**	14	**Potential % change in Neq:2/**	5.6%
(lowest rank possible - with ties)1/	26	**Life History Diversity Rank:1/**	4	**Potential % change in diversity:2/**	2.0%
Preservation Benefit Category:1/	E	**Productivity Rank:1/**	26	**loss in productivity with degradation:2/**	-1.3%
Overall Preservation Rank:1/	24	**Average Abundance (Neq) Rank:1/**	24	**% loss in Neq with degradation:2/**	-1.9%
(lowest rank possible - with ties)1/	30	**Life History Diversity Rank:1/**	18	**% loss in diversity with degradation:2/**	-4.3%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival** Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Mar-Jun	1.0%	-5.6%	8							●	●						•		⬤
Egg incubation	Mar-Jul	1.0%	-49.1%	5	●												⬤	⬤		⬤
Fry colonization	May-Jul	5.0%	-15.3%	2	•				●	•	●					•		⬤		
0-age active rearing	May-Jul	2.9%	-40.1%	1	•		•		●		●				●			⬤		
0,1-age inactive	Oct-Mar	6.1%	-20.1%	5	●				●		●									
1-age migrant	Mar-Jun	11.1%	-0.5%	10							●									
1-age active rearing	Mar-Oct	4.9%	-18.5%	3	•		•		●		●							●		
2+-age active rearing	Mar-Oct	1.8%	-4.0%	9					•		•									
2+-age migrant	Mar-Jun	10.3%	0.0%	13							●									
2+-age transient rearing																				
Prespawning migrant	Nov-Apr	28.4%	0.0%	12							•	•								
Prespawning holding	Dec-May	1.0%	-2.6%	11							•	•								●
All Stages Combined		28.4%																		

1/ Ranking based on effect over entire geographic area.   2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Figure 25. A steelhead "consumer reports diagram" for reach R1 (RM 0.0-0.5) of Rattlesnake Creek, a tributary of the White Salmon River. The registered dataset (BigWhite Removal4_21_04) was used. This diagram summarizes the relative impact of habitat factors on the survival of all life stages. The life stages are ranked with 1 representing the most severe impact relative to historical conditions.

Discussion

Applying the EDT model to the White Salmon River has been successful in organizing the available information and identifying data gaps. Stream reaches were designated for the model and they have been identified and reviewed (Appendix A). The best available information has been used to rate each attribute in each reach, and this information has been reviewed (Appendix A). The model has been run, along with scenarios describing potential future conditions. These EDT results were used to aid identification of key limiting factors (their type and location). The results of these scenarios have been used to guide the White Salmon River Subbasin Plan assessment and management plan (NPCC 2004). In the Subbasin Plan, the EDT results were used to help identify and prioritize restoration actions most likely to achieve specified biological objectives for a target population. The limiting factors described in this document, were also discussed in the White Salmon River Subbasin Plan, and were specifically linked to restoration actions that would help address these limiting factors.

As additional information is collected and evaluated, the model inputs may be refined, which may alter the outputs. As a tool, the model will need to be continually adapted to represent the more current understanding of the watershed and the relationship of the diagnostic fish species to the attributes of interest. Because the model and our understanding of the watershed are continually evolving and because access to the model is restricted until funding for its upkeep is arranged, no diagnostic model run should be considered as final.

There have been several suggested modifications to the dataset that have been described in this text and by attribute in Appendix A. In addition to these suggestions, another useful product might be a summary of the rationales for changes made by WDFW to the dataset titled "BigWhite Removal4_21_04" with a table detailing which reaches were changed and which attributes were changed. Lastly, when funding is secured for additional model runs, an output that is normalized for reach length may prove useful.

The White Salmon River above Condit Dam is currently capable of supporting all the diagnostic species (steelhead trout, spring and fall Chinook salmon, and coho salmon). In general, many of the habitat factors in the White Salmon River and its tributaries are healthy, with adequate food and oxygen throughout the system, essentially no detrimental chemicals or competition, few unscreened water diversions, and little concern for pathogens. The mainstem habitat was in better shape than the tributaries, with maximum temperatures, minimum temperatures, and dissolved oxygen remaining at optimum levels. However, our modeling effort indicated that there is potential for increasing the population performance of the diagnostic species in both the mainstem and tributaries. The environmental attributes with the most significant impact on population performance include: habitat diversity, key habitat quantity, sedimentation, channel stability, flow, and harassment/poaching. Some of the main differences in habitat condition, between the mainstem and tributary habitats, were an increase in maximum water temperatures, decrease in summer low flow, and more degraded riparian conditions in the tributaries. There was a lack of large woody debris and altered riparian conditions in both the mainstem and tributaries, which offer opportunities for restoration.

One must be mindful that the model describes the symptoms but not causes. So when restoration is recommended in certain reaches, often the way to restore those reaches is by doing improvements to the watershed upstream. Restoration measures designed to benefit one species will generally benefit the other diagnostic species.

As stated in Appendix F of the White Salmon River Subbasin Plan (NPPC 2004); validity of current EDT estimates can be assessed when long-term estimates of wild spawners, hatchery spawners, reproductive success of hatchery spawners, and smolts are available. The available information for the White Salmon River was insufficient for this type of analysis. However, in other basins within the Lower Columbia River and the Columbia River Gorge Provinces, the EDT-predicted estimates of smolt and adult performance are reasonably close to empirical estimates from WDFW population estimates (NPCC 2004). Since a similar approach was used in the White Salmon River, we believe the predicted performance of salmon and steelhead in the basin was reasonable.

Acknowledgements

The USGS portion of this work was funded by the Salmon Recovery Funding Board, Bonneville Power Administration and the Yakama Nation (YN). We would like to thank YN staff (Jeff Spencer, Bill Sharp, Greg Morris, Will Conley, Joe Zendt, Chris Fredrickson), WDFW staff (Dan Rawding, Steve Vanderploeg, Lee Van Tussenbrook, Carl Dugger, John Weinheimer, and Steve Manlow), USGS-CRRL staff (Sally Sauter, Brien Rose), Klickitat County Staff (Dave McClure, Domoni Glass, John Runyon, and Karen Kuzis), Tony Grover (NPPC), Robert McDonald (Normandeau Associates), Dick Nason, Klickitat Lead Entity Citizens Review Committee, and others who attended White Salmon River EDT workshops, and who provided data and rationale for this dataset. The staff at Mobrand Biometrics (Rick Paquette, Jen Garrow, Kevin Malone, and Greg Blair) provided assistance with running the EDT model.

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Appendix A: Documentation used in the Ecosystem Diagnosis and Treatment Model (EDT) for the White Salmon River Watershed.

Prepared by

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Dan Rawding (WDFW)

Originally Used as Appendix F of the White Salmon River Subbasin Plan on May 10, 2004

Modified by:
Brady Allen and Patrick Connolly (USGS)

December 30, 2004

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INTRODUCTION

This report summarizes the Ecosystem Diagnosis and Treatment Model (EDT) dataset for the White Salmon River. In this project we rated over 43 reaches with 45 environmental attributes per reach for current conditions and historical conditions. Over 4,000 ratings were assigned, however empirical observations within the reach are not available for all of these ratings. Development of the remaining data was accomplished by expansion of empirical observations where available. Where empirical observations were not available derived information was used. In some cases, where derived information was not available, expert opinion and hypothetical ratings were used. For example, if a stream width measurement existed for a reach and the reach upstream and downstream had similar characteristics, we then used the expansion of empirical information from the middle reach to estimate widths in the downstream and upstream reaches. For the fine sediment attribute, we could find no data within these watersheds, except that collected by G. Morris (YN) in Rattlesnake and Indian creeks. However, Rawding (unpublished 2003) established a relationship between road density and fine sediment in the Wind River watershed. We applied this relationship to White Salmon River reaches; this is an example of derived information. In some cases, such as bed scour, no data was available for these basins. However, data were available from Gobar Creek in the Kalama River and observations had been made in the Wind River. In those systems, we noted that bed scour was related to peak flow, gradient, stream width, and confinement. Based on these observations, expert opinion was used to generate a bed scour look-up table to be consistent across reaches and watersheds. For and explanation of the rationale behind each attribute rating, see the text below. For specific reach scale information, please see the EDT database for the Big White Salmon River, (http://www.mobrand.com/edt/).

Because access to the model is restricted until funding to Mobrand Biometrics is available, USGS-CRRL was not able to correct typographical errors or update the model with new information. Therefore, an attribute specific “suggested modifications” section was included for attributes where clarifying additional information or errors in the dataset have been found.

REACH DESIGNATIONS AND SPAWNING DISTRIBUTIONS

The task of defining reaches for an EDT analysis has three parts: defining the geographic scope, describing "environmentally homogeneous" reaches, and coding the hydrography of the basin – *viz.,* indicating the direction of water flow and the spatial relationship of tributaries such that they can be "understood" by a computer program (Mobrand 2002).

The geographic scope was defined as the locations in the White Salmon River that were expected to be historically accessible by anadromous fish or their progeny prior to the construction of Condit Dam. The reach breaks were defined based upon the locations of tributary junctions, changes in confinement, and potential fish barriers. In all, there were 18 reaches in the mainstem White Salmon River and 25 reaches for the tributaries (Table 1). While tributary junctions and obstructions were easily identifiable, establishing a reach break based on changes in confinement was more subjective. To determine the more subjective reach breaks, representatives from Washington Department of Fish and Wildlife and the Yakama Nation accompanied personnel from USGS's Columbia River Research laboratory on two occasions to the White Salmon River where these breaks were discussed and agreed upon by consensus.

Accessibility for anadromous salmonids into two of the tributaries, Little Buck and Mill creeks, is unknown. These creeks are in the inundated portion of the White Salmon River upstream of Condit Dam and may have waterfalls or cascades, under the reservoir, which could limit fish access. We did not find any historic information on anadromous fish access to these creeks prior to the building of Condit Dam, nor do the historic photos of dam construction show these creek mouths (PacifiCorp unpublished). However, the historic photos do show the topography upstream of the dam. This information indicates a high likelihood of basalt cliffs, which would cause a cascade or waterfall where Little Buck Creek enters the White Salmon River, making anadromous fish access unlikely. The 1912 bathymetry survey of the Condit Dam project (Vestra Resources Incorporated and Pacific Power and Light 1990) shows contour lines indicating a well-developed valley where Mill Creek joins the White Salmon River with a gradient of approximately 6.9%. There is effectively no valley where Little Buck Creek enters the White Salmon River and the gradient is approximately 14%. This supports the possibility of anadromous fish access into Mill Creek and not into Little Buck Creek. Little Buck and Mill creeks were included in a dataset USGS created in collaboration with WDFW. However, because historic and potential anadromous fish access into both creeks is not definitively known, the creeks were removed from analysis in the registered "BigWhite Removal4_21_04" dataset. Historical accounts of the distribution of anadromous fish include Rattlesnake, Indian, Spring and Buck creeks; we believe that this will also be the case once fish passage is established around Condit Dam. All barriers, whether natural or man-made, were attributed a 100% passage rating, except for Condit and Spring Creek dams, which were assigned a 0% passage rating. Further analysis of passage ratings would allow for a more accurate culvert rating and fish distribution.

Historical spawning distributions were estimated based on the life history, swimming/jumping ability of the diagnostic fish species, and our estimates of the historic channel condition in the reach of interest. Spawning distributions for the diagnostic fish species (steelhead trout, coho salmon, fall Chinook and spring Chinook salmon) are shown below (Figures 1-3). The registered fish population definitions, shown in Tables 2-5, were downloaded from MBI's EDT Online Fish Population Editor on 15 December 2004 (http://www.mobrand.com/edt/home.jsp?subbasinID=2). A population definition consists of the age structure and spawning, harvest, and migration patterns of a species. The Big White Salmon River watershed administrator (Dan Rawding, WDFW) collaborated with MBI to establish the diagnostic fish species population definitions. The Big White Salmon River Subbasin Plan (NPCC 2004) provides supporting information regarding the population definitions of each species.

Typically, spring Chinook salmon and summer steelhead spawn higher up in a basin, while fall Chinook and winter steelhead spawn lower in a basin. There is often a transition zone used by both races of Chinook salmon and both races of steelhead. For modeling purposes, registered populations may not have overlapping spawning reaches for the same species. Because summer and winter steelhead juvenile life history patterns in fresh water are likely very similar, a combined steelhead population was modeled. Fall Chinook and spring Chinook salmon are assumed to have different juvenile life history patterns and were modeled separately. The confluence of Little Buck Creek (WS5-WS6) was chosen to separate the two races of Chinook salmon. Due to the timing of entry into the tributaries of the White Salmon River, Chinook and coho salmon were given a reduced distribution compared to steelhead (Figures 1-3).

Table 1. White Salmon River EDT reach breaks, descriptions, and lengths

Reach name	Description	River miles	Length (mi)	Geographic area (river miles)
B1	Buck Creek mouth to diversion intake	(0.0 – 2.0)	2.0	Buck Creek
B2	Diversion intake to Buck Creek Falls 1	(2.0 - 3.2)	1.2	(0.0 - 3.2)
B3	Buck Creek Falls 1 to Buck Creek Falls 2	(3.2 – 4.0)	0.9	
B4	Buck Creek Falls 2 to end of anadromous distribution	(4.0 - 4.2)	0.2	
I1	Indian Creek mouth to Indian Creek culvert 1	(0.0 - 0.1)	0.1	Indian Creek
I2	Indian Creek culvert 1 to Indian Creek culvert 2	(0.1 - 0.8)	0.8	(0.0 - 1.9)
I3	Indian Creek culvert 2 to Indian Creek culvert 3	(0.8 - 1.1)	0.3	
I4	Indian Creek culvert 3 to Indian Creek culvert 4	(1.1 - 1.2)	0.1	
I5	Indian Creek culvert 4 to end of anadromous distribution	(1.2 - 1.9)	0.8	
LB1	Historic Little Buck Creek mouth to top of reservoir	(0.0 - 0.1)	0.1	Little Buck Creek
LB2	Top of reservoir to reach break	(0.1 – 1.0)	0.8	(0.0-2.2)
LB3	Reach break to end of anadromous distribution	(1.0 - 2.2)	1.2	
M1	Historic Mill Creek mouth to top of reservoir	(0.0 - 0.2)	0.2	Mill Creek
M2	Top of reservoir to Mill Creek culvert 1	(0.2 - 0.4)	0.2	(0.0-1.9)
M3	Mill Creek culvert 1to Mill Creek culvert 2	(0.4 - 1.1)	0.7	
M4	Mill Creek culvert 2 to end of anadromous distribution	(1.1 - 1.9)	0.9	
R1	Rattlesnake Creek mouth to Indian Creek confluence	(0.0 - 0.5)	0.5	Rattlesnake Creek
R2	Indian Creek confluence to Rattlesnake Creek Falls 1	(0.5 - 1.6)	1.2	(0-10.2)
R3	Rattlesnake Creek Falls 1 to end of confinement	(1.6 - 3.3)	1.6	
R4	End of confinement to upper confinement	(3.3 - 6.6)	3.3	
R5	Upper confinement to Rattlesnake Creek Falls 2	(6.6 - 10.2)	3.6	
R6	Rattlesnake Creek Falls 2 to end of anadromous distribution	(10.2 - 10.5)	0.4	
S1	Spring Creek mouth to dam	(0.0 - 0.7)	0.7	Spring Creek
S2	Pond behind Spring Creek dam	(0.7 - 0.8)	0.1	(0-1.1)
S3	Top of Spring Creek Pond to forks	(0.8 - 1.1)	0.3	
WS1	Mouth to first riffle-end of Bonneville Dam pool influence	(0.0 - 1.2)	1.2	Below Condit Dam
WS2	End of Bonneville Dam pool influence to Condit Powerhouse	(1.2 - 2.1)	0.9	(0 - 3.4)
WS3	Condit Powerhouse to Steelhead Falls	(2.1 - 2.7)	0.6	
WS4	Steelhead Falls to Condit Dam	(2.7 - 3.4)	0.7	
WS5	Condit Dam to Little Buck Ck.	(3.4 - 3.6)	0.2	Inundated
WS6	Little Buck Creek to Mill Creek	(3.6 - 4.1)	0.5	(3.4 - 4.9)
WS7	Mill Creek to end of deep reservoir	(4.1 - 4.9)	0.8	
WS8	End of deep reservoir to Buck Creek	(4.9 - 5.1)	0.2	Top of Reservoir
WS9	Buck Creek to Sandy Beach (first riffle)	(5.1 - 5.6)	0.5	to Husum Falls
WS10	Sandy Beach (first riffle) to Spring Creek	(5.6 - 6.8)	1.2	(4.9 - 7.9)
WS11	Spring Creek to Deadman's Corner	(6.8 - 7.5)	0.7	
WS12	Deadman's Corner to Rattlesnake Creek	(7.5 - 7.8)	0.3	
WS13	Rattlesnake Creek to Husum Falls	(7.8 - 7.9)	0.2	
WS14	Husum Falls to Sunshine (Big) Eddy	(7.9 - 9.9)	2.0	Husum to BZ
WS15	Sunshine (Big) Eddy to Diversion Hole	(9.9 - 10.3)	0.4	(7.9 - 13.2)
WS16	Diversion Hole to BZ Falls	(10.3 - 13.2)	2.9	
WS17	BZ Falls to Double Drop Falls	(13.2 - 14.4)	1.2	BZ to Big Brother
WS18	Double Drop Falls to Big Brother Falls	(14.4 - 16.5)	2.1	(13.2 - 16.5)

