APPENDIX C

Habitat Suitability Criteria (HSC)

APPENDIX C1

Proposed Habitat Suitability Criteria (HSC) Curves for Application in Habitat-Flow Modeling for the Sultan River Instream Flow Study – RSP 3, June 5, 2008

- DRAFT -

Proposed Habitat Suitability Criteria (HSC) Curves For Application in Habitat – Flow Modeling For the Sultan River Instream Flow Study – RSP 3

Prepared for:

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1. INTRODUCTION

One of the major components in completion of the Sultan River Instream Flow Study (RSP 3) is the selection and use of species and life stage Habitat Suitability Criteria (HSC) curves. HSC curves reflect species and life stage use of selected habitat parameters (depth, velocity, substrate, and cover) (Bovee 1986). Depending on the extent of data available, HSC curves can be developed from the literature (Category 1 curves), or from physical and hydraulic measurements made in the field over species microhabitats (Category 2 curves). When adjusted for availability, these latter curves may more accurately reflect species preference (Category 3 curves) (Bovee 1986).

Because the characteristics of the HSC curves have a major influence on calculations of the relationship between flow and potential habitat, having agreement with the agencies and stakeholders on the specific HSC curves to be used before completing detailed habitat – flow modeling is important. Washington State Instream Flow Study Guidelines (WDFW and WDOE 2008) suggest development of site-specific criteria curves or the use of agency fallback criteria.

Site-specific HSC curves are not available for the Sultan River, and therefore, R2 Resource Consultants (R2), as the contractor to the Snohomish County Public Utility District No. 1 (District) responsible for completing RSP 3 has collected (in cooperation with District biologist) site specific microhabitat use data on several species and selected life stages. This effort focused on two target species, Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*O. mykiss*), both of which are listed as threatened under the federal Endangered Species Act (ESA), and hence decisions regarding an appropriate flow regime for the Sultan River will likely be based heavily on these two species. The instream flow study will also need to develop and consider habitat-flow relationships for other species that utilize the Sultan River including coho (*O. kisutch*), chum (*O. keta*) and pink salmon (*O. gorbuscha*), as well as cutthroat (*O. clarki*) and rainbow trout (*O. mykiss*). Thus, R2 also collected habitat use data for these species as they were encountered during the microhabitat surveys. The periodicities or timing of habitat use of anadromous and resident salmonid species in the Sultan River for different life stages are presented in Tables 1 and 2.

Table 1. Species and life-history stage periodicity chart for anadromous species of interest in the Sultan River, WA (Adapted from Snohomish PUD and City of Everett PAD, 2005). Target life stages in **bold**.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chinook Salmon (Target Species)												
Adult Migration									X			
Spawning									X	X	X	
Fry Emergence	X	X	X									
Juvenile Rearing	X	X	X	X	X	X	X	X				
Juv. Outmigration	X	X	X	X	X	X	X	X				
Winter Steelhead Trout (Target Species)												
Adult Migration	X	X	X	X	X						X	X
Spawning			X	X	X	X						
Fry Emergence					X	X	X					
Juvenile Rearing	X	X	X	X	X	X	X	X	X	X	X	X
Juv. Outmigration				X	X	X	X					
Coho Salmon												
Adult Migration									X	X	X	X
Spawning	X										X	X
Fry Emergence			X	X	X	X						
Juvenile Rearing	X	X	X	X	X	X	X	X	X	X	X	X
Juv. Outmigration				X	X	X						
Chum Salmon												
Adult Migration										X	X	
Spawning											X	X
Fry Emergence			X	X	X						X	X
Juvenile Rearing			X	X	X							
Juv. Outmigration			X	X	X							
Pink Salmon												
Adult Migration							X	X	X	X		
Spawning									X	X		
Fry Emergence			X	X	X							
Juvenile Rearing			X	X	X							
Juv. Outmigration			X	X	X							

Table 2. Species and life-history stage periodicity chart for resident species of interest in the Sultan River, WA (Adapted from Snohomish PUD and City of Everett PAD, 2005). Target life stages in **bold.**

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainbow Trout												
Spawning				X	X	X						
Fry Emergence							X	X	X			
Adult and Juvenile Rearing	X	X	X	X	X	X	X	X	X	X	X	X
Cutthroat Trout												
Spawning					X	X	X					
Fry Emergence								X	X	X		
Adult and Juvenile Rearing	X	X	X	X	X	X	X	X	X	X	X	X

2. OBJECTIVES

The overall objective of this study was to collect a sufficient number of data points (75-150) for each of the target species and life stages to generate a site specific set of HSC curves. For species and life stages for which limited or no microhabitat data were collected, R2 recommends use of the State Fallback Curves (WDFW and WDOE 2008).

3. DESCRIPTION OF STUDY AREA

The reach of the Sultan River affected by Culmback Dam and the City of Everett Diversion Dam extends from Culmback Dam located at River Mile (RM) 16.5 to the confluence with the Skykomish River (RM 0.0) (Figure 1). A detailed description of the physical and geomorphological structure of this section of the Sultan River is provided in the Pre-Application Document (2005) as well as in the RSP 22 (Physical Process Studies, Draft Technical Report; Stillwater Sciences 2008a) and RSP 18 (Riverine, Riparian and Wetland Habitat Assessment Technical Report; Stillwater Sciences 2008b) reports.