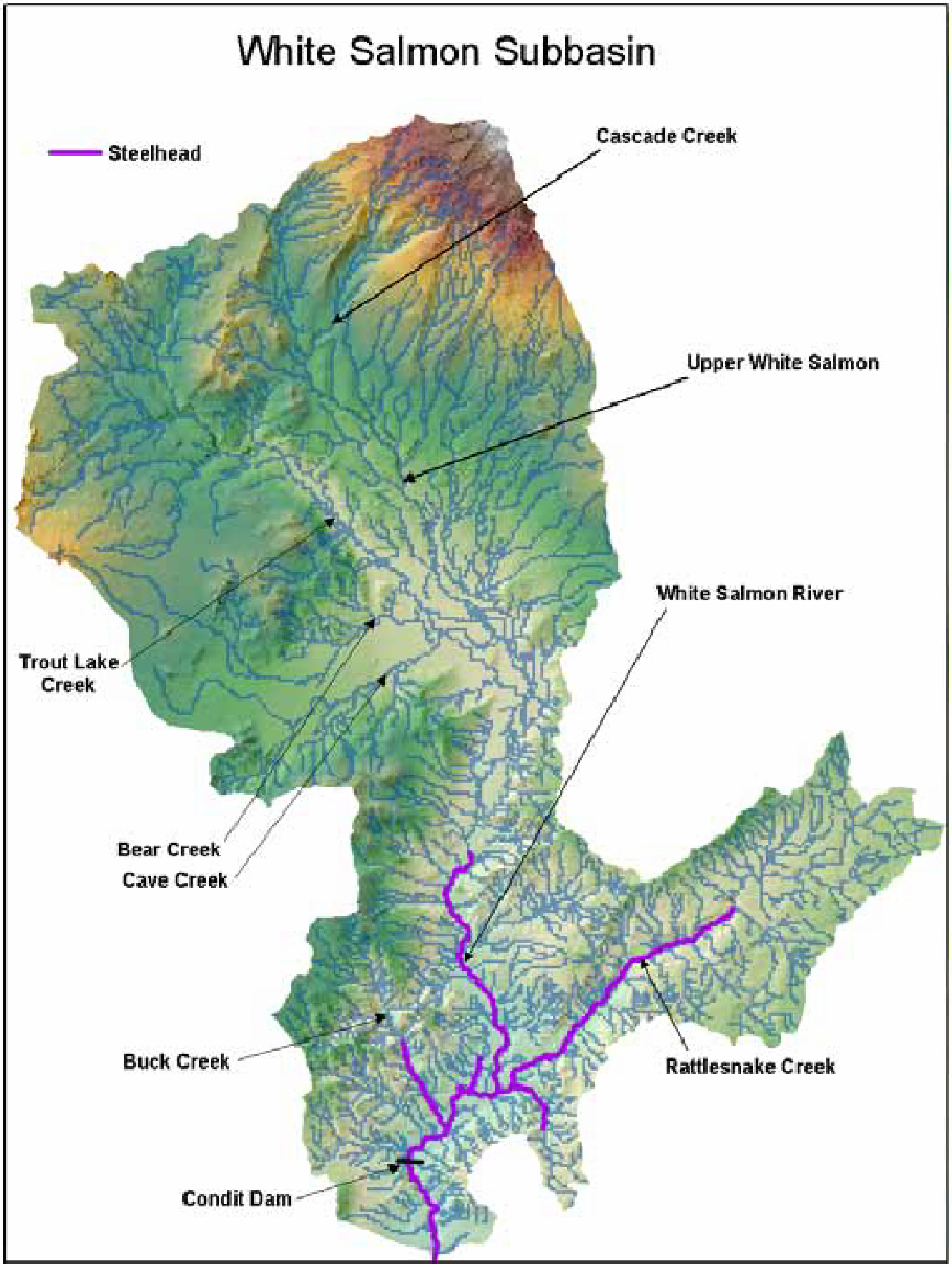

Figure 1. Estimated historic steelhead spawning distribution with passage around Condit Dam. Current spawning distribution is restricted to below Condit Dam. Figure from White Salmon River Subbasin Plan (NPCC 2004).

Table 2. Registered steelhead age structure, spawning reaches and timing, harvest pattern, and migration patterns for the White Salmon River EDT model. Downloaded from MBI's EDT Online Fish Population Editor on 15 December 2004. http://www.mobrand.com/edt/home.jsp?subbasinID=2

Population Name:	LWSRemoval	
Population Description:	Condit removal	
Stream Reach Dataset:	BigWhiteRemoval4_21_04	
Species:	Steelhead	
Spawning Reaches:	**Mainstem Reaches:**	**Tributary Reaches:**
	WS1_A	B1
	WS1_B	Bdiv
	WS2	B2
	WS3	I1
	Steelhead_Falls	ICulv1
	WS4	I2
	Condit_Dam	ICulv2
	WS5	I3
	WS6	ICulv3
	WS7	I4
	WS8	ICulv4
	WS9	I5
	WS10	R1
	WS11	R2
	WS12	RFalls1
	WS13	R3
	Husum_Falls	R4
	WS14	R5
	WS15	S1
	WS16	Sdam
	BZFalls	S2
	WS17	S3
	Double_Drop	
	WS18	
First Week of Spawning:	Mar 26 - Apr 1	
Last Week of Spawning:	May 28 - Jun 3	
Harvest Pattern:	L Col. Winter Steelhead	

Migration Pattern	**Percent**	**Adult Age**	**Juvenile Age**
Big White Salmon Winter Steelhead- Resident	30%	Big White Salmon Winter Steelhead	Big White Salmon Winter Steelhead
Big White Salmon Winter Steelhead- Transient	70%	Big White Salmon Winter Steelhead	Big White Salmon Winter Steelhead
Combined percentage:	100 %	(combined percentage must total 100%)	

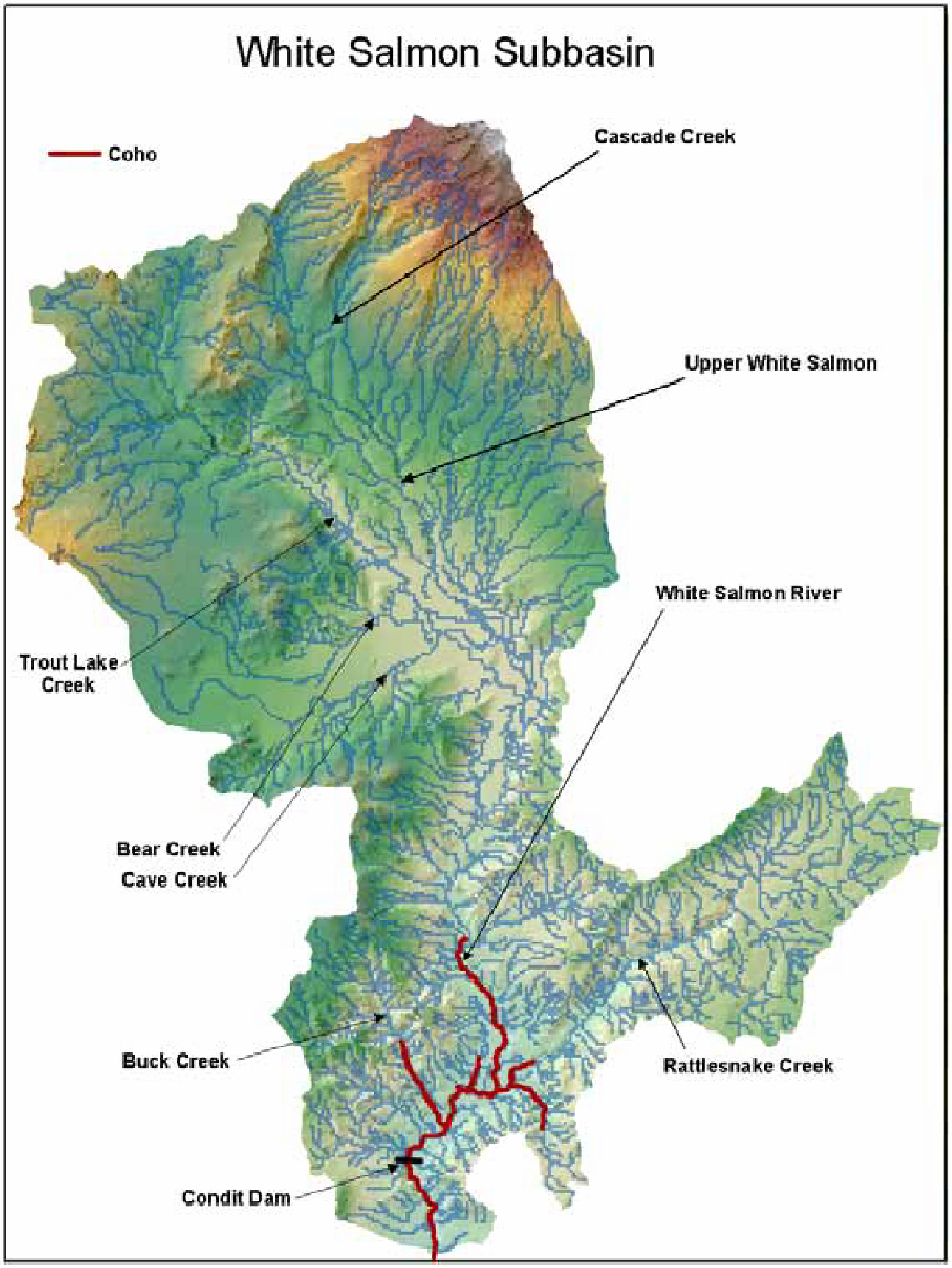

Figure 2. Estimated historic coho salmon spawning distribution with passage around Condit Dam. Current spawning distribution is restricted to below Condit Dam. From White Salmon River Subbasin Plan (NPCC 2004).

Table 3. Registered coho salmon age structure, spawning reaches and timing, harvest pattern, and migration patterns for the White Salmon River EDT model. Downloaded from MBI's EDT Online Fish Population Editor on 15 December 2004.
http://www.mobrand.com/edt/home.jsp?subbasinID=2

Population Name:	COHORemoval	
Population Description:	Condit removal after habitat reaches equilibrium 20 years	
Stream Reach Dataset:	BigWhiteRemoval4_21_04	
Species:	Coho	
Spawning Reaches:	**Mainstem Reaches:** WS1_A WS1_B WS2 WS3 Steelhead_Falls WS4 Condit_Dam WS5 WS6 WS7 WS8 WS9 WS10 WS11 WS12 WS13 Husum_Falls WS14 WS15 WS16	**Tributary Reaches:** B1 Bdiv B2 I1 ICulv1 I2 ICulv2 I3 ICulv3 I4 ICulv4 I5 R1 R2 S1 Sdam S2 S3
First Week of Spawning:	Oct 29 - Nov 4	
Last Week of Spawning:	Dec 23 - 31	
Harvest Pattern:	Lower Columbia Coho	

Migration Pattern	**Percent**	**Adult Age**	**Juvenile Age**
Big White Salmon Coho-Resident	50%	Big White Salmon Coho	Coho Juvenile Age
Big White Salmon Coho-Migrant	50%	Big White Salmon Coho	Coho Juvenile Age
Combined percentage:	100 %	(combined percentage must total 100%)	

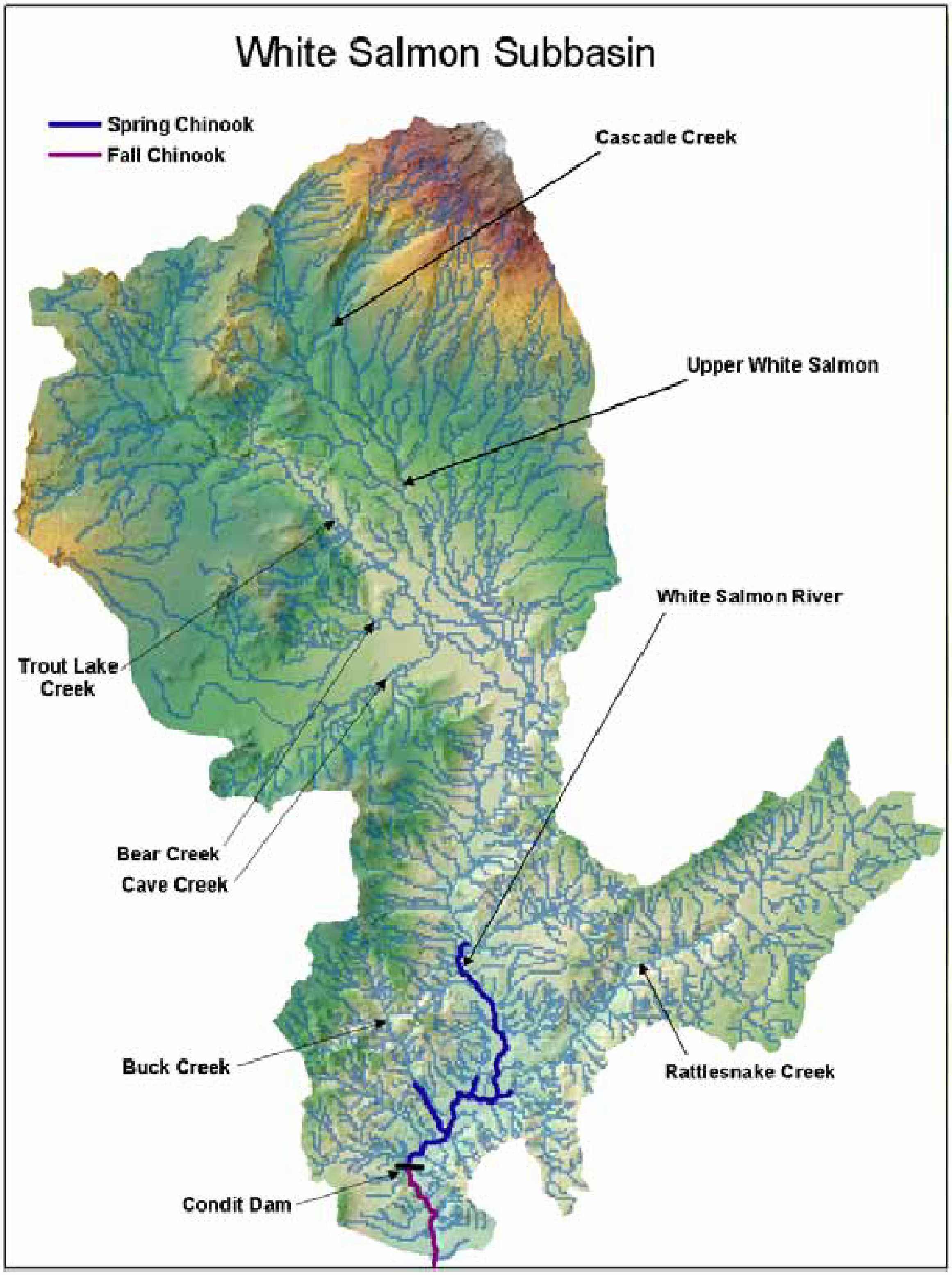

Figure 3. Estimated historic spring and fall Chinook salmon spawning distribution with passage around Condit Dam. Current spawning distribution is restricted to below Condit Dam. From White Salmon River Subbasin Plan (NPCC 2004).

Table 4. Registered fall Chinook salmon age structure, spawning reaches and timing, harvest pattern, and migration patterns for the White Salmon River EDT model. Downloaded from MBI's EDT Online Fish Population Editor on 15 December 2004. http://www.mobrand.com/edt/home.jsp?subbasinID=2

<table>
<tr><td colspan="2">Population Name:</td><td colspan="2">FCHINRemoval</td></tr>
<tr><td colspan="2">Population Description:</td><td colspan="2">Condit Removed</td></tr>
<tr><td colspan="2">Stream Reach Dataset:</td><td colspan="2">BigWhiteRemoval4_21_04</td></tr>
<tr><td colspan="2">Species:</td><td colspan="2">Fall Chinook</td></tr>
<tr><td colspan="2">Spawning Reaches:</td><td>Mainstem Reaches:

WS1_A
WS1_B
WS2
WS3
Steelhead_Falls
WS4
Condit_Dam
WS5</td><td>Tributary Reaches:</td></tr>
<tr><td colspan="2">First Week of Spawning:</td><td colspan="2">Sep 10 - 16</td></tr>
<tr><td colspan="2">Last Week of Spawning:</td><td colspan="2">Nov 5 - 11</td></tr>
<tr><td colspan="2">Harvest Pattern:</td><td colspan="2">Bonn Pool Hatch Fall Chin</td></tr>
<tr><td>Migration Pattern</td><td>Percent</td><td>Adult Age</td><td>Juvenile Age</td></tr>
<tr><td>Big White Salmon Fall Chinook- Transient</td><td>10%</td><td>Big White Salmon Fall Chinook</td><td>Fall Chinook Ocean type</td></tr>
<tr><td>Big White Salmon Fall Chinook- Spring Migrant</td><td>90%</td><td>Big White Salmon Fall Chinook</td><td>Fall Chinook Ocean type</td></tr>
<tr><td>Combined percentage:</td><td>100 %</td><td colspan="2">(combined percentage must total 100%)</td></tr>
</table>

Table 5. Registered spring Chinook salmon age structure, spawning reaches and timing, harvest pattern, and migration patterns for the White Salmon River EDT model. Downloaded from MBI's EDT Online Fish Population Editor on 15 December 2004. http://www.mobrand.com/edt/home.jsp?subbasinID=2

<table>
<tr><td colspan="2">Population Name:</td><td colspan="2">SpChinRemoval</td></tr>
<tr><td colspan="2">Population Description:</td><td colspan="2">Condit Removal</td></tr>
<tr><td colspan="2">Stream Reach Dataset:</td><td colspan="2">BigWhiteRemoval4_21_04</td></tr>
<tr><td colspan="2">Species:</td><td colspan="2">Spring Chinook</td></tr>
<tr><td colspan="2">Spawning Reaches:</td><td>Mainstem Reaches:
WS6
WS7
WS8
WS9
WS10
WS11
WS12
WS13
Husum_Falls
WS14
WS15
WS16</td><td>Tributary Reaches:
B1
R1
S1</td></tr>
<tr><td colspan="2">First Week of Spawning:</td><td colspan="2">Aug 6 - 12</td></tr>
<tr><td colspan="2">Last Week of Spawning:</td><td colspan="2">Sep 10 - 16</td></tr>
<tr><td colspan="2">Harvest Pattern:</td><td colspan="2">Spring Chinook</td></tr>
<tr><td>Migration Pattern</td><td>Percent</td><td>Adult Age</td><td>Juvenile Age</td></tr>
<tr><td>Big White Salmon Spring Chinook- Resident</td><td>50%</td><td>Big White Salmon Spring Chinook- Stream Type</td><td>Spring Chinook Stream type</td></tr>
<tr><td>Big White Salmon Spring Chinook- Transient</td><td>50%</td><td>Big White Salmon Spring Chinook- Stream Type</td><td>Spring Chinook Stream type</td></tr>
<tr><td>Combined percentage:</td><td>100 %</td><td colspan="2">(combined percentage must total 100%)</td></tr>
</table>

HYDROLOGIC CHARACTERISTICS

Hydrologic Regime

Hydrologic regime – natural

Definition: The natural flow regime within the reach of interest. Flow regime typically refers to the seasonal pattern of flow over a year; here it is inferred by identification of flow sources. This applies to an unregulated river or to the pre-regulation state of a regulated river.