The 16.5 mile project reach contains a variety of fish habitat conditions. In general, the Sultan River from its mouth to Culmback Dam travels through two distinct channel forms, a low gradient alluvial channel with a broad floodplain (RM 0.0 to RM 2.7) and a relatively high gradient, confined canyon with steep side slopes (RM 2.7 to RM 16.5). There are relatively few perennial flowing tributary streams that enter the project reach; Chaplain Creek enters near RM 5.9, Marsh Creek enters near RM 7.6, and Big Four Creek near RM 11.2.

As a result of habitat surveys completed by the District in 2003 and 2004, the study reach was divided into 4 distinct reaches based on flow regime and channel characteristics (Figure 1). These reaches included:

- Reach 1A: Confluence with the Skykomish River (RM 0.0) upstream to the Bonneville Power Administration (BPA) transmission line crossing (RM 2.7)
- Reach 1B: BPA transmission line crossing (RM 2.7) upstream to Jackson powerhouse (RM 4.3)
- Reach 2: Jackson powerhouse (RM 4.3) upstream to City of Everett Diversion Dam (RM 9.7)
- Reach 3: City of Everett Diversion Dam (RM 9.7) upstream to Culmback Dam (RM 16.5)

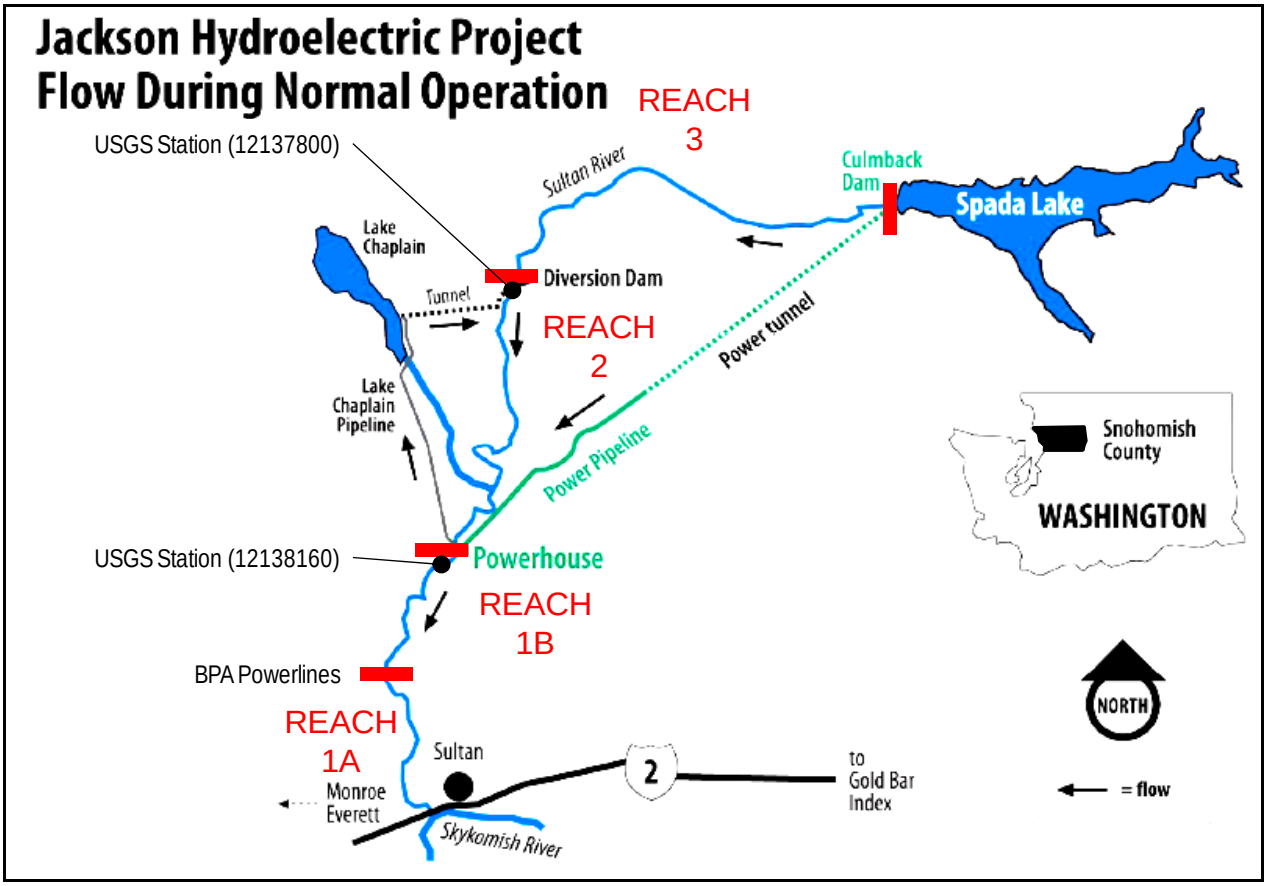


Figure 1. Jackson Hydroelectric Project - Sultan River operational reach breaks and locations of USGS stream flow monitoring stations.