Rationale: These watersheds originate on the southern slope of Mt. Adams. The maximum elevation is approximately 12,307 ft, which is above the elevation of substantial snow accumulation. The higher elevations in the White Salmon River exhibit a snow-melt pattern (USGS Trout Lake gauge). However, we rated the White Salmon River and its tributaries from BZ Corner downstream. These elevations are consistent with rain-on-snow transitional patterns based on the USGS Underwood Gauge and are classified as such. Therefore the reaches were given an EDT rating of 2 for the historic and current conditions. The exception to this is Spring Creek (S1 – S3), which is groundwater-source-dominated, and was given an EDT rating of 0 for the historic and current conditions.

Level of Proof: Expansion of empirical observations and derived information were used to estimate the current and historical conditions and the level of proof is thoroughly established (USGS gauge data) or has a strong weight of evidence in support but not fully conclusive (expanded USGS data).

Hydrologic regime – regulated

Definition: The change in the natural hydrograph caused by the operation of flow regulation facilities (e.g., hydroelectric, flood storage, domestic water supply, recreation, or irrigation supply) in a watershed. Definition does not take into account daily flow fluctuations (See Flow-intra-daily variation attribute).

Rationale: This attribute is not rated in the template condition, since there was no hydro-electric development. There is no evidence of change in the natural hydrograph above Northwestern Reservoir. Water retention time in Northwestern Reservoir was not available. However, based on acre-feet of storage (615 ac/ft, PacifiCorp 1996) and inflow data averaged monthly from 1915 to 2002 (USGS gauge in Underwood), the estimated water retention ranged from 0.3 to 0.5 days, and averaged 0.3 days. This converted to an EDT rating of 1. This rating for all reaches from the powerhouse to the mouth includes reach 1, which is also influenced by Bonneville. This rating does not apply to the bypass reach (WS3&4).

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

Flow Variation

Flow: change in interannual variability in high flows

Definition: The extent of relative change in average peak annual discharge compared to an undisturbed watershed of comparable size, geology, orientation, topography, and geography (or as would have existed in the pristine state). Evidence of change in peak flow can be empirical where sufficiently long data series exist, can be based on indicator metrics (such as TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development. Relative change in peak annual discharge here is based on changes in the peak annual flow expected on average once every two years (Q2yr).

Rationale: By definition the template conditions for this attribute are rated as a value of two because it describes the attribute rating for watersheds in pristine conditions. Direct measures of inter annual high flow variation are not available for most basins. USFS has conducted watershed analysis in the White Salmon River (USFS 1997). Peak flow analysis was conducted using the State of Washington "Standard methodology for conducting watershed analysis". The primary data used for the peak flow analysis is vegetation condition, elevation, road network, and aspect. The USFS found that compared to historical conditions, peak flows had increased up to 12% in the Upper White Salmon River, Trout Lake Creek, and Cave and Bear Creeks (USFS 1997a, USFS 1997b, and USFS 1996).

Peak flow in the White Salmon River as measured at the USGS Underwood gauge has increased (Figure 1). For the White Salmon River a change in Q2yr was estimated according to the methods in the EDT manual. A 10% increase in peak flow was estimated for the White Salmon River above the Underwood Gauge (USGS), which corresponds to an EDT rating of 2.3. Below RM 16, basin size is 195 sq miles with 675 miles of roads. This yields a road density of 3.5 mi/mi^2. The USFS Watershed Analysis of similar road densities suggested increase in peak flow of ~ 10%. This rating was applied to the remainder of the basin but if additional information for tributaries is available, it should be used.

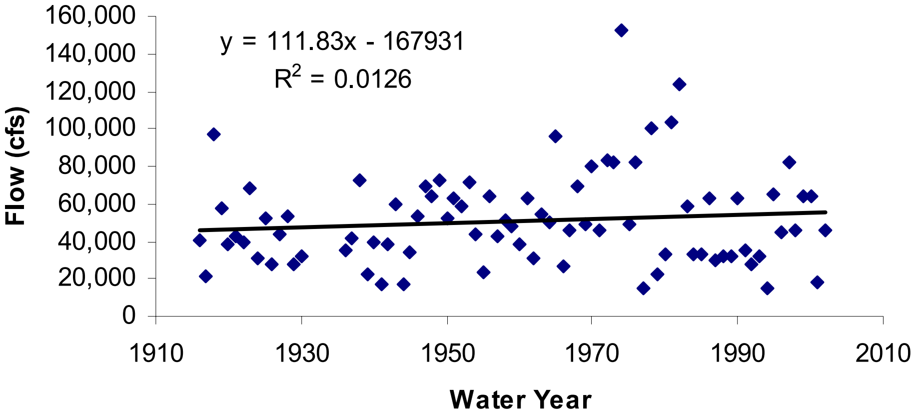

Figure 4. Peak discharge by water year in the White Salmon River measured at the Underwood Gauge by USGS.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Empirical information was used to estimate the current ratings for this attribute for the mainstem and derived information was used for the tributaries. The current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive.

Suggested modifications: Tributary road densities are provided for the sediment and embeddedness attributes. The same road densities could be used to refine peak flow increases in the tributaries.

Flow: changes in interannual variability in low flows

Definition: The extent of relative change in average daily flow during the normal low flow period compared to an undisturbed watershed of comparable size, geology, and flow regime (or as would have existed in the pristine state). Evidence of change in low flow can be empirically-based where sufficiently long data series exist, or known through flow regulation practices, or inferred from patterns corresponding to watershed development. Note: low flows are not systematically reduced in relation to watershed development, even in urban streams (Konrad 2000). Factors affecting low flow are often not obvious in many watersheds, except in clear cases of flow diversion and regulation.

Rationale: By definition the template conditions for this attribute are rated as a value of two because this describes the attribute rating for watersheds in pristine conditions. Research on the effects of land use practices on summer low flow is inconclusive (Spence et al. 1996). Therefore, we rated the template and current conditions the same (EDT rating of 2).

The bypass reach (WS3, WS4) has a minimum flow requirement of 15 cfs (Haring 2003). Low flow in the bypass reach is drastically reduced from the template condition. It received an EDT rating of 4.

Irrigation from the White Salmon River occurs in the Trout Lake valley, and Mt Adams Orchard withdraws water at Gilmer Creek, Glacier Creek, and Northwestern Reservoir. However, the water withdrawals relative to the inflow are believed to be small. Therefore, low flow was assumed to be the same as the template condition in the mainstem White Salmon River. At the top of Buck Creek reach 1 (B1), an irrigation diversion diverts up to 70% of flow, which yielded an EDT rating of 4. Further upstream the water was diverted for the city of White Salmon, although it is now an unused alternate source for the city. Young and Rybak (1987) reported that the lower water diversion removed 70% of water from Buck Creek.

A water right on Rattlesnake Creek can divert a substantial amount of flow and water may be used by landowners on Indian Creek. Based on this information we assumed slight reduction in low flow for both creeks, which is an EDT rating of 3.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive.

Suggested modifications: There are anecdotal reports of substantial reductions in low flow for Rattlesnake Creek compared to historic low flows (WWA 1997). Probable reasons include draining, ditching and down cutting of streams in the Panakanic plateau where historic headwater wetlands existed, and disassociation of the stream from its floodplain in much of the rest of Rattlesnake Creek. This analysis would benefit from obtaining the allocated and actual water withdrawals and then use the field estimates of summer low flow for Rattlesnake and Indian creeks (Connolly 2003) to complete the low flow calculation. However, a more thorough study of the reasons for reduced summer flows may be warranted.

Flow: intra-daily (diel) variation

Definition: Average diel variation in flow level during a season or month. This attribute is informative for rivers with hydroelectric projects or in heavily urbanized drainages where storm runoff causes rapid changes in flow.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes the attribute rating for watersheds in pristine conditions. For the majority of the watershed, impervious surfaces are low, and we assumed no change in this attribute.

Below Condit Dam, data from the Underwood USGS gauge, from 2-15-04 to 3-17-04, shows max hourly change of 4.3inches per hour resulting in an EDT rating of 2.1. Typical Condit Dam load factoring operations involve ramping from about 1400 cfs to approximately 800 cfs. This range of flow reduction would precipitate a concomitant stage change of 0.8 feet in Segment 2 (PacifiCorp 1994). Entrix's (1991) ramping rate evaluation (page 143) suggested the change in gauge height would occur over a 1-2 hour period. This would equate to 4.8 to 9.6 inches/hour. These correspond to EDT ratings of 2.3 to 3.1. For this analysis, we used an EDT rating of 2.6 for the WS2 reach.

For WS1, Bonneville operations can cause stage fluctuations up to 4.5 feet per day, but averaging 2-3 ft/day (PacifiCorp 1994). A 2 foot daily fluctuation if conducted in an even manner would equate to 1 inch/hour. This equates to an EDT rating of 1. We could find no information on diel variation in the bypass reach (WS3&4). We assumed diel variation was minimal in the reach, and it received an EDT rating of 0.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Empirical observations were used to estimate WS1 and WS2. Derived information was used to estimate the current ratings for this attribute in the remaining reaches and the level of proof has a strong weight of evidence in support but is not fully conclusive.

Suggested modifications: We suggest an individual monthly pattern be developed for diel variation. Hourly forebay elevation data from Bonneville Dam during 2002-2004 indicated elevation changes regularly occur up to 3.6 inches/hour and range from 0 to 10 inches/hour, this would equate to an updated EDT rating of 1.9 in reach WS1.

Flow: intra-annual flow pattern

Definition: The average extent of intra-annual flow variation during the wet season -- a measure of a stream's "flashiness" during storm runoff. Flashiness is correlated with % total impervious area and road density, but is attenuated as drainage area increases. Evidence for change can be empirically derived using flow data (e.g., using the metric TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development.

Rationale: By definition, the template conditions for this attribute are rated as a value of 2 because this describes the attribute rating for watersheds in pristine conditions. Similar to high flows, monthly and seasonal flow patterns have been affected by land use practices in this watershed. Since there was no data for this attribute, it was suggested that its rating should be similar to that for changes in inter-annual variability in high flows (L. Lestelle, Mobrand, Inc., personal communication).

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

STREAM CORRIDOR STRUCTURE

Stream Morphology

Channel length

Definition: Length of the primary channel contained within the stream reach. Note: this attribute will not be given by a category but rather will be a point estimate. Length of channel is given for the main channel only--multiple channels do not add length.

Rationale: The length of each reach was provided by Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP) GIS layers with the exception of R6, which was applied a field length (USGS unpublished data). We assumed the stream length was the same in both the historical and current conditions.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute for all reaches but R6, and the level of proof has a strong weight of evidence in support but is not fully conclusive, especially for historical length. Empirical observations were used to estimate the current ratings for this attribute for the reach R6, and the level of proof is thoroughly established.

Channel width – month minimum width

Definition: Average width of the wetted channel. If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: We assigned the same value for both the current and historical conditions, unless a major hydromodification within the reach affects stream width. Representative reaches in the White Salmon River watershed were surveyed by WDFW and USGS in 2003 (WDFW unpublished). Surveys were completed during a low-flow period in December and wetted widths corresponded to average summer low flows (August) in the mainstem White Salmon River, based on the USGS Underwood gauge data. Rattlesnake and Indian creeks were surveyed intensively from 2001 through 2004 during the summer months to measure average summer low flows (Connolly, 2003). Ratings for non-surveyed reaches were inferred by applying data from representative reach surveys with similar habitat, gradient and confinement, by measuring GIS aerial photos, or cited from PacifiCorp's FERC re-licensing document.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

Channel width – month maximum width

Definition: Average width of the wetted channel during peak flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: Wetted widths corresponding to average high flows were not measured as part of the habitat surveys conducted. Historical reaches were assigned the same value as the current condition for all reaches, unless a major hydromodification within the reach currently affects stream width.

VanderPloeg (2003) surveyed several tributaries of the Lower Columbia River and measured wetted widths during average low flows and average high flows. We compared the percent increase between low and high flow widths to the EDT (SSHIAP) confinement rating for each reach. Regression analysis demonstrated little correlation between confinement rating and percent increase in stream width. Mean increase in stream width was 60% after removing outliers for subterranean flow in the summer and Kalama questionable data. A possible explanation for this relationship is that all unconfined reaches in the dataset are downcut due to lack of large woody debris, which increases hydroconfinement. If maximum wetted width exceeded bankfull width using the multiplier it was capped at bankfull. For streams that have very low summer flows due to natural or manmade dewater, a 1.6 multiplier may under estimate stream widths. In confined reaches, a 1.2 multiplier was used based on review of some confined reaches in the dataset.

Level of Proof: A combination of empirical observations, expansion of empirical observations, derived information, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information, we expanded current empirical observations and the level of proof has theoretical support with some evidence from experiments or observations.

Gradient

Definition: Average gradient of the main channel of the reach over its entire length. Note: Categorical levels are shown here but values are required to be input as point estimates for each reach.

Rationale: The average gradient for each stream reach (expressed as % gradient) was calculated by dividing the change in reach elevation by the reach length and multiplying by 100. SSHIAP GIS segments layer (WDFW 2003) was used to provide the beginning elevation, ending elevation, and length for each EDT reach.

Average reach gradient was generated from SSHIAP GIS segments layer (WDFW 2003), by dividing the change in reach elevation by reach length. Reaches within Northwestern Lake (LB1, M1, and WS5-7) were given 0.1% gradient for current conditions. The M2 reach was visually estimated to be 3% in the field, which is considerably less than SSHIAP segments layer estimate. USGS surveyed Rattlesnake 1-6 and Indian 2 and 5, and the field-measured gradients were applied (USGS unpublished).

Historic gradient for the lake was generated by using GIS-provided elevations below Condit Dam and at the top of the lake. The difference in elevation was then divided by the total length from below Condit Dam to top of the lake. Elevations for historical mouths of Mill and Little Buck creeks were obtained by multiplying the calculated historical gradient by the length of each reach. Historical gradients for these two reaches were then calculated using GIS-provided reach lengths and derived historical elevations. For the remaining reaches, historical gradient was assumed to be the same as current.

Level of Proof: Empirical information was used for the field-measured reaches (R1-R6, I2, I5) and derived information (GIS) was used to estimate the current and historical ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive, especially for historical length. Professional opinion was used for the current rating for M2 and the level of proof has a strong weight of evidence in support but is not fully conclusive.

Suggested modifications: Ratings for the historic gradients of reaches that are within the lake (M1, LB1, and WS5 - WS8) could be refined by using the gradients generated from the 1912 bathymetry map (Vestra Resources Incorporated and Pacific Power and Light. October1990). Hand measurements of gradients using the bathymetry map give adjusted gradients as shown in Table 6. This could be further refined using a digitized bathymetry map and GIS.

Table 6. Suggested changes in historic gradient ratings for the reaches of the White Salmon River that are currently inundated by Condit Dam.

Reach	**Historic Gradient** (currently in model)	**Adjusted Historic Gradient** (suggested refinement)
LB1	4.5%	14.2%
M1	5.8%	6.9%
WS5	1.2%	1.9%
WS6	1.2%	1.3%
WS7	1.2%	0.6%
WS8	1.0%	0.7%

Confinement

Confinement – natural

Definition: The extent that the valley floodplain of the reach is confined by natural features. It is determined as the ratio between the width of the valley floodplain and the bankfull channel width. Note: this attribute addresses the natural (pristine) state of valley confinement only.

Rationale: Representative reaches in the White Salmon River watershed were surveyed by WDFW/USGS in 2003. Confinement ratings were estimated during these surveys (WDFW unpublished). In addition, SSHIAP confinement ratings for the watersheds were consulted. Field surveys noted discrepancies between GIS and field ratings. Washington Department of Natural Resources digital elevation maps (WDFW 2003) were consulted when SSHIAP ratings fell between the 0.5 increments to determine which rating should be applied. As described in table 3, EDT confinement ratings were developed by converting SSHIAP ratings of 1-3 to EDT ratings of 0-4:

Table 7. Conversion used to adjust SSHIAP confinement rating to EDT confinement rating.

Method	Rating				
SSHIAP	1	1.5	2	2.5	3
EDT	0	1	2	3	4

There are likely to be multiple SSHIAP segments per EDT segment. In those cases, the average SSHIAP confinement rating is calculated and then converted into an EDT rating.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive.

Confinement – hydromodifications

Definition: The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream's floodplain (due to streamside roads, revetments, diking or levees) or the extent that the channel has been ditched or channelized, or has undergone significant streambed degradation due to channel incision/entrenchment (associated with the process called "headcutting"). Flow access to the floodplain can be partially or wholly cut off due to channel incision. Note: Setback levees are to be treated differently than narrow-channel or riverfront levees--consider the extent of the setback and its effect on flow and bed dynamics and micro-habitat features along the stream margin in each reach to arrive at rating conclusion. Reference condition for this attribute is the natural, undeveloped state.

Rationale: In the historic condition (prior to manmade structures) reaches were fully connected to the floodplain. By definition, the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. Most hydromodification consists of roads and diking in the floodplain. We consulted the SSHIAP GIS roads layer (WDFW 2003), DNR digital ortho-photos (WDFW 2003), USGS maps, and WRIA 29 LFA (Haring 2003), and used professional judgment to assign EDT ratings.

Hydroconfinement occurs at the SR-14 Bridge (WS1), the fish-rearing raceways (WS2), houses on the mainstem above Buck Creek (WS9), road and houses below the confluence with Rattlesnake Creek (WS12), & a house and an old diversion near the Bend Hole (WS14). These reaches all received EDT ratings of 1. Hydroconfinement occurs on R1 due to road encroachment and downcutting. This reach received an EDT rating of 3. Hydroconfinement occurs at: B1 due to road and diking, B2 due to spotty road rip rap and I2-5, R4, and S1 due to downcutting. These reaches all receive EDT ratings of 1.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive.

Habitat Type

Habitat Types

Definition:
Backwater pools are the percentage of the wetted channel surface area comprising backwater pools.
Beaver ponds are the percentage of the wetted channel surface area comprising beaver ponds. Note: these are pools located in the main or side channels, not part of off-channel habitat.
Primary pools are the percentage of the wetted channel surface area comprising pools, excluding beaver ponds.
Pool tailouts are the percentage of the wetted channel surface area comprising pool tailouts.
Large cobble/boulder riffles are the percentage of the wetted channel surface area comprising large cobble/boulder riffles.
Small cobble/gravel riffles are the percentage of the wetted channel surface area comprising small cobble/gravel riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).
Glides are the percentage of the wetted channel surface area comprising glides. Note: There is a general lack of consensus regarding the definition of glides (Hawkins et al. 1993), despite a commonly held view that it remains important to recognize a habitat type that is intermediate between pool and riffle. The definition applied here is from the ODFW habitat survey manual (Moore et al. 1997): an area with generally uniform depth and flow with no surface turbulence, generally in reaches of <1% gradient. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. They are generally deeper than riffles with few major flow obstructions and low habitat complexity.

Rationale: B1, B2, M2, S1, WS8-16 were surveyed by WDFW/USGS in 2003 (WDFW unpublished). R1-6, I2 and I5 have been extensively surveyed by USGS (Connolly 2003). Habitat type composition was measured or estimated during these surveys. Ratings for non-surveyed reaches were inferred by applying data from representative reach surveys or averages of representative reach surveys with similar habitat, gradient and confinement. Comments are provided in the stream reach editor.

In WS1-4, during 1991, ENTRIX performed a Physical Ramping Study and provided maps of their results. Habitat types were measured in WS2-4 and the percentages were provided in the report. The construction of Bonneville Dam inundated portions of the lower White Salmon River corresponding to EDT reach WS1. Based on field observation the estimated habitat in this reach is 78% pool, 20% glide and 2% small gravel riffle.

The reservoir reaches are S2, WS5-7, M1 and LB1. These reaches are rated at 50% primary pool and 50% dammed pool for the current condition. Table 4 illustrates ratings inferred from surveyed reaches.

Table 8. Habitat-type inferences for the White Salmon Subbasin EDT model.

Unsurveyed reach(es)	**Inferred reach data**
WS17 & 18	WS16
S3	S1
B3	B1
B4	B2
M3 & 4	Average of M2, B1, B2 and S1
I1, 3 & 4	Average of I2 and I5
LB2 & 3	Average of B1 and B2

Habitat simplification has resulted from timber harvest activities. These activities have decreased the number and quality of pools. Reduction in wood and hydromodifications are primary causes for reduction in primary pools. Historic habitat type composition was estimated by examining percent change in large pool frequency data (Sedell and Everest 1991) and applying this to current habitat type composition estimates. On Germany Creek, the Elchoman River and the Grays River the frequency of large pools between 1935 and 1992 has decreased by 44%, 84%, and 69%, respectively. However, the frequency of large pools increased on the Wind River, but this is likely due to different survey times. The original surveys were conducted in November and the 1992 surveys were conducted during the summer, when flows are lower and pools more abundant.

In general, for historical conditions we assumed that the percentage of pools was slightly higher than the current percentage in the mainstem and significantly higher in the tributaries. This assumption was based on observations that geology (bedrock canyon) in the mainstem is the dominant characteristic in the forming and maintenance of pools. Therefore in the mainstem primary pools and gravel riffles slightly increased due to an increase in wood.

In the tributaries wood played a larger role in pool forming processes. In the tributaries with gradients less than 2%, historical pool habitat was estimated to be 50%, which is similar to pool frequency for good habitat (Petersen et al. 1992). For habitats with gradients 2-5% and greater than 5% we estimated pool habitat to be 40% and 30% respectively (DNR 1994).We assumed that tail-outs represent 15 – 20% of pool habitat, which is the current range from WDFW surveys. Glide habitat decreased as gradient increased (Mobrand 2002). Habitat surveys on the Washougal River demonstrated a strong relationship between gradient and glides and this regression was used to estimate glide habitat, which ranged from 25% at gradients less than 0.5%, to 6% for gradients greater than 3%. Riffle habitat was estimated by subtracting the percentage of pool, tailout, and glide habitat from 100%. This yielded a relationship where the percentage of riffle habitat decreased, and cobble/boulder riffle habitat increased with stream gradient. The percentage of gravel riffles compared to the total riffle habitat ranged from over 60% at gradients of less than 1%, to 15% at gradients greater than 6%. Surveys done by WDFW indicated backwater and dammed habitat increased as gradient decreased. For historical ratings, unconfined low gradient reaches were assumed to have some of these habitat types, and expert opinion was used to assign ratings.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute. Stream surveys allowed accurate classification of fast water (riffles) and slow water (pools and glides) habitat. However, there was likely inconsistency in distinguishing pools from glides and this is likely to affect coho production due to this species' extended freshwater rearing and preference for pools. The level of proof for current ratings has a strong weight of evidence in support but is not fully conclusive. We expanded empirical observations and used expert opinion for historical information and the level of proof has theoretical support with some evidence from experiments or observations.

Habitat types – off-channel habitat factor

Definition: A multiplier used to estimate the amount of off-channel habitat based on the wetted surface area of the all combined in-channel habitat.

Rationale: When rivers are unconfined they tend to meander across their floodplains forming wetlands, marshes, and ponds. These are considered off-channel habitat. Confined and moderately confined reaches (Rosgen Aa+, A, B, and F channels [Rosgen 1994, Rosgen 1996]) typically have little or no off-channel habitat. Off-channel habitat increases in unconfined reaches (Rosgen C and E channels). An EDT rating of 0 was assigned to Aa+ and A channels, a rating of 0 to 1 for B channels, while low gradient C channels were assigned EDT ratings of 1 to 2 for the current rating and 2 to 3 for the historical rating. The White Salmon River is very confined and little off-channel habitat was believed to exist except historically in reach WS1 at the mouth. Old photographs suggested that limited off-channel habitat was historically present.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

Obstructions

Obstructions to fish migration

Definition: Obstructions to fish passage by physical barriers (not dewatered channels or hindrances to migration caused by pollutants or lack of oxygen).

Rationale: Falls and culverts were identified based on local knowledge and SHHIAP data. Due to time constraints, all falls and culverts were assumed to have 100% passage. Exceptions to this are Spring Creek Dam and Condit Dam, which were rated as 0% passage.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive.

Suggested modifications: Completing fish passage analysis at all waterfalls, diversions and culverts would allow a more detailed analysis.

Water withdrawals

Definition: The number and relative size of water withdrawals in the stream reach. This attribute identifies risk of a fish species being entrained or injured by screening or other structures associated with withdrawals of water from stream courses.

Rationale: No water withdrawals occurred in the pristine condition.

There is only one large withdrawal on the mainstem White Salmon River, and that is at Condit Dam (above WS4). A large proportion of the total flow is sent through an unscreened diversion into turbines. The WS4 reach received an EDT rating of 3.

Several small irrigation pumps in WS 14, 15 and 16, appear screened; entrainment probability is considered low and these reaches received EDT ratings of 1. There is an unscreened irrigation withdrawal at the top of B1, where up to 70% of flow is claimed. Young and Rybak (1987) reported that the lower water diversion removed 70% of water from Buck Creek, which is one of the largest anadromous tributaries in the basin. The B1 reach received an EDT rating of 3.

There is an unscreened withdrawal in Spring Creek at the top of S1 that diverts all flow and appears to empty into a plunge pool directly below the dam. S1 received an EDT rating of 1. There are only three recorded water rights for the Rattlesnake Creek area, two of which are for groundwater and one is a surface water right for 166 acre/feet/yr in EDT reach R5 of Rattlesnake Creek (WPN 2003). It is an unscreened irrigation withdrawal and the water right exceeds low summer flow. R5 received an EDT rating of 2. All other reaches were rated at 0

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

Riparian and Channel Integrity

Bed Scour

Definition: Average depth of bed scour in salmonid spawning areas (i.e., in pool-tailouts and small cobble-gravel riffles) during the annual peak flow event over approximately a 10-year period. The range of annual scour depth over the period could vary substantially. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).

Rationale: No bed scour data was available for this subbasin. Historic bed scour ratings were determined by applying gradient, confinement, and wetted width-high ratings to a bed scour look-up table developed by Dan Rawding (WDFW unpublished). Current bed scour ratings were increased by 5% for every 0.1 increase in EDT peak flow rating and 5% for each 1.0 increase in EDT hydroconfinement rating.

The exception to this is the groundwater reaches of Spring Creek, which receive a rating of 1. In reaches inundated by Northwestern Lake, scour was rated as 0. In WS1, where scour was likely decreased due to inundation from Bonneville pool, ratings were reduced to 50% of current. In the by-pass reach (WS3 & 4) bed scour was reduced by 50% from historic due to decreased flows. There was some contention about bed scour in the reach above the deep reservoir of Northwestern Lake (WS8). For this reach, bed scour was not increased for peak flow, and confinement ratings were reduced for use with the look-up table and the bed-scour rating remained the same at an EDT value of 2.0.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

Icing

Definition: Average extent (magnitude and frequency) of icing events over a 10-year period. Icing events can have severe effects on the biota and the physical structure of the stream in the short-term. It is recognized that icing events can, under some conditions, have long-term beneficial effects to habitat structure.

Rationale: These watersheds are rain-on-snow dominated. Anchor ice and icing events are likely to be rare based on elevations in the watersheds of interest. Therefore, EDT ratings of 0 were assigned to all reaches in the historical and current condition.

Level of Proof: Derived information was used to estimate the ratings for this attribute and the level of proof is theoretical with some evidence of support. The most uncertainty for this attribute is the upper elevations of tributaries.

Suggested modifications: Icing could be possible in the R5 and R6 reaches because the elevation in these reaches ranges from approximately 1000 ft to 1500 feet above sea level. This would adjust the rating from 0 to 1 indicating some anchor ice may occur infrequently, having little or no impact to physical structure of stream, in-stream structure, and stream banks/bed.

Riparian

Definition: A measure of riparian function that has been altered within the reach.

Rationale: By definition, the template conditions for this attribute are rated as a value of zero because this describes the attribute rating for watersheds in pristine conditions. The following rules were developed for use in EDT analysis for the Lower Columbia River tributaries. These rules were also used as guidelines in rating the White Salmon River subbasin for EDT riparian function values.

Riparian zones with mature conifers are rated at 0.0 - 1.0 depending on floodplain connectivity. Riparian zones with saplings and deciduous trees are rated at 1.5 due to loss of shade and bank stability. Riparian zones with brush and few trees would be rated as 2.0. For an EDT rating to exceed 2.0, residential developments or roads need to be in the riparian zone. Therefore, for current conditions, if the riparian area has trees, it should have an EDT rating of 2.0 or less.

Most vegetated riparian zones with no hydro-confinement should be rated as a 1.0 - 1.5. Where hydro-confinement exists, rating is adjusted from rules based on percent hydro-confinement and the rating is increased based on lack of vegetation. Key reaches were established for current riparian function throughout the watershed. Other reaches were referenced to these key reaches to develop a final EDT rating. Reservoir riparian habitat has substantially changed from the historical condition but is still very functional. It should be noted there was debate on the rating of riparian function in the mainstem White Salmon River. Some thought the ratings should be decreased to zero due to mature conifers and no natural floodplain.

Level of Proof: There is no statistical formula used to estimate riparian function. Therefore, expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

Wood

Definition: The amount of wood (large woody debris or LWD) within the reach. Dimensions of what constitutes LWD are defined here as pieces >0.1 m diameter and >2 m in length. Numbers and volumes of LWD corresponding to index levels are based on Peterson et al. (1992), May et al. (1997), Hyatt and Naiman (2001), and Collins et al. (2002). Note: channel widths here refer to average wetted width during the high flow month (< bank full), consistent with the metric used to define high flow channel width. Ranges for index values are based on LWD pieces/CW and presence of jams (on larger channels). Reference to "large" pieces in index values uses the standard Timber Fish Wildlife (TFW) definition as those > 50 cm diameter at midpoint.

Rationale: Density of LWD equals pieces/length * width. Template condition for wood is assumed to be 0 for all reaches, except the large canyon sections on the White Salmon River, which are assumed to be 2 because these confined reaches would have difficulty accumulating large amounts of wood. Template conditions for Rattlesnake and Indian creeks were assumed to be 2 due to eastside climate and vegetation. To determine current EDT ratings we used survey data listed below. USGS surveyed all wood pieces measured to be >10 cm diameter and 2 m length counted within bankfull width in 20 meter increments for all of Indian Creek's I2 and I5 and Rattlesnake Creek's R1-R6. USGS and WDFW (unpublished) counted wood pieces visually estimated to be >10 cm diameter and 2 m length within the wetted width (12-18-03) in reaches WS16-8. USGS and WDFW (unpublished) counted wood pieces visually estimated to be >10 cm diameter and 2 m length within the wetted width (12-23-03) while surveying representative length of reaches B1, B2, M1, M2, S1, and S2.

For 'west-side' tributary reaches lacking data (B3&4, M3&4, and LB1-3), we used the average rating from Spring, Buck, and Mill Creeks, which was 2.8. For 'east-side' tributary reaches lacking data (I1, I3 and I4), we used the average rating from Rattlesnake and Indian creeks, which was 3.1. For mainstem reaches lacking data, we used average rating for mainstem reaches surveyed (3.8). Since there are no reservoir rules, Northwestern Lake was rated at 2 due to aquatic vegetation and submerged wood, and S2 was rated at 3 for aquatic vegetation.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information, derived information was used to estimate the ratings for this attribute and the level of proof is thoroughly established.

Suggested modifications: Indian Creek is north facing and has a climate pattern more similar to the 'west-side' tributaries than to upper Rattlesnake Creek. Currently there are large cedar and Douglas fir trees and stumps in the riparian area, and the vegetation is more similar to Spring and Buck creeks than to upper Rattlesnake Creek. Therefore, this would suggest an historic EDT rating for Indian Creek that is more similar to the ratings of the 'west-side' tributaries. This would be an adjustment from the current rating of 2 for all reaches of Indian Creek to a rating of 0 in lower Indian Creek, possibly adjusting to a rating of 1 in I4 and I5 due to increased confinement and gradient. The R1 and R2 reaches should have a rating of 0 to 1, because the climate and vegetation patterns in Rattlesnake Creek tend to "feather" towards an 'east-side' pattern in the upper drainage, with much of the watershed in a transition between west- and east-side climates.

Sediment Type

Fine Sediment (intragravel)

Definition: Percentage of fine sediment within salmonid spawning substrates, located in pool-tailouts, glides, and small cobble-gravel riffles. Definition of "fine sediment" here depends on the particle size of primary concern in the watershed of interest. In areas where sand size particles are not of major interest, as they are in the Idaho Batholith, the effect of fine sediment on egg to fry survival is primarily associated with particles <1 mm (e.g., as measured by particles <0.85 mm). Sand size particles (e.g., <6 mm) can be the principal concern when excessive accumulations occur in the upper stratum of the stream bed (Kondolf 2000). See guidelines on possible benefits accrued due to gravel cleaning by spawning salmonids.

Rationale: In the template (pristine) condition, SW Washington watersheds were assumed to have had between 6% and 11% fines (Peterson et al. 1992), which corresponds to an EDT rating of 1. Rawding (WDFW unpublished) found as road densities increased by 1 mile per square mile, the percent fine sediment in spawning gravels increased by 1.3% in the Wind River. To rate percent fines in the current condition, a scale was developed relating road density to percent fines. Individual sub-watershed polygons were created to obtain the following sub-watershed road densities and EDT Ratings described in table 5.

Table 9. Estimates of percentage of fines in the White Salmon River from the road density model and conversion to EDT fine sediment rating.

Sub-Watershed	**Road Density (mi/mi^2)**	**EDT Rating**
Indian Creek	3.27	1.8
Little Buck Creek	4.60	2.0
Mill Creek	4.31	2.0
Buck Creek	5.05	2.0
Spring Creek	3.28	1.8
Rattlesnake Creek	3.54	1.8
White Salmon River above Condit Dam	3.25	1.8

Exceptions to this rule were: fines were increased in S1 due to visual survey from 1.8 to 2; fines below Condit Dam (WS2, WS3, and WS4) remained at the template condition based on information from sampling below the Merwin project that indicated fines dropped out in the reservoir. Reservoir and inundated tributaries had a rating of 4.

Level of Proof: Expert opinion was used to estimate the historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. Derived information was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations

Embeddedness

Definition: The extent that larger cobbles or gravel are surrounded by or covered by fine sediment, such as sands, silts, and clays. Embeddedness is determined by examining the extent (as an average %) that cobble and gravel particles on the substrate surface are buried by fine sediments. This attribute only applies to riffle and tailout habitat units and only where cobble or gravel substrates occur.