4. DESCRIPTION OF STUDY SITES

The selection of study sites for collecting HSC microhabitat data was based on several factors, including:

- Selected sites needed to include a wide variety of habitat types that reflect or represent habitat conditions within the overall study reach.
- Sites should be sufficiently distant to compensate for differences in local fish densities that may result in behavioral shifts in habitat selections.
- Study sites must be readily accessible and pose a low hazard of potential injury to surveyors.
- To the extent possible, the study sites should encompass segments that were part of the instream analysis and the juvenile fish study (RSP 5).

5. METHODS

The Sultan River microhabitat study focused on collecting data related to spawning habitat use, and juvenile (and adult – *for resident salmonids*) rearing habitat use. Adult spawner surveys were conducted on-foot during three time periods:

- Fall (September – November) 2006 and 2007,
- Summer (June and July) 2007, and
- Spring 2008 (April and May).

Juvenile and adult rearing surveys were completed using snorkel survey techniques during the summer (July/August) of 2007. Specific methodologies pertaining to habitat measurements, stream flow conditions during the sampling periods, and data analysis are described below.

5.1 SPAWNING SURVEYS

Spawner surveys were conducted as part of a larger monitoring program conducted by District fish biologists to monitor spawning activity in the Sultan River basin. Active spawning locations were identified by District staff during pedestrian and helicopter surveys of the river completed as part of their annual spawner surveys. This information was used to identify areas with the highest concentration of spawning activity for each of the target fish species (Chinook salmon and steelhead trout).

All spawning surveys were conducted by walking the stream channel in an upstream direction, and identifying the location of newly constructed spawning nests (redds). For each identified redd, the following measurements were made: 1) redd dimensions (length and width [to nearest 0.5 ft] to allow computation of area); 2) water depth to the nearest 0.1 feet at the upstream end of each redd measured using a top setting wading rod; 3) mean water column velocity (fps) at the upstream end of each redd measured to the nearest 0.01 fps using a Swoffer Model 2100 current meter; and 4) substrate size (dominant, sub-dominant, and percent dominant) characterized in accordance with the size classifications described in WDFW Instream Flow Study Guidelines (February 12, 2008). In addition, representative digital photographs of selected redds were taken.

5.2 SNORKEL SURVEYS – JUVENILE AND ADULT REARING

Snorkel surveys were conducted by a team of two or three fish biologists with extensive experience in salmonid species identification. In general, the steps used in completing these surveys included:

1. ***Survey Preparation*** – All field equipment used for collecting microhabitat data was checked and assembled for use. This included completing a spin test of calibrated velocity meters, and assembling/gathering the top setting rod, marking weights and/or flagging, underwater lights, and dry suits. Stream discharge data for the Sultan River was obtained from the District and USGS. Stream flows were monitored on the day of the survey and at least two days prior to the survey to ensure stable flow conditions during sampling.

2. ***Sampling Conditions/Visibility Assessment*** – Prior to each survey, a secchi disk reading was taken to determine the visibility corridor for sampling. For this, a secchi disk was held underwater by the data recorder, and a tape measure extended by the snorkeler from the secchi disk outward to a point where the disk is no longer clearly visible (Figure 2). As a rule, when visibility conditions were less than four feet, no sampling occurred. Water temperature was also recorded at the beginning of each survey.

   To ensure accurate estimation of fish size underwater, the snorkelers calibrated their sight to a ruler prior to beginning each survey. Rulers and objects of know length (e.g., fingers, marks on diving gloves) were used during the survey to maintain accuracy in the estimation of fish length.

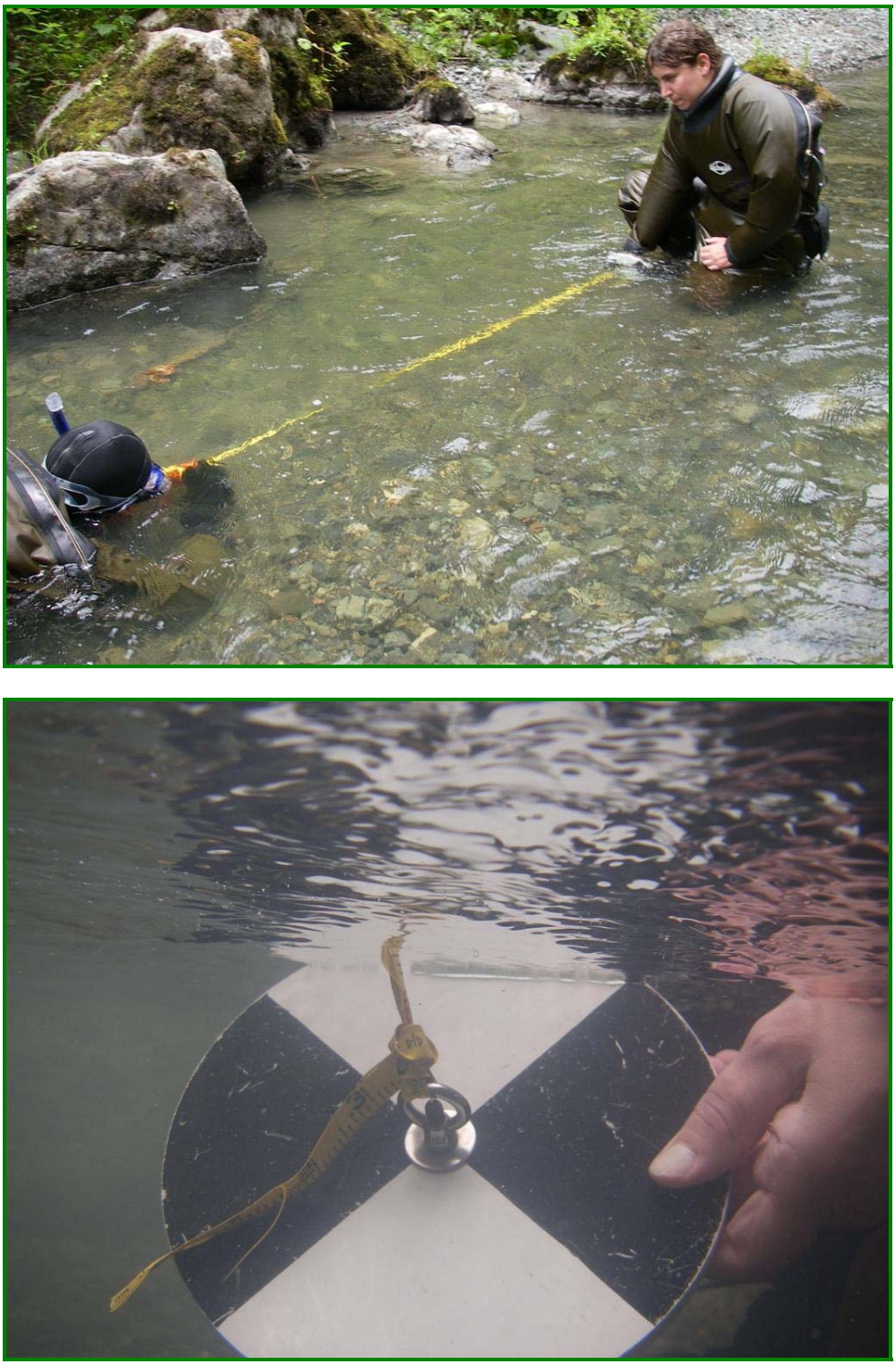


Figure 2. Visibility conditions were assessed using a secchi disk prior to conducting microhabitat snorkel surveys in the Sultan River, Washington.

3. ***Snorkel Survey/Fish Observations*** – Starting at the lower/downstream point within a study site, the snorkelers proceeded in an upstream direction making observations of all microhabitat types within their line of sight (Figure 3). When two divers were working together, both sides of the river were covered, with the midpoint of the river serving as the delineation point of coverage for each diver. When a fish was observed the snorkeler verbally transmitted the following information to the data recorder:
    - Fish species
    - Fish length (mm)
    - Location in water column (distance from the bottom)
    - Substrate use classification
    - Proximity/affinity to habitat structure/cover features (e.g., boulder, undercut bank, overhanging vegetation, large woody debris)
    - Relevant comments pertaining to cover associations and/or behavioral characteristics of the fish observed.

Only fish holding over a fixed position were included in the microhabitat survey. Moving fish were not be enumerated in order to minimize inaccurate habitat measurements, and to prevent double-counting of fish.

1. ***Microhabitat Measurements*** – Subsequent to locating a fish observation, the data recorder proceeded to the fish location and collected the following information:
    - Water depth – measured to the nearest 0.1 feet using a top setting rod
    - Mean column velocity (fps) – measured using a Swoffer Model 2100 current meter
    - Substrate classification – classified in accordance with the size classifications described in WDFW Instream Flow Study Guidelines (February 12, 2008)

All data were recorded in a waterproof survey book; the data were reviewed in the field to ensure that all measurements were properly recorded and were legible prior to departure. Digital photographs were taken of representative habitat types where fish of different species and size classes were observed.