Rationale: Peterson et al. (1992) estimated fines to be 6% to 11% in the template (pristine) condition, which is an EDT rating of 1. Under these same conditions we assumed embeddedness was less than 10%, which corresponds to an EDT rating of 0.5.
Rawding (WDFW unpublished) found as road densities increased by 1 mile per square mile, the percent fine sediment in spawning gravels increased by 1.3% in the Wind River. To rate percent fines in the current condition, a scale was developed relating road density to percent fines. Using fines as a surrogate for embeddedness, EDT ratings were developed. Individual sub-watershed polygons were created to obtain the following sub-watershed road densities and EDT Ratings described in table 6.

Table 10. Estimates of percentage of fines in the White Salmon River from the road density model and conversion to EDT embeddedness rating.

Sub-Watershed	Road Density (mi/mi^2)	EDT Rating
Indian Creek	3.27	0.7
Little Buck Creek	4.60	0.8
Mill Creek	4.31	0.8
Buck Creek	5.05	0.8
Spring Creek	3.28	0.7
Rattlesnake Creek	3.54	0.7
White Salmon River above Condit Dam	3.25	0.7

Exceptions to this rule were: fines were increased in S1 due to visual survey from 0.7 to 0.9; fines below Condit Dam (WS-2, 3, &4) remained at the template condition based on sampling information from below the Merwin project that indicated fines dropped out in the reservoir. Reservoir and inundates tributaries had ratings of 0.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

Turbidity (suspended sediment)

Definition: The severity of suspended sediment (SS) episodes within the stream reach. (Note: this attribute, which was originally called turbidity and still retains that name for continuity, is more correctly thought of as SS, which affects turbidity.) SS is sometimes characterized using turbidity but is more accurately described through suspended solids; hence the latter is to be used in rating this attribute. Turbidity is an optical property of water where suspended, including very fine particles such as clays and colloids, and some dissolved materials cause light to be scattered; it is expressed typically in nephelometric turbidity units (NTU). Suspended solids represents the actual measure of mineral and organic particles transported in the water column, either expressed as total suspended solids (TSS) or suspended sediment concentration (SSC)—both as mg/L. Technically, turbidity is not SS but the two are usually well correlated. If only NTUs are available, an approximation of SS can be obtained through relationships that correlate the two. The metric applied here is the Scale of Severity (SEV) Index taken from Newcombe and Jensen (1996), derived from: $SEV = a + b(\ln X) + c(\ln Y)$, where, X = duration in hours, Y = mg/L, $a = 1.0642$, $b = 0.6068$, and $c = 0.7384$. Duration is the number of hours out of month (with highest SS typically) when that concentration or higher normally occurs. Concentration would be represented by grab samples reported by USGS. See rating guidelines.

Rationale: Suspended sediment levels in the template (pristine) condition were assumed to be at low levels, even during high flow events. An EDT rating of 0, 0.3, and 0.5 were assigned to all small tributary, medium tributary, and mainstem reaches.

Turbidity (mg/L) from water quality monitoring was 35, 25, and 90 mg/L for the White Salmon River, Gilmer Creek, and Rattlesnake Creek. Since these were grab samples, the duration of values is unknown. Using SEV index assuming short duration (1-24 hours), these values yield EDT ratings of 0.4-0.9, 0.3-0.8, and 0.7-1.1, respectively. For current conditions, mainstem reaches were rated as 0.7 and smaller tributaries 0.3.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

Suggested modifications: Although there were many turbidity and suspended sediment measurements recorded by various agencies, few were taken during a flushing flow event and none recorded the duration of the event. These ratings should be re-visited if new measurements become available that include the duration of high suspended sediment events because the duration has not been measured in the past and would substantially alter the rating for any given watershed.

WATER QUALITY

Temperature Variation

Temperature – daily maximum (by month)

Definition: Maximum water temperatures within the stream reach during a month.

Rationale: The Underwood Conservation District, U. S. Geological Survey and Yakama Nation placed thermographs (temperature loggers) in various locations within the White Salmon River watershed during the summers of 1995-1999 and year-round from 2000 through 2003 (UCD, USGS, YN, unpublished data). Mainstem reaches with thermographs are: WS1, WS2, WS11, and above WS18. Tributary reaches with thermographs are: R1, R2, R3, R4, R5, I2, B1, and B2. This data was entered into the EDT temperature calculator provided by Mobrand, Inc. to produce EDT ratings for July and August. To develop maximum temperature ratings for the remaining months, we used the template monthly pattern "Temperature maximum pattern in rain-on-snow transitional stream" for Little Buck, Mill, Buck, Rattlesnake, and Indian creeks. The template monthly pattern of "Temperature maximum pattern in groundwater dominated stream" was used for Spring Creek, and "Temperature maximum pattern in glacial melt dominated system" was used for the mainstem White Salmon River.

The EDT ratings generated by the temperature calculator were used for reaches with a temperature logger present, and ratings for other reaches were inferred/extrapolated from these based on proximity and similar gradient, habitat, and confinement. If temperature loggers were mid-reach, we used the reading for the entire reach. If temperature loggers were at the end of the reach and evidence from other temperature loggers above indicated there was cooling within the reach (as you move upstream), professional judgment was used to develop an average for the reach. The same logic was applied to reaches without temperature loggers located between reaches with temperature loggers – ratings from reaches with temperature loggers were "feathered" for reaches in between. Readings from loggers at the end of a reach were used to estimate the rating for the reaches downstream.

Specifically we used the following expansions. Reaches B3, B4, LB2, M2, and M3 were assumed equal to B2. The reaches LB3 and M4 were decreased 0.1 based on increased elevation and distance upstream. Reaches LB1, M1, and WS3- WS8 were assumed equal to WS2. Reaches S1- S3 and WS9- WS18 were assumed equal to WS11. Reaches I2- I4 were assumed to be equal to I1 and I-5 was rated 0.1 lower due to increased elevation and distance upstream from thermograph.

Historical maximum stream temperature data was limited in the White Salmon River. The Regional Ecosystem Assessment Project estimated the range of historical maximum daily stream temperatures for the Lewis at 15-19 C, the Hood/Wind at 7-20 C (USFS 1993). However, this broad range was not very informative for historical individual reach scale temperatures. The only historical temperature data that we located were temperatures recorded in the 1930's and 1940's while biologists inventoried salmon abundance and distribution (WDF 1951). Since this data consisted of spot measurements and many basins had already been altered by human activity, it was not useful in estimating maximum water temperatures. Stream temperature generally tends to increase in the downstream direction from headwaters to the lowlands because air temperature tends to increase with decreasing elevation, groundwater flow compared to river volume decreases with elevation, and the stream channel widens decreasing the effect of riparian shade as elevation decreases (Sullivan et al. 1990).

To estimate historical maximum temperature, human activities that effect thermal energy transfer to the stream were examined. Six primary processes transfer energy to streams and rivers: 1) solar radiation, 2) radiation exchange with the vegetation, 3) convection with the air, 4) evaporation, 5) conduction to the soil, and 6) advection from incoming sources (Sullivan et al. 1990). The four primary environmental variables that regulate heat input and output are: riparian canopy, stream depth, local air temperature, and groundwater inflow. Historical riparian conditions along most stream environments in the White Salmon River and its tributaries consisted of old growth forests. Currently most riparian areas are dominated by immature forest in the lower portions of many rivers. Trees in the riparian zone have been removed for agriculture, and residential or industrial development (Haring 2003). Therefore, on average, historical maximum temperatures should be lower than current temperatures.

A temperature model developed by Sullivan et al. (1990) assumed there is a relationship between elevation, percentage of shade and the maximum daily stream temperature. This model was further described in the water quality appendix of the current Washington State Watershed Analysis Manual (WFPB 1997). Elevation of stream reaches is estimated from USGS maps. The sky view percentage is the fraction of the total hemispherical view from the center of the stream channel. To estimate the sky view we used the estimated maximum width and assumed that trees in the riparian zone were present an average of 5 meters from the maximum wetted width. Next we assumed that the riparian zone would consist of old growth cedar, hemlock, Douglas fir, and Sitka spruce. Mature heights of these trees are estimated to be between 40 to 50 meters for cedar and 60 to 80 meters for Douglas fir (Pojar and MacKinnon 1994). For modeling, we used 49 meters as the average riparian tree height within the western hemlock zone and a canopy density of 85% was assumed (Pelletier 2002). The combination of the height of the bank and average effective tree height was 40 meters for old growth reaches. A relationship was developed between forest shade angle and bankfull width. To estimate the percentage of shade we used the relationship between forest angle and percentage of shade (WFPB 1997 Appendix G-33). Finally we used the relationship between elevation, percentage of shade and the maximum daily stream temperature to estimate the maximum temperature (Sullivan et al. 1990, page 204 Figure 7.9). This information was used to establish the base for historical water temperature. These were converted to EDT ratings based on a regression of EDT ratings to maximum temperatures.

The percentage shade from old growth forests in Oregon was estimated to be 84% (Summers 1983) and 80% to 90% in western Washington (Brazier and Brown 1973). For small streams our estimates of stream shade were similar. In comparison to Pelletier (2002), our historical temperatures were slightly lower in small tributaries and slightly higher in the lower mainstem reaches. These differences are not unexpected, since our simplistic temperature model used only elevation/air temperature, and shade, while Pelletier (2002) used QUAL2K, which includes other parameters. We recommend more sophisticated temperature models be used in future analysis because they more accurately estimate temperatures. However due to limited resources available for this study, the shade/elevation model was used for consistency with other EDT efforts in the Lower Columbia River.

Level of Proof: A combination of derived information and expert opinion was used to estimate the historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive.

Suggested modifications: The model assumed western Washington canopy densities; this could be adjusted for eastern Washington vegetation for Rattlesnake Creek historical. Johnson (2002) found a historic median canopy density of 65% for NE Washington. Because the climate of the Rattlesnake Creek watershed is not as dry as the area surveyed by Johnson, he recommended an intermediate canopy density between western Washington and eastern Washington may be most representative of Rattlesnake Creek historic canopy density. We also recommend more sophisticated temperature models be used in future analysis to more accurately estimate temperatures.

Temperature – daily minimum (by month)

Definition: Minimum water temperatures within the stream reach during a month.

Rationale: The Underwood Conservation District, U. S. Geological Survey and Yakama Nation placed temperature loggers in various locations within the White Salmon River watershed during the summers of 1995-1999 and year round in 2000-2003 (UCD, USGS, YN, unpublished data). Mainstem reaches with thermographs are: WS1, WS2, WS11, and above WS18. Tributary reaches with thermographs are: R1, R2, R3, R4, R5, I2, B1, and B2. Thermograph data was consolidated to number of days below 4 C and 1 C by month. It was then entered into an Excel spreadsheet provided by Chris Fredrickson of the Yakama Nation (Fredrickson unpublished), which generates EDT ratings and monthly patterns.

As with daily maximum temperatures, ratings were expanded into adjacent and similar reaches. Spring Creek has no thermograph data and significant groundwater input. Therefore temperatures were assumed not to exceed EDT standards. WS2 rating was expanded to WS3, and WS4. WS11 ratings expanded from WS5 to WS18. B1 and B2 (1.6) expanded to the remaining Buck Creek reaches, as well as Mill, and Little Buck Creeks. R5 expanded to R6. I2 was expanded to remaining Indian Creek reaches. Historic ratings were assumed to be the same as current ratings.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. Expert opinion was used to estimate historic ratings.

Suggested modifications: The rating in the inundated sections of Mill (M1) and Little Buck Creeks (LB1) are expanded from Buck Creek. They should be rated the same as the Northwestern reservoir reaches (a change from 1.6 to 1.2). This is only valid for the "No Passage" dataset with the reservoir in place. Because Mill and Little Buck creeks were removed from the analysis by WDFW until fish passage can be verified, this suggested adjustment to the stream reach editor will not alter the results.

Temperature – spatial variation

Definition: The extent of water temperature variation within the reach as influenced by inputs of groundwater.

Rationale: Historically there was likely significant groundwater input in low gradient, unconfined to moderately confined reaches of the White Salmon River tributary watersheds. Higher gradient reaches of the tributaries higher in the watershed likely had less groundwater input. We found limited data on the current or historical conditions for groundwater input. In the current condition, groundwater input in low gradient, unconfined to moderately confined reaches low in the watershed has likely been reduced by current land use practices. The removal of wood from the mainstem and tributaries has reduced pool depths that may have provided coldwater refugia.

Specific reach rationale for ratings is presented below. Instream flow analysis shows no flow accretion below Condit Dam (PacifiCorp 1994). Diversion of the majority of flow in the bypass reach and lack of gravel recruitment has left several deep pools with the opportunity to stratify. Therefore the bypass reach was rated at 2 and the reach below the powerhouse at 4. Historically, these areas would have fast turbulent water due to higher flows (Entrix 1991) and were rated at 4. Currently, WS1 has stratification due to pooling effects of Bonneville Dam and was rated at 3.

There are abundant springs entering the reaches WS18 and WS17. This also occurs to a lesser extent in reaches WS16 and WS15. These spring sources have probably not changed much from historic. EDT ratings were 0 for WS17 and WS18, 1 for WS16, and 2 for WS15. Northwestern Lake is deep enough to stratify and provide coldwater refugia, particularly in its downstream reaches, and was rated at 0. Groundwater inputs are present in upper Buck Creek, and this reach was rated at 2 (G. Morris-YN, personal communication). EDT ratings were reduced for lower Buck Creek reaches.

Indian and Rattlesnake Creeks have lost their historic deeper pools due to the removal of pool forming structures (WWA 1997). These factors have reduced the thermal refugia that historically occurred. The upper Panakanic Plateau of Rattlesnake Creek historically had large wetlands, beaver ponds, and a higher water table, which slowed and retained flow longer into the summer. This would have allowed for more groundwater infiltration, providing more spring influence in the lower reaches of Rattlesnake Creek particularly during low flow periods. Currently, the plateau has been ditched, wetlands have been drained, cattle have compacted the land surface, and streams have down cut, thereby lowering the water table and reducing the opportunity for recharge of subsurface flows. Additionally Indian and Rattlesnake Creeks have lost their historic deeper pools due to the removal of pool forming structures (WWA 1997). These factors have reduced the thermal refugia that historically occurred.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

Chemistry

Alkalinity

Definition: Alkalinity, or acid neutralizing capacity (ANC), measured as milliequivalents per liter or mg/L of either HCO_3 or $CaCO_3$.

Rationale: Alkalinity (Hardness, HCO_3) in the historic condition was given the same value as the current condition. Current alkalinity levels were measured by UCD at Buck and Rattlesnake creeks, below Trout Lake Valley, at BZ, and below the White Salmon River bypass reach. Alkalinity was also measured by USGS, WDOE, and USBOR. These measurements were used to rate these reaches. Where alkalinity (mg/L) was not measured but conductivity (µs/cm) was, the following conversion was used: ALK = 0.421* CON - 2.31 developed by Ptolemy (1993).

Reaches without data were rated based on similar or adjacent reaches with measurements. Empirical estimates were available for B1, R1, WS2, WS14, WS5, above WS18, and R4. These estimates were expanded to adjacent reaches.

Level of Proof: A combination of empirical information, expansion of empirical information and derived information was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

Dissolved oxygen

Definition: Average dissolved oxygen (DO) within the water column for the specified time interval.

Rationale: Dissolved oxygen in the template (historic) condition was assumed to be unimpaired with an EDT rating of 0. Current USGS/UCD water quality data have no DO measurements less than 8 mg/L in the mainstem White Salmon River, or the tributaries Buck, Rattlesnake, and Indian creeks. No records were found for Little Buck, Mill, and Spring creeks. All reaches assumed to have EDT rating of zero.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

Metals – in water column

Definition: The extent of dissolved heavy metals within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Currently no toxicity is expected due to dissolved heavy metals to salmonids under prolonged exposure. Arsenic, copper, lead, and zinc were routinely sampled at the mouths of White Salmon River, Buck, and Rattlesnake creeks as well as at BZ and WS below TLV. Of these, total levels were below analytical detection limits for all except arsenic, which was well below EPA drinking water standards and DOE aquatic life criteria. Key references are Stampfli (1994) and PacifiCorp (1996).

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information, derived information and expert opinion were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

Metals/Pollutants – in sediments/soils

Definition: The extent of heavy metals and miscellaneous toxic pollutants within the stream sediments and/or soils adjacent to the stream channel.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Currently, all reaches were assumed to be at natural (background) levels except WS5 and WS8, which had low levels of metals and pollutants and were rated at 1.

The only data available for this analysis were lake sediments. Stratified random boring of lake sediments measured metal concentrations, as well as pesticides and herbicides. Metals tested: Antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, silver, thallium, zinc. Uppermost sediment samples were below both Provincial Sediment Quality Guidelines (PSQG, no effect - severe effect), and EPA ranges for non-polluted sediments, except mercury in the 7.4-foot sample (0.52 ppm exceeded the no effect - severe effect guideline of 0.2-2 in the region near the dam). "A comparison of the detected concentrations indicates that, in general, the metal concentrations in the reservoir sediments are below levels of concern. The exception is the elevated concentrations detected in the 10-ft zone of Area 4 (upper reservoir near boat launch). According to the PSQG, the sediment collected from this zone barely exceeded the "No Effect" limit for cadmium, chromium and mercury. Copper, nickel, and zinc all fall into the "Moderately Polluted" category. According to these guidelines, the lead contamination indicates "Heavy Pollution" also considered "Heavy Pollution" by the EPA Region V guidelines. Mercury concentration generally exceeded guideline values, but were considered background concentrations, also true for nickel and copper."
Dioxin, pentachlorophenol, gasoline, diesel, PCB, PAH, Volatile Organic Compounds, PP metals were not found. Chlorinated pesticides were detected in mid-level sediments (area 1, 2, 3 (mid-way between Buck and Mill creeks), but not in shallow or deep sediments (basically deposited during the period of use [banned 20 yrs ago]) (PacifiCorp 1994).

Level of Proof: A combination of empirical observations, expansion of empirical observations and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support because of the lack of data except in the reservoir reaches.