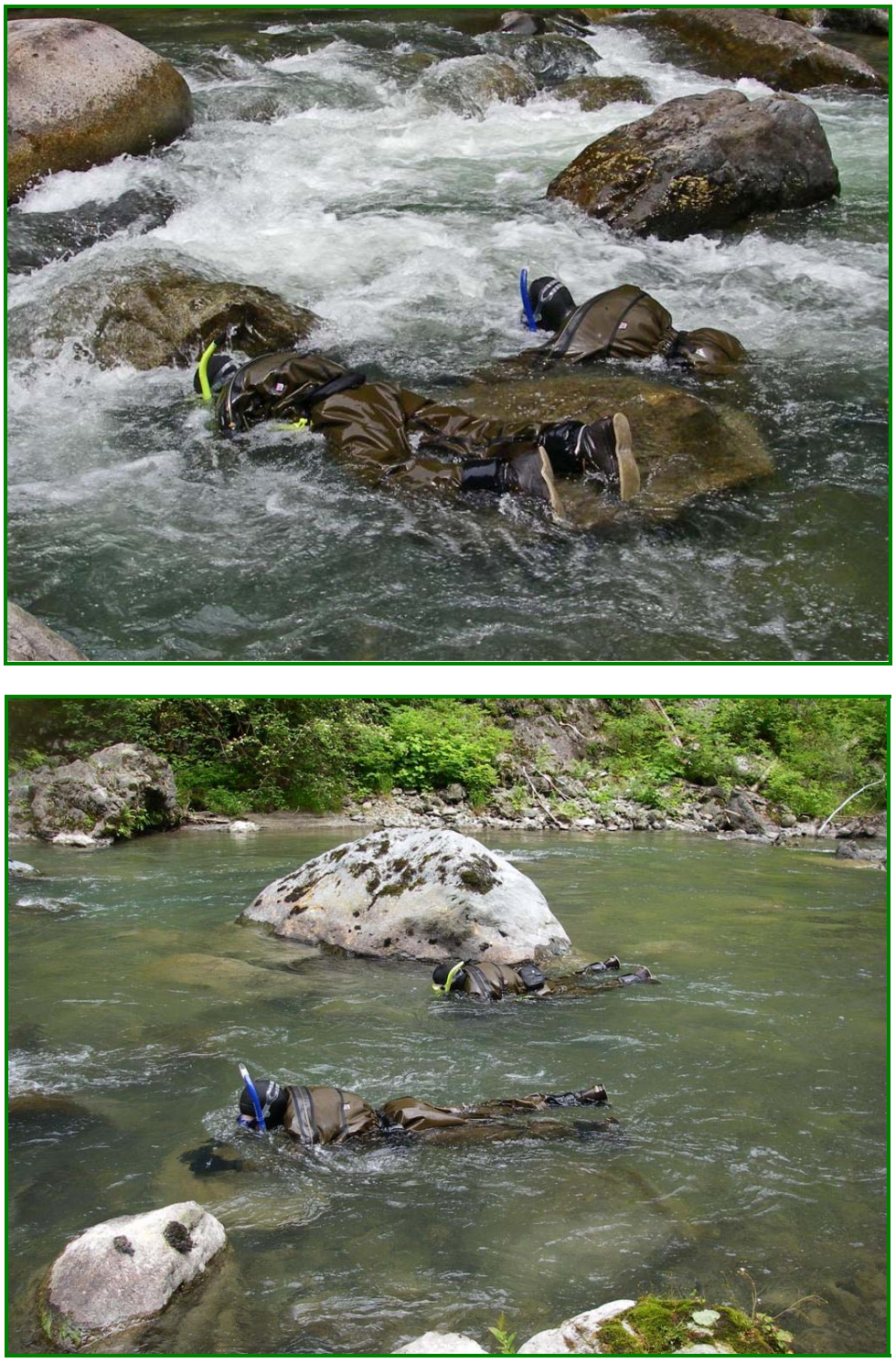


Figure 3. Photographs of snorkelers making fish observations in Reach 2 of the Sultan River, Washington.

5.3 FLOW CONDITIONS

The quantity and rate (cubic feet per second) of stream flow within the Sultan River during the time of fish use, to a large degree, determines the distribution of microhabitat (depth and velocity) combinations that are available to fish. Stream flow records for the Sultan River are available from two USGS continuous flow monitoring stations. The upstream most station (USGS 12137800) is located at the upper end of river Reach 2 just downstream of the City of Everett Diversion Dam (Figure 1). The second station (USGS 12138160) is located at the upper most end of river Reach 1B just downstream of the Jackson Powerhouse (Figure 1). Average daily flow records were obtained for each of these gages for the spawning periods of both steelhead trout (March 15 – June 15) and Chinook salmon (September 15 – November 15). The spawning period for both species was identified by reviewing long-term spawner survey data and personal communications with District fisheries biologist Keith Binkley. The period of flow record obtained from each gage corresponds to the year(s) that site specific HSC data collection occurred.

5.4 DATA ANALYSIS

Prior to calculation of the HSC curves, the habitat data collected in the Sultan River were entered into commercially available spreadsheets and subsequently checked for data entry accuracy. Data were sorted according to species type and life-history stage. Frequency distributions were then generated for mean velocity, depth, and substrate type for each species. Frequency bin widths of 0.1 were initially used to evaluate the mean velocity and depth utilization distributions. Histogram plots of depth and mean column velocity utilization were produced using a 0.2 bin width (Appendix B).

The 0.2 bin sizes were generally found to be too small for constructing meaningful HSC curves. Sturges (1926) suggested that the optimal bin size could be determined using the formula:

$$R/(1+3.322\text{Log}(n))$$

Where R is the range of values and n is the total number of observations. Optimal velocity and depth bin sizes determined using the Sturges' formula were around 0.3 ft/s and ~0.5-1.0 ft, respectively. The frequency distribution of the field observations was then converted into HSC curves by scaling the distribution between 0 and 1 (utilization values divided by the maximum value observed). For comparative purposes, these HSC curves were then plotted together with the State Fallback Curves.

6. RESULTS

This section presents the results of the microhabitat surveys completed on the Sultan River during the fall of 2006; spring, summer, and fall of 2007; and spring 2008. Specific sections pertain to results of the microhabitat surveys for Chinook and steelhead spawning redds, adult and juvenile snorkel surveys, and recommended modifications to the State Fallback Curves are presented below.

6.1 CHINOOK SALMON HSC SURVEYS

Chinook spawning HSC surveys were first conducted in the fall of 2006. Redd measurements were completed by District staff during four separate surveys occurring between October 2 and October 10, 2006. A total of 75 individual redd HSC measurements were made during the 2006 Chinook spawning period. Of this total, 45 measurements were made in study Reach 1A and the remaining 30 were made in study Reach 2 (Appendix A). Stream flow conditions during the spawning period (and redd measurement) were relatively stable with median flows of approximately 160 cfs in Reach 2 and 316 cfs in Reach 1A (Figure 4).

In the fall of 2007, a total of 58 individual redd HSC measurements were made during three separate surveys between September 24 and October 15. Of the total measurements, 51 were made in Reach 2 and 7 were made in Reach 1A (Appendix A). Stream flow conditions during the 2007 Chinook spawning period were similar to conditions observed in 2006, with median daily flows of approximately 166 cfs in Reach 2 and 383 cfs in Reach 1A (Figure 4).

Water depth at the Chinook redds (measured just upstream of the redd pit) ranged from 0.7 to 3.6 feet, with the highest utilization occurring between 1.0 and 2.4 feet deep (Appendix B). Mean column water velocity (measured just upstream of the redd pit) ranged from 0.58 fps to a high of 3.35 fps, with the highest utilization occurring between 1.2 and 2.7 fps (Appendix B). Substrate composition (dominant and subdominant) at each of the redd locations was characterized as predominately large gravels and cobble (1.5 inch to 12 inch diameter). HSC curves for this species and life stage were derived from the utilization data and plotted with the State Fallback Curves for comparison.

6.2 STEELHEAD TROUT HSC SURVEYS

Steelhead spawning HSC surveys were conducted in 2007 and 2008 and resulted in the measurement of a total of 67 redds. Due to poor visibility in the Sultan River during the spring steelhead spawning period, the 2007 surveys could not be conducted until after the first week of July. The surveys were conducted by District staff during two separate surveys occurring on July 7th and 13th. A total of 34 individual redd HSC measurements were made during the two

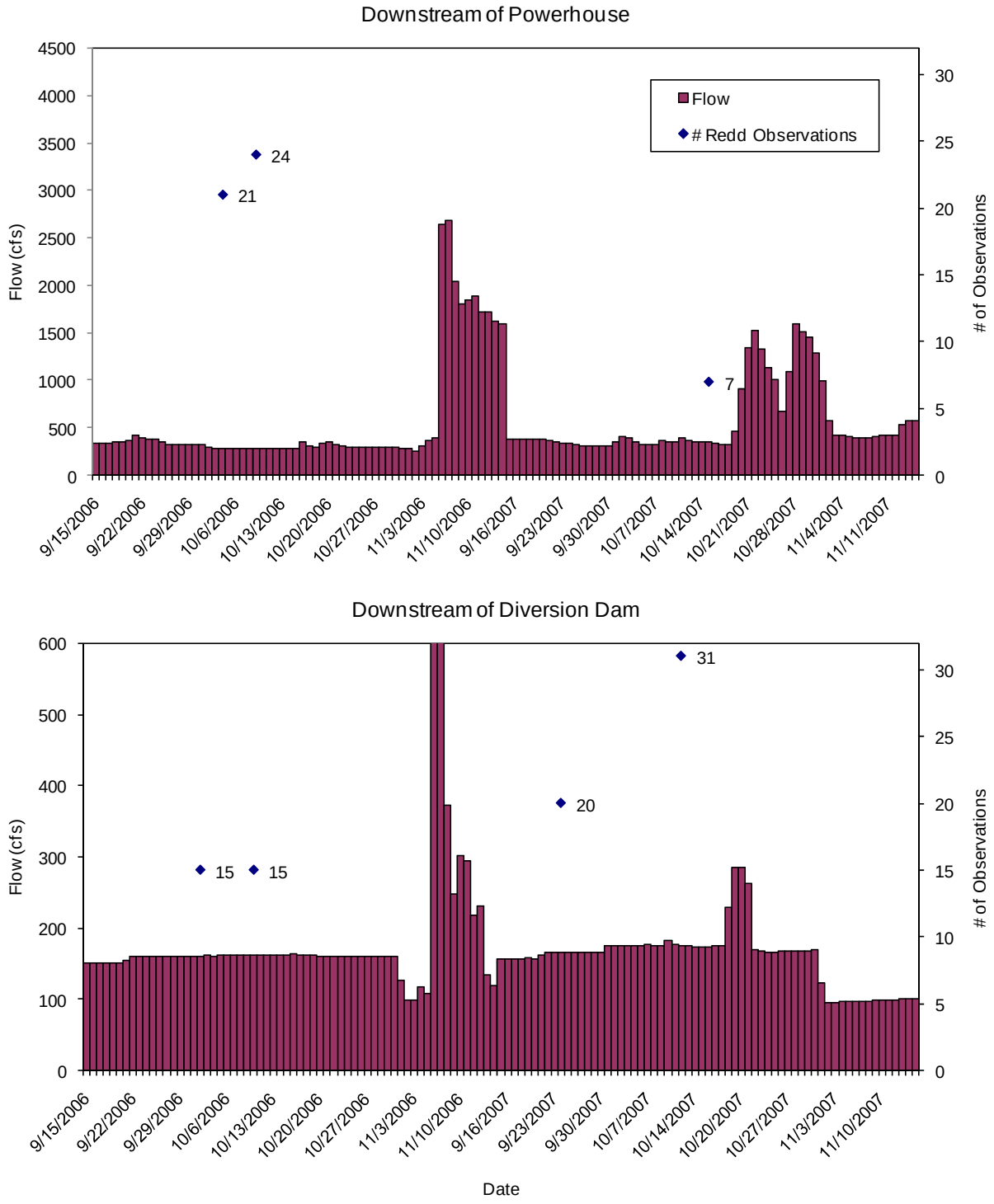


Figure 4. Average daily flows (2006 and 2007) downstream of the powerhouse (top) and diversion dam (bottom) during Chinook spawning period (September 15 to November 30), Sultan River, Washington. Points indicate date and number of redd observations.

surveys. The number of observations was nearly evenly split between Reach 1A and Reach 2, with 18 and 16 redd measurements respectively. Stream flow conditions during most of the 2007 steelhead spawning period (and redd measurement) were relatively stable with median flows of approximately 597 cfs in Reach 1A and 178 cfs in Reach 2 (Figure 5).