Miscellaneous toxic pollutants – water column

Definition: The extent of miscellaneous toxic pollutants (other than heavy metals) within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. The current conditions were assumed to be the same as the template condition. Current levels are unknown except in the reservoir and reaches B1, R1, WS2, WS16, and WS18. Dioxin, pentachlorophenol, gasoline, diesel, PCB, PAH, Volatile Organic Compounds, PP metals were sampled for and not found. Chlorinated pesticides were detected in mid-level sediments (area 1, 2, 3 (mid-way between Buck and Mill creeks), but not in shallow or deep sediments (basically deposited during the period of use [banned 20 yrs ago]) (PacifiCorp 1994).

Stampfli (1994) lists the acres of each land use type within each basin and types and quantities of chemicals used by each land use type. Relative water quality concern is listed for each chemical used. There are several chemicals applied to forestland and orchards that were of high concern for water quality.

Level of Proof: In the reaches with measurements empirical observations were used to estimate the ratings. In the reaches with no measurements, expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support because of the lack of data.

Nutrient enrichment

Definition: The extent of nutrient enrichment (most often by either nitrogen or phosphorous or both) from anthropogenic activities. Nitrogen and phosphorous are the primary macronutrients that enrich streams and cause buildups of algae. These conditions, in addition to leading to other adverse conditions such as low DO, can be indicative of conditions that are unhealthy for salmonids. Note: care needs to be taken when considering periphyton composition since relatively large mats of green filamentous algae can occur in Pacific Northwest streams with no nutrient enrichment when exposed to sunlight.

Rationale: Actual data (collected as chlorophyll a concentrations) for this attribute was unavailable. Historically nutrient enrichment did not occur because watersheds were in the "pristine" state. To determine the amount of nutrient enrichment in various reaches the following features were examined: fish rearing ponds, visual surveys for presence of filamentous algae in shaded areas, fecal coliform levels associated with agriculture and septic tanks.

There is a USFWS fish-rearing pond present in the WS2 reach, which qualifies this reach as an EDT rating of 1. There is significant cattle presence in the Panakanic plateau of Rattlesnake Creek. Upper Rattlesnake Creek has exceeded fecal coliform standards regularly; however large mats of filamentous green algae typically are not seen. The entire creek was given an EDT rating of 0.5 to indicate that nutrient enrichment is higher than historic levels, yet not high enough to give a rating of 1.

In lower Buck Creek, several surveyors reported the smell of sewage, likely small nutrient enrichment from houses adjacent to the creek. This reach has exceeded fecal coliform standards regularly; therefore the B1 reach was given an EDT rating of 0.5. The reaches adjacent to Northwestern Lake were increased slightly to a rating of 0.3 to indicate the increased nutrient input from the houses adjacent to the reservoir.

The White Salmon River below Trout Lake Valley has exceeded fecal coliform standards regularly (RM18.2 = exceeded 53% of the time). However, dilution from water contributed by springs reduces nutrient enrichment levels from WS17 down. Therefore the entire length of the White Salmon River was given an EDT rating of 0.2 as a placeholder to indicate that nutrient enrichment is higher than historic but not enough to give an EDT rating of 1. Key references for this attribute are Hennelly et al. (1994), USFS (1995, 1996) and UCD unpublished data.

Level of Proof: A combination of expansion of empirical observations and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information, this attribute is rated 0 by definition and the level of proof is thoroughly established.

Suggested modifications: The fecal coliform data used for this rating are about 10 years old and changes have likely occurred since the last measurements. A new round of water quality measurements that include chlorophyll a concentrations along with fecal coliform concentrations would provide data in the correct format for input into the model.

BIOLOGICAL COMMUNITY

Community Effects

Fish community richness

Definition: Measure of the richness of the fish community (number of fish taxa, i.e., species).

Rationale: Historic fish community richness was estimated from the current distribution of native fish in these watersheds; personal communications with professional fish biologists and other personnel familiar with fish behavior and habitat preferences; and historical accounts as referenced in the Panakanic Watershed Analysis report (WWA 1997). Current fish community richness was estimated from direct observation (stream surveys and electrofishing), referenced reports, personal communications with professional fish biologists and other personnel familiar with these areas, and local knowledge. Some of the referenced reports are: Connolly (2002), Connolly et al. (2001), Hardisty et al. (1971), Moyle (2002), PacifiCorp (1996), Thiesfeld (2001), WWA (1997), Wydoski et al. (1979). Page 3-16 of the FERC FEIS document (PacifiCorp 1996) has a table listing anadromous and resident fish species in the White Salmon River from the mouth to Condit Dam. Page E-3-4, Tables E-4, E-5, list of salmonids and non-salmonids and their lifestage use of the White Salmon River below Condit Dam split into segments 1 (bridge to first riffle), 2 (first riffle to powerhouse), and 3 (powerhouse to Condit Dam). Page 235 and subsequent maps of the Panakanic Watershed Analysis contain information on current and historic salmonid distribution obtained from historic accounts (WWA 1997). A spreadsheet summarizing the list of species obtained from the listed data sources was developed (Allen unpublished).

Using the sources mentioned above we think 36 species are found in the Bonneville inundated section (WS1). Most of these fish likely drop out in the WS2 reach as gradient increases and water temperatures are reduced. The list includes fish such as mirror carp and goldfish. We do not think that these fish inhabit the mouth of the White Salmon River in meaningful numbers; however they may be present in small numbers. Because we used integer EDT rankings, the exact number of species present is less critical, therefore these species remained on the list. In the majority of rankings the presence or absence of a few fish species in either the historic or current scenarios does not change the ranking. However, in a few instances the ranking could change. For example, the presence of longnose dace is presumed in the mainstem White Salmon River above Husum Falls. If this species is not present, the current ranking would change from a 1 to a 0. Additional information is needed to be certain of some species distributions.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information a combination of empirical observations, historical accounts, and professional opinion was used to estimate ratings and the level of proof has a strong weight of evidence in support but is not fully conclusive.

Suggested modifications: Brook trout were collected in reaches S1, S2, and S3 (Theisfeld 2001). This would change the current rating from a 0 to a 1 for the S2 and S3 reaches.

Fish pathogens

Definition: The presence of pathogenic organisms (relative abundance and species present) having potential for affecting survival of stream fishes.

Rationale: For this attribute the release of hatchery salmonids is a surrogate for pathogens. In the historic condition there were no hatcheries or hatchery outplants and we assumed an EDT rating of zero.

Due to the large number of 'dip ins' in the Bonneville Pool inundated area and the rearing pond operations within the last decade in WS2, reaches WS1 and WS2 received an EDT rating of 3. Due to the lesser number of strays and rearing pond effects, reaches WS3 and 4 received ratings of 2. Northwestern Lake is regularly stocked with rainbow trout therefore by definition received a rating of 2. The adjacent tributary reaches and mainstem reaches also received a rating of 2.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information, expansion of empirical observations and expert opinion were used to estimate the ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations thoroughly established.

Fish species introductions

Definition: Measure of the richness of the fish community (number of fish taxa). Taxa here refers to species.

Rationale: By definition, the template conditions for this attribute are rated as a value of 0 because this describes the attribute rating for watersheds in pristine conditions. Introduced species were derived from current fish species richness data (see Fish Community Richness above). Because we have more certainty about the number of introduced fish in each reach, the data precision of this attribute was rated non-categorically. Additional sources are detailed below:

Bair et al. (2002) stated that brook trout are a non-indigenous species to the White Salmon River and although hatchery outplants have been discontinued, brook trout have established naturally reproducing populations above Condit Dam. In Connolly (2002) on Page A-45, Table 8 documented the presence of brook trout (n=1) in the R2 section of Rattlesnake Creek. Data also includes all fish species found in the Rattlesnake Creek Basin during two years of intensive electrofishing.

On page 3-16 of the FERC FEIS document (PacifiCorp 1996), table 3-5 lists anadromous and resident fish species in the White Salmon River from the mouth to Condit Dam. Page E-3-4, Tables E-4 and E-5 list salmonids and non-salmonids and their life stage use of the Whites Salmon River below Condit Dam split into segments 1 (bridge to first riffle), 2 (first riffle to powerhouse), and 3 (powerhouse to Condit Dam).

Of the six species of anadromous fish that are believed to inhabit the lower White Salmon River below Condit Dam (Table 3-5 cited above), one species, the American shad, is non-native to the lower White Salmon River. One of the three resident salmonids, the brook trout, is non-native, and 13 of 24 resident non-salmonids are non-native. Of the non-native species cited above, only the lepomis spp. (n=2) are documented (table e-5 cited document above) above the first riffle section (WS2 and WS3). This account is questionable due to the cold turbulent water that would need to be passed to get to those reaches and was not included until the accuracy of the information in the table can be verified.

To the best of our knowledge brook trout are the only non-indigenous fish species present above Condit Dam. Although their precise distribution and population within the watershed is largely unknown at this time, we believe that they inhabit all mainstem reaches and all tributary streams below residential fish barriers.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information, this attribute is rated 0 by definition and the level of proof is thoroughly established.

Suggested modifications: Because brook trout have been collected in Spring Creek reaches S1, S2, and S3 (Thiesfeld 2001), the “patient” rating should be changed from 0 to 0.5 in those reaches.

Harassment

Definition: The relative extent of poaching and/or harassment of fish within the stream reach.

Rationale: In the historic condition (prior to 1850 and European settlement), harassment levels were assumed to be low. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. The exception to this is where there were known Native American fishing locations or longhouses. These include reaches I1, R1, R2, R4, WS1, and WS14 and were rated at 4.

Harassment is high in all White Salmon River reaches from the mouth to BZ due to fishing below Condit Dam, recreation use in the lake, and whitewater use from BZ to Northwestern Lake. These reaches were given an EDT rating of 4. Reaches above BZ have limited access but also see limited kayak use (EDT=1). A road runs along Buck and Rattlesnake creeks (EDT=2). Other tributaries considered low (EDT =1). Inundated reaches in Little Buck and Mill Creeks were considered high due to reservoir activity. Bypass reach has less harassment (EDT=3).

Level of Proof: There is no statistical formula used to estimate harassment. Therefore, expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

Hatchery fish outplants

Definition: The magnitude of hatchery fish outplants made into the drainage over the past 10 years. Note: Enter specific hatchery release numbers if the data input tool allows. "Drainage" here is defined loosely as being approximately the size that encompasses the spawning distribution of recognized populations in the watershed.

Rationale: By definition, the template conditions for this attribute are rated at a value of 0 because this describes the attribute rating for watersheds in pristine conditions. In the historic condition (prior to 1850 and European settlement), there were no hatcheries or hatchery outplants.

WDFW releases trout into Northwestern Lake annually, which are caught up to Sandy beach. WDFW/USFWS releases anadromous fishes below the lake. WS1-9 were given an EDT rating of 4.

Level of Proof: For current and historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

Predation risk

Definition: Level of predation risk on fish species due to presence of top level carnivores or unusual concentrations of other fish eating species. This is a classification of per-capita predation risk, in terms of the likelihood, magnitude and frequency of exposure to potential predators (assuming other habitat factors are constant). NOTE: This attribute is being updated to distinguish risk posed to small-bodied fish (<10 in) from that to large bodied fish (>10 in).

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. The magnitude and timing of yearling hatchery smolt and trout releases, and increases in exotic/native piscivorous fishes were considered when developing this rating. In general, reaches from Condit

Dam to the Sandy Beach were rated 3 due to the potential of increased predation from hatchery and native rainbow trout. In WS1, introduced fishes and northern pike minnow increased predation relative to historical and was rated at and EDT=4. In WS2, effects from introduced fishes and northern pike minnow are reduced, and the reach was given an EDT rating of 2.5.

Level of Proof: There is no statistical formula used to estimate predation risk. A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information, expansion of empirical observations and expert opinion were used to estimate the ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations thoroughly established.

Salmon carcasses

Definition: Relative abundance of anadromous salmonid carcasses within watershed that can serve as nutrient sources for juvenile salmonid production and other organisms. Relative abundance is expressed here as the density of salmon carcasses within subdrainages (or areas) of the watershed, such as the lower mainstem vs. the upper mainstem, or in mainstem areas vs. major tributary drainages.

Rationale: Historic carcass abundance was estimated based on the distribution of anadromous fish in the watershed. Reaches with historic chum presence (spawning) were given a rating of 0. Mainstem reaches with Chinook and coho salmon, but no chum salmon were given a rating of 2. Reaches with only coho were given a rating of 3. Reaches with only cutthroat or steelhead were given a rating of 4, since these fish are iteroparus (repeat spawners).

For the current condition, the twelve-year average (Harlan 2003) for fall Chinook salmon escapement was 1729 from the powerhouse down. This is an average of 809 carcasses per mile in reaches WS1 and WS2, which corresponds to an EDT rating of 0. Carcasses were not counted in WS3 and WS4 but were assumed to be in the range of 25 to 200, giving an EDT rating of 3.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this.

Macroinvertebrates

Benthos diversity and production

Definition: Measure of the diversity and production of the benthic macroinvertebrate community. Three types of measures are given (choose one): a simple EPT count, Benthic Index of Biological Integrity (B-IBI)—a multimetric approach (Karr and Chu 1999), or a multivariate approach using the BORIS (Benthic evaluation of ORegon RIverS) model (Canale 1999). B-IBI rating definitions from Morley (2000) as modified from Karr et al. (1986). BORIS score definitions based on ODEQ protocols, after Barbour et al. (1994).

Rationale: No direct measures of benthos diversity were available for these watersheds. We assigned an EDT rating of "0" and assumed that in the historic condition macroinvertebrate populations were healthy, diverse, and productive and in the natural/pristine state.

Disturbed and undisturbed Rosgen B channel reaches on the Wind River had B-IBI scores of 44 (EDT=0.6). We assumed the same on the White Salmon River and its tributaries. Degraded C channels in the Wind River had B-IBI scores of 1.5. This rating was applied to Indian, Rattlesnake, and Spring creeks since they may have lower B-IBI scores due to reduced summer flows, increased temperature, and sediment.

The B-IBI score in Northwestern Lake and Spring Creek pond are unknown. We assumed the habitat was degraded for stoneflies. We used an EDT rating of 2.6, which was derived from B-IBI scores on Cedar Creek (tributary of North Fork Lewis River with high levels of fines).

Level of Proof: Expansion of empirical observations, derived information, and expert opinion were used to estimate the current and historical conditions and the level of proof is thoroughly established or has a strong weight of evidence in support but not fully conclusive.

Suggested modifications: The Underwood Conservation District (UCD) has collected aquatic insects in the R1, R3, R4, and WS12 reaches for a stable isotope study funded by Bonneville Power Administration. As of December 20, 2004, the UCD has a draft report available that lists the species found in these reaches. This information was not available when this EDT model was being populated. After a cursory look at the list of species and the EDT attribute rating, it is doubtful that the ratings would change.

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Appendix B: Level 1 information used in the Ecosystem Diagnosis and Treatment Model (EDT) for the White Salmon River Watershed

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Table of Contents:

Introduction

This appendix lists level 1 information gathered from sources that were later used to develop level 2 ratings for the EDT model. The USGS-CRRL and WDFW collaborated to populate the EDT model. This appendix includes the information collected by USGS-CRRL personnel. The contact for WDFW information is Dan Rawding. Attributes for which USGS-CRRL had no useful referenced information are not included in this appendix and a more thorough rationale for the rating of each attribute is included in the main body of this report.

Reach lengths and barriers

References:

Upper distribution of trout in Rattlesnake Creek is at 4 m-high falls at rkm 16.6 (USGS-CRRL), UTM Coordinates = northing 5081502, easting 0628374, el 423 +-9m.
The distance from the mouth of the White Salmon River to Condit Dam is 3.23 miles. (Encon Corporation 1973)
Steelhead Falls at RM 2.8 is not a major obstacle to spring chinook, steelhead or lamprey. 15-foot falls at RM 16, "double drop". RM 16.17, 13-foot waterfall. RM 16.2, 21-foot waterfall "Big Brother". (Chapman et al. 1990)

Chapman et al. (1990) and WDF et al.(1989) both describe two major water diversions in the Buck Creek watershed that are estimated as not passable (at river mile 3.9 for White Salmon city water supply and at river mile 1.9 for irrigation). WDF et al. (1989) also stated that there is a natural impassable fish barrier at river mile 3.8.

WDF et al. (1989) stated in reference to Mill Creek that "At RM 0.8, a five-foot natural falls will probably limit upstream migration for salmon but steelhead should be able to pass".

WDF et al. (1989) described a man-made dam at RM 0.7 on Spring Creek as an upstream barrier to fish migration.

WDF et al. (1989) stated that "a 6-12-foot high falls may be a partial barrier to upstream-bound fishes at certain flows". They also stated that at "RM 12.4, a fifteen-foot-high falls is a partial barrier to upstream migration at some flows. A series of falls near RM 16.2 presents a major obstacle to upstream-bound anadromous salmonids at all flows. At RM 16.2, a two-tiered falls consisting of a 21-foot-high crest and a lower notch, 16.5 feet high (Crawford 1985) is regarded as the upstream limit to salmon migration. However, steelhead might have negotiated the falls under favorable flows. Affidavits signed by long-time residents in Trout Lake area indicated that large salmonids were seen upstream of the falls before Condit Dam was in place." These fish may have been either steelhead or large resident rainbow trout.

Hydrologic regime – regulated

References:

Average annual amounts of surface water used in White Salmon by domestic=1 cfs, irrigation= 4.3 cfs, industry =1.3 cfs, other =0.1 cfs. Total claimed 261.8 cfs/ average annual 7 day low flow 500 cfs. (Encon Corporation 1973, p.77.)

Within the White Salmon River watershed there are 25 water right certificates recorded with annual allowances greater than 100 AFY. Seventeen of these rights are for surface water withdrawal and the remaining eight are for groundwater withdrawal. An exact detailed list of allocated water rights for the White Salmon River is described in table c-9. There are only three recorded water rights for the Rattlesnake Creek area, two of which are for groundwater and one is a surface water right to Frank Markgraf for 166 acre/feet/yr in the r-5 section of Rattlesnake Creek. (Klickitat County 2003.)

Caufield (1984) stated that 6 of 16 mainstem unscreened water diversions that were thought to effect fish were located above river mile 17.

USFS (1991) stated that Pacific Power Company claims 1,200 cfs at the Condit Dam Facility, or almost all of the current flow. They also stated that most of summer low flow for Rattlesnake, Buck, and Gilmer Creek was claimed.

Chapman et al. (1990) and WDF et al. (1989) describe two major water diversions in the Buck Creek watershed (at RM 3.8 for White Salmon city water supply and an unscreened irrigation diversion at RM 1.9). Collectively they result in the withdrawal of 75% of the river's natural flow.

Young and Rybak (1986) reported that the lower water diversion removed 70% of water from Buck Creek.

Flow changes in interannual variability in low flows

References:

Research on the effects of land use practices on summer low flow is inconclusive. However, water withdrawals may reduce summer flow and the specific withdrawals listed below reduced summer low flow.

Average annual amounts of surface water used in White Salmon by Domestic=1 cfs, Irrigation = 4.3 cfs, Industry = 1.3 cfs, other = 0.1 cfs. Total claimed 261.8 cfs/ average annual 7 day low flow = 500 cfs. (Encon Corporation 1973, p.77.)

Within the White Salmon River watershed, there are 25 water right certificates recorded with annual allowances greater than 100 AFY. 17 of these rights are for surface water withdrawal and the remaining eight are for groundwater. An exact detailed list of allocated water rights for the

White Salmon River is described in table c-9. There are only three recorded water rights for the Rattlesnake Creek area, two of which are for groundwater and one is a surface water right to Frank Markgraf for 166 acre/feet/yr in the r-5 section of Rattlesnake Creek. (Klickitat County 2003.)

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Young and Rybak (1986) reported that the lower water diversion removed 70% of water from Buck Creek.

Channel length

References:
Steve VanderPloeg (WDFW) provided the length of each reach from SSHIAP GIS layers. We assumed the stream length was the same in both the historical and current conditions. Where field measurements were available (R1, R2, R3, R4, R5, R6), they were used.

Channel width – month minimum width

References:
We assigned the same value for both the current and historical conditions, unless a major hydromodification within the reach affects stream width. Representative reaches in M1, B1, B2, S1 and WS9 through WS15 were surveyed by WDFW and USGS-CRRL in 2003. Wetted widths corresponding to average summer low flows were measured as part of these surveys. All Rattlesnake Creek reaches, 800 m of reach I2, and 88 m of reach I5 were surveyed in 20 m increments by USGS-CRRL (Connolly 2002). Ratings for non-surveyed reaches were inferred by applying data from representative reach surveys with similar habitat, gradient and confinement.

Gradient

References:

All Rattlesnake Creek reaches, 800 m of reach I2, and 88 m of reach I5 were surveyed in 20 m increments by USGS-CRRL (Connolly 2002). The reach breaks are slightly different from those reported in Connolly 2002, so these gradients were calculated specifically for EDT from the 20 m increments.

A 1912 bathymetry map of the Condit Hydroelectric Project obtained from Pacificorps allows gradient to be calculated in the historic river channel of the inundated reaches. (Vestra Resources Incorporated and Pacific Power and Light 1990)

Habitat type

References:

A few references included rough habitat typing as follows:

Habitat composition of the White Salmon River downstream of Condit Dam split into the Below Powerhouse, and Bypass Reach respectively:
Deep pool = 25, 39. Run = 40, 22. Boulder pocket water = 26, 17. Shallow pool = 3, 17. Riffle = 4, 3. Cascade = 2, 2. (FERC, 1996.)

Hennelly (1994) visually surveyed habitat types for reaches throughout the basin. This provides a rough guide where no other data exists:
Confluence to first riffle (RM 0-1.1): 100% pool.
First riffle to Condit Dam (RM 1.1-3.25): 50% riffle, 25% pool, 25% glide. Substrate primarily boulders and bedrock.
Northwestern Lake (RM 3.25- 4.9): 100% pool.
Northwestern Lake to Husum Falls (RM 4.9- 7.6): primarily riffle with cobble, boulder substrate.
Husum Falls to Big Eddy (Sunshine eddy RM 7.6 – 10): 10% pool, 90% riffle, more exposed bedrock than reaches below.
Big Eddy to BZ (RM 10 – 11.75): no data.
Through BZ (11.75-12.55): waterfalls, riffles.
Buck Creek: Confluence to first bridge (RM 0-0.2): cobble stream channel, no pools, no boulders no logs. No other data for Buck Creek. (Hennelly et al. 1994).

Western Watershed Analysts (1997) report percent pool for different reaches of Rattlesnake Creek; R1(mouth to Indian Creek): 37%, R2 (Rattlesnake from Indian to ~covered bridge: 20%, R6 (middle unconfined reach): 32%, R9 (upper unconfined section): 29% pool, I2 (Indian Creek) 6.6% pool.

Rattlesnake and Indian creeks were thoroughly sampled and habitat-typed by USGS-CRRL in 2001-2003. Some of the information is summarized in Connolly (2002) However, the data is in electronic format as was analyzed specifically for the reaches in the EDT model.

Representative reaches in the lower White Salmon River and its tributaries were surveyed by WDFW and USGS-CRRL in 2003 (VanderPloeg and Allen 2003 unpublished). Habitat type composition was measured during these surveys. Ratings for non-surveyed reaches were inferred by applying data from representative reach surveys with similar habitat, gradient and confinement. Habitat surveys conducted in 2003 primarily followed USFS stream survey level 2 protocols which delineate between riffles and slow water, but not pools and glides.

Habitat simplification has resulted from timber harvest activities. These activities have decreased the number and quality of pools. Reduction in wood and hydromodifications are primary causes for reduction in primary pools. Historic habitat type composition was estimated by examining percent change in large pool frequency data and applying this to current habitat type composition estimates. (Sedell and Everest 1991).

We assumed current primary pool habitat has been reduced by 50% on average. Stable historical flows and abundant large woody debris maintained higher levels of spawning gravel than the current condition. Due to increases in primary pools and spawning riffles/tail-outs, glides were assumed to be less abundant in the template condition.

In general, we assumed for historical conditions that the percentage of pools was twice the current percentage. We assumed that tail-outs represent 5% of pool habitat. Rosgen C channels historically had more backwater habitat than they currently do.

Obstructions to fish migration

References:
Local knowledge of the watershed combined with WDFW SSHIAP database information and documents assessing fish passage were used to identify existing barriers within these watersheds. EDT requires that obstructions be rated for species, life stages, effectiveness, and percentage of passage effectiveness. This has not been completed for all barriers. In most cases, known fish distribution stopped at all barriers. In some cases where known distribution occurred above barriers passage was assumed to be 100% for the species and all life stages. Since steelhead, chum salmon, and chinook salmon are generally mainstem and large tributary spawners, barrier effects on these species are minimal. Coho salmon, due to their preference for spawning in small tributaries, are impacted by barriers. The ratings should be completed for barrier analysis.

Reference information:
Steelhead Falls at RM 2.8 not a major obstacle to spring chinook, steelhead or lamprey. 15-foot falls at RM 16, “double drop”. RM 16.17, 13-foot waterfall. RM 16.2, 21-foot waterfall (Chapman et al. 1990).

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WDF et al. (1989) described a man-made dam at RM 0.7 on Spring Creek as an upstream barrier to fish migration.

WDF et al. (1989) stated that “a 6-12-foot-high falls may be a partial barrier to upstream-bound fishes at certain flows”. They also stated that at “RM 12.4, a fifteen-foot-high falls is a partial barrier to upstream migration at some flows. A series of falls near RM 16.2 presents a major obstacle to upstream-bound anadromous salmonids at all flows. At RM 16.2, a two-tiered falls consisting of a 21-foot-high crest and a lower notch, 16.5 feet high (Crawford 1985) is regarded as the upstream limit to salmon migration. However, steelhead might have negotiated the falls under favorable flows. Affidavits signed by long-time residents in Trout Lake area indicated that large salmonids were seen upstream of the falls before Condit Dam was in place.” These fish may have been either steelhead or large resident rainbow trout.

Water withdrawals

References:
Additional information available in the WRIA 29 Water Rights and Water Use Assessment. Good overall WS coverage, but nothing specific about Buck, Rattlesnake, or Spring creeks.

There is a small domestic water withdrawal in the upper section of the S1 reach.

Average annual amounts of surface water used in White Salmon by domestic=1 cfs, irrigation = 4.3 cfs, industry =1.3 cfs, other= 0.1 cfs. Total claimed 261.8 cfs/ average annual 7 day low flow 500 cfs. (Encon Corporation 1973, p.77).

Within the White Salmon River there are 25 water right certificates recorded with annual allowances greater than 100 AFY. 17 of these rights are for surface water withdrawal and the remaining eight are for groundwater withdrawals. An exact detailed list of allocated water rights for the White Salmon River is described in table c-9. There are only three recorded water rights for the Rattlesnake Creek area, two of which are for groundwater and one is for a surface water right to Frank Margraf for 166 acre/feet/yr in the R-5 Section of Rattlesnake Creek. (Klickitat County 2003.)

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USFS (1991) stated that Pacific Power Company claims 1,200 cfs at the Condit Dam Facility, or almost all of the current flow through an unscreened diversion. They also stated that most of summer low flow for Rattlesnake, Buck, and Gilmer Creek was claimed.

Chapman et al. (1990) and WDF et al. (1989) describe two major water diversions in the Buck Creek watershed (at river mile 3.8 for White Salmon city water supply and an unscreened irrigation diversion at river mile 1.9). Collectively they result in the withdrawal of 75% of the river’s natural flow.

Young and Rybak (1986) reported that the lower water diversion removed 70% of water from Buck Creek.

Wood

References:
Large woody debris surveys were done by USGS-CRRL/WDFW on representative reaches. All pieces >0.1 m diameter and >2 m in length were counted in WS8 to WS16, S1, M1, B1, B2, R1, R2, R3, R4, R5, R6, 800 m of I2, and 880 m of I5.

Fine Sediment (intragravel)

References:
White Salmon River immediately upstream of Northwestern Lake: “temporary storage of fines only in slack water locations. Fines are transported at most flows”; Rattlesnake to Husum: “Fine sediment transported through this segment at all flows”; Lower Indian Creek: “Fine sediment has the potential to deposit on the bed and in pools in the lower gradient reaches between flushing flows.” Fine sediment measured in lower Rattlesnake Creek ranged between 3.3 and 20.1 % of total sample volume, with an average (N=20) of 10.4%. “Visual estimates of streambed embeddedness support measurements suggesting that in most sections of Rattlesnake Creek, fine sediment deposits on the surface were localized and mostly on the channel margins.”
“Fine sediment on the fish-bearing segments of Rattlesnake Creek was relatively absent due to simplification of the channel and a lack of wood, but surprising in light of the potential for fine sediment in the system.” (Western Watershed Analysts 1997).

WDF et al.’s (1989) description of Spring Creek states “the substrate is composed mostly of silt with some spawning gravel”.

Accumulated sediment thickness in Northwestern Lake varies from approximately 13 ft. – 65 ft., average thickness of 31 ft. Therefore the lake is 100% covered with fine sediments (PacifiCorp 1994).

FERC (2002) indicates that grain size within the reservoir sediment is 2.3% gravel, 21.7% sand, 68.6% fine sand and silt, 7.4% clay.

Road density in Rattlesnake Creek: 4.8 miles/sq. mile. The document also includes erosion modeling indicating a high hazard level for fine sediment due to forestry and grazing in the Panakanic WAU (Western Watershed Analysts1997).

Road density by sub-basin in linear feet /sq. mi. Upper White Salmon (to WQ-6): 12850 ft/ mi2; Lower White Salmon: 17641 ft/mi2; Buck Creek: 18931 ft/m2; Rattlesnake Creek: 17554 ft/m2 (Stampfli 1994).

"Bottom composition for RM 12-35 averaged a boulder-rubble-gravel-sand ratio of 30-30-20-10, and RM 0-12 averaged a boulder-rubble-gravel-sand ratio of 25-50-15-10." "The substrate in Spring Creek is mostly silt from stream bank erosion with some spawning gravel" (FERC 1996.)

In the template (pristine) condition, SW Washington watersheds were assumed to have been 6%-11% fines (Peterson et al.. 1992) and were given an EDT rating of 1.

Rittmueller (1986) found that as road density increased by 1 km/sq.km, fine sediment levels increased by 4.3%. To rate % fines in the current condition, a scale was developed relating road density to % fines. The majority of Rittmueller's data was on streams with gradients of 0.5% to 1.5%. As gradients increased, % fines would decrease. For gradients between 2% and 5% we assumed fines were reduced by 25%, and for gradients above 5% we assumed fines decrease by 50%.

Embeddedness

References:

In the template (pristine) condition, SW Washington watersheds were assumed to have less than 10% embeddedness. Reaches with low gradient and slower flows likely had increased fine sediment and embeddedness and were given an EDT rating of 1.

The Yakama Nation also has data for Indian Creek, however it was not collected/reported in a way that was readily useable for the EDT attribute. Embeddedness was measured in R1, R3, and I5 (DNR land on Indian Ck.): % embeddedness= 1% in cobble, 0% or NA in other size classes in R1. 0% for all size classes in R3. Embeddedness= 6% cobble, 0% for all other size classes (Morris 2003).

Chapman et al. (1990) described Spring Creek stating that "We assessed the stream as having only fair steelhead rearing because of lack of depth and presence of a highly embedded channel".

Accumulated sediment thickness in Northwestern Lake varies from approximately 13 ft – 65 ft. Average thickness of 31 ft. Therefore the lake is 100% embedded (PacifiCorp 1994).

FERC (2002) indicates that grain size within the reservoir sediment is 2.3% gravel, 21.7% sand, 68.6% fine sand and silt, 7.4% clay.

Road density in Rattlesnake Creek= 4.8 miles/sq. mile. The document also includes erosion modeling indicating a high hazard level for fine sediment due to forestry and grazing in the Panakanic WAU (Western Watershed Analysts 1997).

Road density by sub-basin in linear feet /sq. mi. Upper White Salmon (to WQ-6): 12850 ft/ mi2; Lower White Salmon: 17641 ft/mi2: Buck Creek: 18931 ft/m2; Rattlesnake Creek: 17554 ft/m2 (Stampfli1994).

Rittmueller (1986) found that as road density increased by 1 km/sq. km, fine sediment levels increased by 4.3%. To rate embeddedness for the current condition, we assumed that the percent embeddedness was directly related to percentage of fines in spawning gravel. A scale was then developed relating road density to percent embeddedness. The majority of Rittmueller's data was on streams with gradients of 0.5% to 1.5%. As gradients increased, percent embeddedness would decrease. For gradients between 2% and 5%, we assumed embeddedness was reduced by 25% and for gradients above 5%, we assumed embeddedness decreased by 50%.

Turbidity (suspended sediment)

References:

Suspended sediment levels in the template (pristine) condition were assumed to be at low levels, even during high flow events. An EDT rating of 0 was assigned to all reaches.

Turbidity measurements were taken by various agencies, however the timing was relatively random (except the Underwood Conservation District's flush flow measurements) and the duration was not measured, limiting its usefulness for EDT ranking.

Rattlesnake Creek near mouth mean by quarters (Oct-Dec, Jan-Mar, Apr-Jun, Jul-Sep; 1995, 1996, 1997). Suspended solids (mg/L)= 7.0 (n=6), 5.5 (n=6), 1.8 (n=6), 1.7 (n=6). Six year range (undetectable – 21 mg/L), Turbidity (NTU)= 7.9 (n=6), 9.0 (n=6), 2.5 (n=6), 1.1 (n=6). Six year range (0.5 – 25 NTU) (Hallock et al. 1998).

White Salmon River at Underwood suspended solids: range=1-27 mg/L, mean= 3.1 mg/L, (n=61) measured monthly from 1980-1995.
Rattlesnake Creek suspended solids (mg/L) = range = 1-21, mean = 3.5 n=36 monthly 1994-1997 (Washington State Department of Ecology Data File).

White Salmon base (WQ-1) turbidity (NTU) 1992-2001: 2.5 mean, n=19, range = 0.65-9.8. Jan 31, 2003 flush flow measurement = 165 NTU.
Buck Creek (WQ-2) turbidity (NTU) 1992-2001: 3.74 mean n=19, range = 0.36-48.3. Jan 31, 2003 flush flow measurement = 98 NTU.
Buck Creek DNR (WQ-2a) turbidity (NTU): 0.63 mean, n=11, range = 0.24-2.1.
Rattlesnake Creek (WQ-3) turbidity (NTU) 1992-2001: 9.87 mean, n=20, range = 0.49-133. Jan 31, 2003 flush flow measurement = 54 NTU.
Other sites available but none at flush flows.
Below Trout Lake Valley (WQ-6) Turbidity (NTU) 1992-2001: mean =17.9, n=19, range 1.4 - 200 (maximum of range collected on 24 Sept., 1992). Jan 31, 2003 flush flow measurement = 224 NTU (Underwood Conservation District unpublished data file).

Turbidity data from UCD 1992-1994. Steady and flush flows (although it appears the UCD was used the ranges were less than the data summarized above) (USFS 1995).

Columbia at The Dalles (Oct 1994- Sept. 1995) Turbidity (NTU) Mean = 25, n = 12, Range = 1.3 - 210 (FERC 2002).

Turbidity values for steady (n=4) and flush (n=3) flows during select sampling times 1992-1994. WQ-1 s=1.88 f=5.71; WQ-2 s=0.79 f=1.95; WQ-3 s=3.0 f=8.1 (Stampfli 1994).