In the spring/summer of 2008, a total of 33 individual redd HSC measurements were made during two separate surveys of Reach 2. The first survey occurred on April 23 and the second survey was completed approximately two weeks later on May 6th. Again, the number of observations was nearly evenly split between the two surveys; with 18 redd measurements completed during the April 23 survey and 15 on the May 6th visit. Stream flows in Reach 2 during the 2008 steelhead spawning period were stable with a maximum flow of 202 cfs and minimum flow of 174 cfs (Figure 6).

Water depths at the steelhead redds (measured just upstream of the redd pit) ranged from 0.8 to 3.5 feet, with the highest utilization occurring between 1.5 and 2.5 feet deep (Appendix A). Mean column water velocity (measured just upstream of the redd pit) ranged from a low of 0.78 fps to a high of 3.5 fps, with the highest utilization occurring between 1.0 and 2.5 fps (Appendix B). Substrate composition (dominant and subdominant) at each of the redd locations was characterized as predominately large gravels and cobble (1.5 inch to 12 inch diameter). HSC curves for this species and life stage were derived from the utilization data and plotted with the State Fallback Curves for comparison.

6.3 JUVENILE/FRY SALMONID HSC SNORKEL SURVEYS

Snorkel surveys were conducted by a team of R2 staff consisting of two to three snorkelers and one note taker during two separate site visits in 2007. The first survey occurred on July 27th and the second on August 8th. The snorkel surveys were completed in conjunction with field studies being carried out as part of juvenile fish abundance and habitat use surveys (RSP-5). Stream flow conditions prior to each of the surveys were stable within both Reach 1A and Reach 2, with flows of approximately 350 cfs and 95 cfs respectively (Figure 7). Large numbers of juvenile steelhead/rainbow trout and coho salmon were observed results of HSC measurements are presented separately for each species. Only three adult trout (rainbow trout >120 mm length) were observed during either of the two surveys; no results are presented for this life stage.