Alkalinity

References: Many references detailed below:
Below BZ falls: conductivity= 51.1-76.6 (62.95 mean µs/cm); Buck Creek conductivity = 49.7-114.3 (79.47 mean µs/cm), Rattlesnake Creek conductivity = 62.5-191.8 (121.3 µs/cm) Alkalinity: bicarbonate = 22 mg/L-31mg/L above NW lake; Buck Creek = 24-50 mg/L; Rattlesnake Creek = 30-85mg/L (Bair et al. 2002).

Near Underwood (at USGS gauge): conductivity = 41-68 µs/cm winter, 40-70 µs/cm summer. Bicarbonate (mg/L) = 22-36 winter, 22-38 summer- measured from 1966-1970 (Encon Corporation 1973).

White Salmon River 1 mile east of Trout Lake, dates of measurements: 7/23/1975, 8/25/1975, 9/22/19975, 10/20/1975, 11/17/1975. Conductivity = 55 µs/cm 65 µs/cm, 58 µs/cm, 60 µs/cm, 55 µs/cm; at a temperature of 25 C = 63 µs/cm, 62 µs/cm, 64 µs/cm, 63 µs/cm, 57 µs/cm for preceding dates ; HCO3 = 20 mg/L, 20 mg/L 20 mg/L, 21 mg/L, 20 mg/L (USBR 1993).

USGS gauge station in Husum during 3/10/1972, 7/23/1975, 8/25/1975, 9/22/19975, 10/20/1975, 11/17/1975. Conductivity = 50 µs/cm, 62 µs/cm, 62 µs/cm, 59 µs/cm, 62 µs/cm, 50 µs/cm. At a temperature of 25 C = 49 µs/cm, 60 µs/cm, 65 µs/cm, 64 µs/cm, 63 µs/cm, 53 µs/cm. HCO3 = 26 mg/L, 32 mg/L, 32 mg/L, 32 mg/L, 32 mg/L, 26 mg/L (USBR 1993).

In Northwestern Lake during 7/23/1975, 8/25/1975, 9/22/19975, 10/20/1975, 11/17/1975. Conductivity= 70 µs/cm, 60 µs/cm, 60 µs/cm, 70 µs/cm, 50 µs/cm. At 25 C= 66 µs/cm, 71 µs/cm, 68 µs/cm, 66 µs/cm, 50 µs/cm. HCO3= 35 mg/L, 34 mg/L, 36 mg/L, 33 mg/L, 26 mg/L (USBR 1993).

Rattlesnake Creek (river mile 5.5) at county road bridge during 3/10/1972, 7/23/1975, 8/25/1975, 9/22/19975, 10/20/1975, 11/17/1975. Conductivity = 50 µs/cm, 120 µs/cm, 125 µs/cm, 125 µs/cm, 140 µs/cm, 100 µs/cm. At a temperature of 25 C= 54 µs/cm, 112 µs/cm, 116 µs/cm, 128 µs/cm, 139 µs/cm, 110 µs/cm. HCO3= 32 mg/L, 68 mg/L, 74 mg/L, 76 mg/L, 85 mg/L, 59 mg/L (USBR 1993).

White Salmon at Underwood conductivity: range = 35-87 µs/cm, mean = 60 µs/cm , n = 187 measured monthly from 1960-1983 (Washington State Department of Ecology unpublished data file).

White Salmon River near Underwood. Data file for Conductivity and Alkalinity (as CaCO3 and HCO3) monthly from 1960 through 1983, summarized in Stampfli (1994).

Rattlesnake Creek near mouth mean by quarters (Oct-Dec, Jan-Mar, Apr-Jun, Jul-Sep; 1995, 1996, 1997). Conductivity = 115 µs/cm (n=6), 61 µs/cm (n=6), 91.8 (n=6), 143.6 µs/cm (n=6). Six year range (56 µs/cm –205 µs/cm) (Hallock et al. 1998).

WQ-1(WS at base)= Conductivity = 55.8-82.2 µs/cm mean= 69.3 µs/cm (n=6)
Alkalinity CaCO3 = 25-31mg/L mean = 28.5 mg/L (n=4)
WQ-2(Buck Creek) = Conductivity = 49.7-114.3 µs/cm mean= 79.5 µs/cm (n=6)
Alkalinity CaCO3 = 24-50 mg/L mean = 39 mg/L (n=4)
WQ-3(Rattlesnake Creek) = Conductivity = 62.5-191.8 µs/cm mean= 121.3 µs/cm (n=6)
Alkalinity CaCO3 = 30-85 mg/L mean = 60.5 mg/L (n=4)
WQ-4(BZ)= Conductivity = 51.1-77.6 µs/cm mean= 63.0 µs/cm (n=6)
Alkalinity CaCO3 = 23-35 mg/L mean = 27.8 mg/L (n=4)
WQ-6(Below Trout Lake Valley) Conductivity = 42.3-79.8 µs/cm mean= 58.1 µs/cm (n=6)
Alkalinity CaCO3 = 17-22 mg/L mean = 19.8 mg/L (n=4) (Stampfli 1994).

Range of Results, UCD with others. WQ-1(WS river at base) conductivity (1992-1994) = 55.8-82.2µs/cm, bicarb alkalinity CaCO3 = 25-31 mg/L . PacifiCorp at WQ-1 (1989-1990)= 40-87µs/cm, bicarb alkalinity = 22-28 mg/L. Dept of Ecol., USGS at base (Near Underwood; 1960-1983) = 35-80 µs/cm. bicarb alkalinity = 13-66 mg/L. Bureau of Reclamation at Northwestern Lake (1975) = 50-70 µs/cm.

Dissolved oxygen

References:
Many references to current DO levels listed below:

White Salmon at Underwood: DO (mg/L) fall=11.6, winter = 12.3, spring = 11.5, summer = 10.7 (WDW et al., 1990)

White Salmon near Underwood: (USGS 1975-1980) mean = 11.6 mg/L (9.5 – 13.7 mg/L).

White Salmon PacifiCorp lower reach and raceway sites (Apr. 1989-Dec. 1992) mean = 11.7 (10.2-13.9) (FERC 1996).

Rattlesnake Creek near mouth, mean by quarters (Oct-Dec, Jan-Mar, Apr-Jun, Jul-Sep; 1995, 1996, 1997). DO (mg/L)= 11.8 (n=5), 12.95 (n=6), 10.8 (n=6), 9.7 (n=6); six year min max = 9.0-13.8 (Hallock et al. 1998).

Near Underwood (at USGS gauge) DO (mg/L) = 10.8-13.3 winter, 10.4-13.3 summer - measured from 1966-1970 (Encon Corporation 1973).

WS river 1 mile east of Trout Lake, dates of measurements: 7/23/1975, 8/25/1975, 9/22/1975, 10/20/1975, 11/17/1975. DO (mg/L)(% saturation) = 11.6 (100%), 11.4 (98.3), 12.0 (NA), 14.0 (112%), 14.0 (101) (USBR 1993).

USGS gauge station in Husum at 3/10/1972, 7/23/1975, 8/25/1975, 9/22/19975, 10/20/1975, 11/17/1975. DO (mg/L)(% saturation)= 14.9 (122.1%), 12.9 (105.7%), 12.3 (106%), 12.4 (NA), 14.4 (118%), 16.8 (128.2) (USBR 1993).

In NW lake during 7/23/1975, 8/25/1975, 9/22/19975, 10/20/1975, 11/17/1975. DO (mg/L)(% saturation) = 11.2 (112%), 13.0 (125%), 13.1 (NA), 13.8 (116%), 15.3 (1167%) (USBR 1993). Rattlesnake Creek (mile 5.5) at county road bridge during 3/10/1972, 7/23/1975, 8/25/1975, 9/22/19975, 10/20/1975, 11/17/1975. DO (mg/L)(% saturation) = 14.0 (117%), 9.5 (103%), 10.6 (106%), 10.6 (106%), 9.8 (98%), 11.9 (105%), 14.1 (113%) (USBR 1993).

White Salmon at Underwood DO (mg/L): range =9.5-14 , mean = 11.9, n = 157 measured monthly from 1967-1995.
Rattlesnake Creek DO (mg/L) = range = 9-14.2, mean = 11.2, n = 35 measured monthly 1994-1997 (Washington State Department of Ecology Data File).

Metals – in water column

References:
Currently, salmonids are not expected to suffer from toxicity due to prolonged exposure to dissolved heavy metals.
References with data provided below:

Arsenic, copper, lead, and zinc were routinely sampled at the mouths of White Salmon River, Buck, and Rattlesnake creeks as well as at BZ Corners and the WS River below Trout Lake Valley. Of these, total levels were below analytical detection limits for all except arsenic, which was well below EPA drinking water standards and DOE aquatic life criteria (Stampfli 1994).

WS at USGS gauge (measured by USGS [range]; acute/chronic Washington Department of Ecology standards):
Chromium = 1.36 µg/L (0-10); 16 / 11
Copper = 1.59 (0-<10); 4.37 / 3.32
Lead = 6.68 (0-20); 12.31 / 0.48
Mercury = 0.133 (0-0.4); 2.40 / 0.012
Zinc = 4.57 (0-20); 33.18 / 30.06
(FERC 1996).

White Salmon at Underwood: Arsenic (µg/L): range = 0 – 3, measured monthly from 7/1968, 11/1971-6/1980.
Boron (µg/L): range = 0 – 80, measured 1960-1968 annually.
Cadmium (µg/L): range = 0 – 9, with one measurement at 110 (5/9/1979), measured monthly 1977-1980.
Chromium (µg/L): range = 0 – 10, measured monthly from 11/1976-6/1980.
Copper (µg/L): range = 0 – 20, most at 1 to 3 measured monthly from 11/1976-6/1980.
(Washington State Department of Ecology Data File, also summarized in Stampfli, 1994).

Metals/Pollutants – in sediments/soils

References:
Stratified random boring of lake sediments measured metal concentrations, pesticides and herbicides. Metals tested: antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, silver, thallium, zinc. Uppermost sediment samples were below both Provincial Sediment Quality Guidelines (PSQG, no effect – severe effect), and EPA ranges for non-polluted sediments, except mercury in the 7.4-foot sample (0.52 ppm exceeded the no effect - severe effect guideline of 0.2-2 in the region near the dam).
"A comparison of the detected concentrations indicates that, in general, the metal concentrations in the reservoir sediments are below levels of concern. The exception is the elevated concentrations detected in the 10-ft zone of Area 4 (upper reservoir near boat launch). According to the PSQG, the sediment collected from this zone barely exceeded the "no effect" limit for cadmium, chromium and mercury. Copper, nickel, and zinc all fall into the "moderately polluted" category. According to these guidelines, the lead contamination indicates "heavy pollution" also considered "heavy pollution" by the EPA Region V guidelines. Mercury concentration generally exceeded guideline values, but were considered background concentrations, also true for nickel and copper (PacifiCorp 1994).

Miscellaneous toxic pollutants – water column

References:
Current levels are unknown and, except in the reservoir, were assumed to be the same as the template condition. Dioxin, pentachlorophenol, gasoline, diesel, PCB, PAH, Volatile Organic Compounds, and PP metals were not found. Chlorinated pesticides were detected in mid-level sediments (area 1, 2, 3 [mid-way between Buck and Mill creeks], but not in shallow or deep sediments--basically deposited during the period of use [banned 20 yrs ago]) (PacifiCorp 1994).

Stampfli (1994) includes acres of each land use type within each basin and types and quantities of chemicals used by each type of land use. Relative water quality concern is listed for each chemical used. There are several chemicals applied to forestland and orchards that were of high concern for water quality.

Nutrient enrichment

References:
Actual data for this attribute in the form needed for the EDT model is very limited. Historically nutrient enrichment did not occur because watersheds were in the "pristine" state. To determine the amount of nutrient enrichment in various reaches, the following features were examined: fish rearing ponds, visual surveys were conducted to determine presence of filamentous algae in shaded areas, fecal coliform levels associated with agriculture, and septic tanks.

Although there are significant cattle operations above WS18, springs contribute water which nearly doubles the flow, and lowers nutrient enrichment levels. There is a rearing unit in WS2, giving that reach an EDT rating of 1.

"Incidence of cow manure in Rattlesnake Creek is common. Baseline water quality sampling and testing found total coliform levels in the creek exceeded limits for State Water Pollution Control Commission water quality standards of class C waterways (50/ml)" (Hennelly et al. 1994).

"A 1989 Report on Water Quality (305b Report) issued by the state Department of Ecology identified the White Salmon River from its mouth to headwaters as a 'threatened' water body due to fecal coliform" (USFS 1995).

"Maximum fecal coliform levels in Lower Trout Lake Creek (TLC) and the White Salmon below TLC are 34 and 54 times the standard for class AA and A. Dairies, other animal keeping operations, and residential development are likely contributors to these high levels" (USFS 1996).

Fecal coliform exceeded part 2 of Fecal Coliform Bacteria Standards: RM1.1 = 12%, RM12 = 21%, RM18.2 = 53%, RM28.3=0% of the time.
For the tributaries: Buck Creek RM 0.25= 23%, Buck Ck. DNR = 0%, Rattlesnake Creek RM 0.25 = 25% (Underwood Conservation District data 1999-2001).

Fish community richness

References:
Page 3-16 has a table listing anadromous and resident fish species in the White Salmon from the mouth to Condit Dam. Page E-3-4, Tables E-4, E-5, list of salmonids and non-salmonids and their life stage use of the White Salmon River split into segments 1 (bridge to first riffle), 2 (first riffle to powerhouse), and 3 (powerhouse to Condit Dam) (FERC 1996).

In the Panakanic Watershed Analysis, page 235 and subsequent maps contain information on current and historic salmonid distribution (Western Watershed Analysts 1997).

Historical fish community richness was estimated from the current distribution of native fish in these watersheds (see below).
Current fish community richness was estimated from direct observation (stream surveys and electro-shocking), personal communications with professional fish biologists/hatchery personnel familiar with these areas, and local knowledge.
Some of the referenced reports are: Connolly (2002), Connolly et al. (2001), Hardisty et al. (1971), Moyle (2002), PacifiCorp (1996), Thiesfeld (2001), WWA (1997), Wydoski et al. (1979). Page 3-16 of the FERC FEIS document (PacifiCorp 1996) has a table listing anadromous and resident fish species in the White Salmon River from the mouth to Condit Dam.

Page E-3-4, Tables E-4, E-5, list of salmonids and non-salmonids and their lifestage use of the White Salmon River below Condit Dam split into segments 1 (bridge to first riffle), 2 (first riffle to powerhouse), and 3 (powerhouse to Condit Dam). Page 235 and subsequent maps of the Panakanic Watershed Analysis contain information on current and historic salmonid distribution obtained from historic accounts (WWA 1997). A spreadsheet summarizing the list of species obtained from the listed data sources was developed (Allen unpublished).

A spreadsheet summarizing the above data sources was developed: (WSReachData_3_8_BA.xls, Allen USGS-CRRL).

Fish species introductions

References:

By definition the template conditions for this attribute are rated as a value of 0 because this describes the attribute rating for watersheds in pristine conditions. Introduced species were derived from current fish species richness data (see Fish Community Richness, above).

Bair et al. (2002) stated that brook trout are a non-indigenous species to the White Salmon River, and although hatchery outplants have been discontinued, brook trout have established naturally reproducing populations above Condit Dam.

Connolly (2002) Pg. A-45 Table 8 documented the presence of brook trout (n=1) in the r2 section of Rattlesnake Creek. Data also includes all fish species found in the Rattlesnake Creek basin during two years of intense electro-fishing sampling.

To the best of our knowledge, brook trout are the only non-indigenous fish species present above Condit Dam. Although their distribution and population within the watershed is largely unknown at this time, we believe that they inhabit all mainstem reaches and all tributary streams below residential fish barriers.

Page 3-16 has a table (table 3-5) listing anadromous and resident fish species in the White Salmon from the mouth to Condit Dam. Page E-3-4, Tables E-4, E-5, list salmonids and non-salmonids and their life stage. Use by fish species in the White Salmon River was split into segments 1 (bridge to first riffle), 2 (first riffle to powerhouse), and 3 (powerhouse to Condit Dam) (FERC 1996).

Of the six species of anadromous fish that are believed to inhabit the lower White Salmon River below Condit Dam (table 3-5 cited above), one species, the American shad, is non-native to the lower White Salmon River. One of the three residential salmonids listed in table 3-5 is non-native, and 13 of 24 resident non-salmonids are non-native. Of the non-native species cited above, only the lepomis spp. (n=2) are documented (table e-5 cited document above) above the first riffle (section WS2).

Historical fish community richness was estimated from the current distribution of native fish in these watersheds (see below). Reimers and Bond (1967) identify 17 species of fish endemic to the Lower Columbia River and its tributaries, and their current distribution.

Salmon carcasses

Rationale: Historic carcass abundance was estimated based on the potential distribution of anadromous fish in the watershed. Reaches with historic chum presence (spawning) were given a rating of 0. Mainstem reaches with chinook and coho, but no chum were given a rating of 2. Reaches with only coho were given a rating of 3. Reaches with only cutthroat or steelhead were given a rating of 4, since these fish do not die after spawning.

During template development, EDT reaches were delineated by Brady Allen (USGS-CRRL) according to current/potential fish distribution. Using potential fish distribution, EDT reach lengths were summed to develop the total number of miles of available habitat for each species. The potential spawn escapement estimate was divided by the corresponding number of miles of habitat to generate the average number of carcasses per mile for each species. These values were summed according to the species present within each reach to develop the total number of carcasses per mile within the reach.

Benthos diversity and production

The Underwood Conservation District (UCD) has collected aquatic insects in the R1, R3, R4, and WS12 reaches for a stable isotope study funded by Bonneville Power Administration. As of December 20, 2004, the UCD has a draft report available which lists the species found in these reaches. This information was not available when this EDT model was being populated. After a cursory look at the list of species and the EDT attribute rating, it is doubtful that the ratings would change.

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Appendix C: Reference list sent to the technical working group for populating the attributes used in the Ecosystem Diagnosis and Treatment Model (EDT) for the White Salmon River Watershed

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