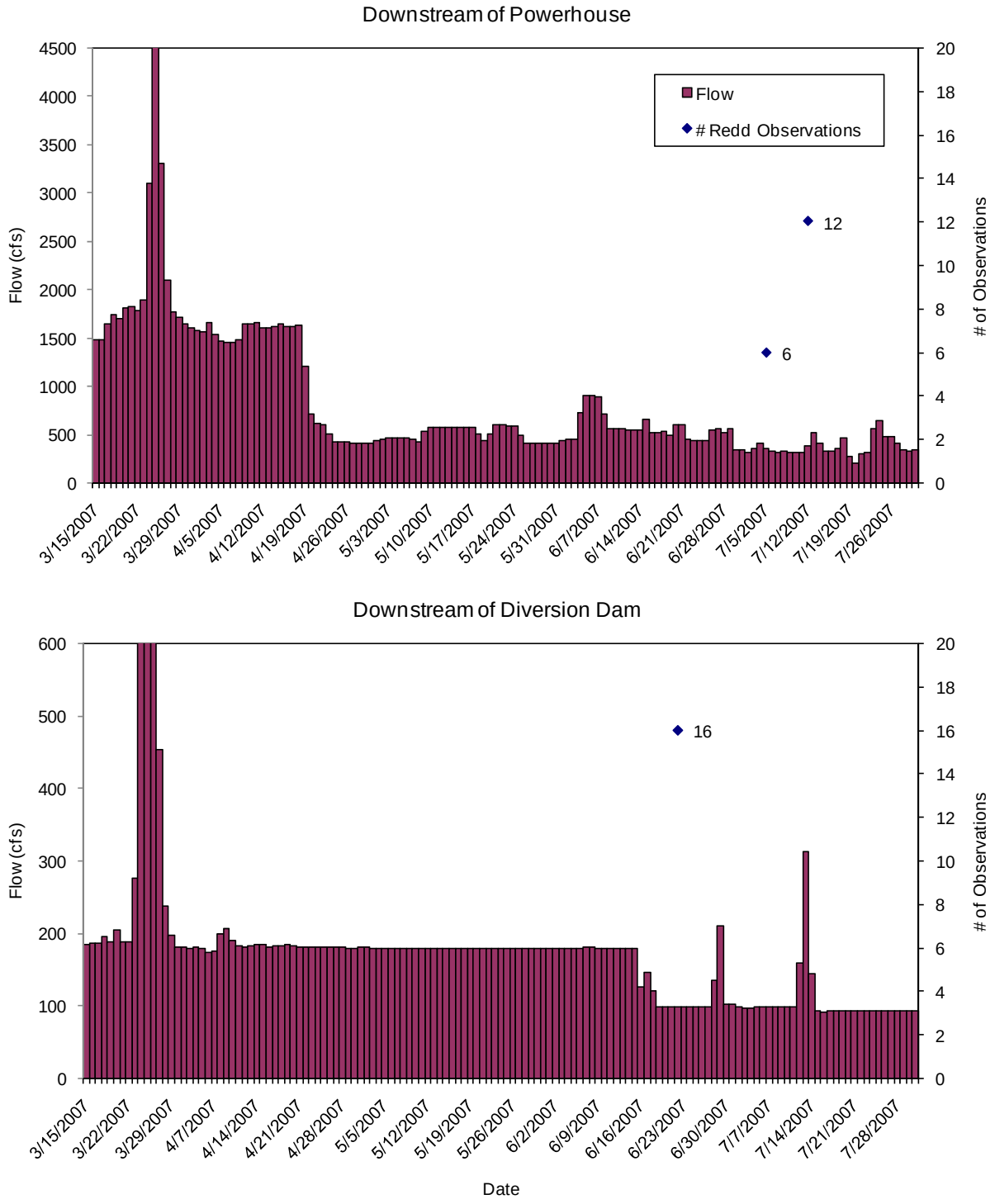


Figure 5. Average daily flows (2007) downstream of the powerhouse (top) and diversion dam (bottom) during steelhead spawning period (March 15 to June 15), Sultan River, Washington. Points indicate date and number of redd observations.

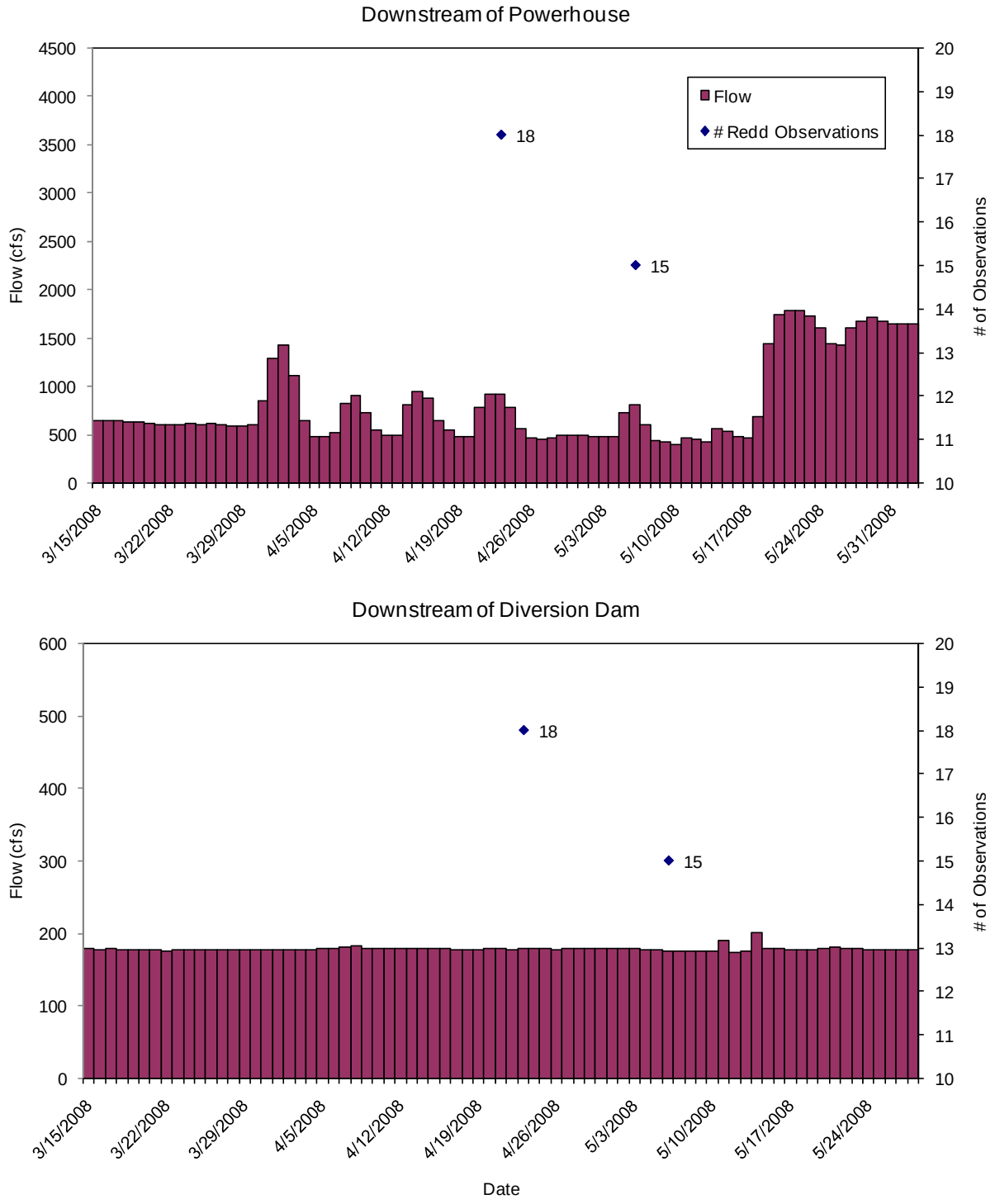


Figure 6. Average daily flows (2008) downstream of the powerhouse (top) and diversion dam (bottom) during steelhead spawning period (March 15 to June 15), Sultan River, Washington. Points indicate date and number of redd observations.

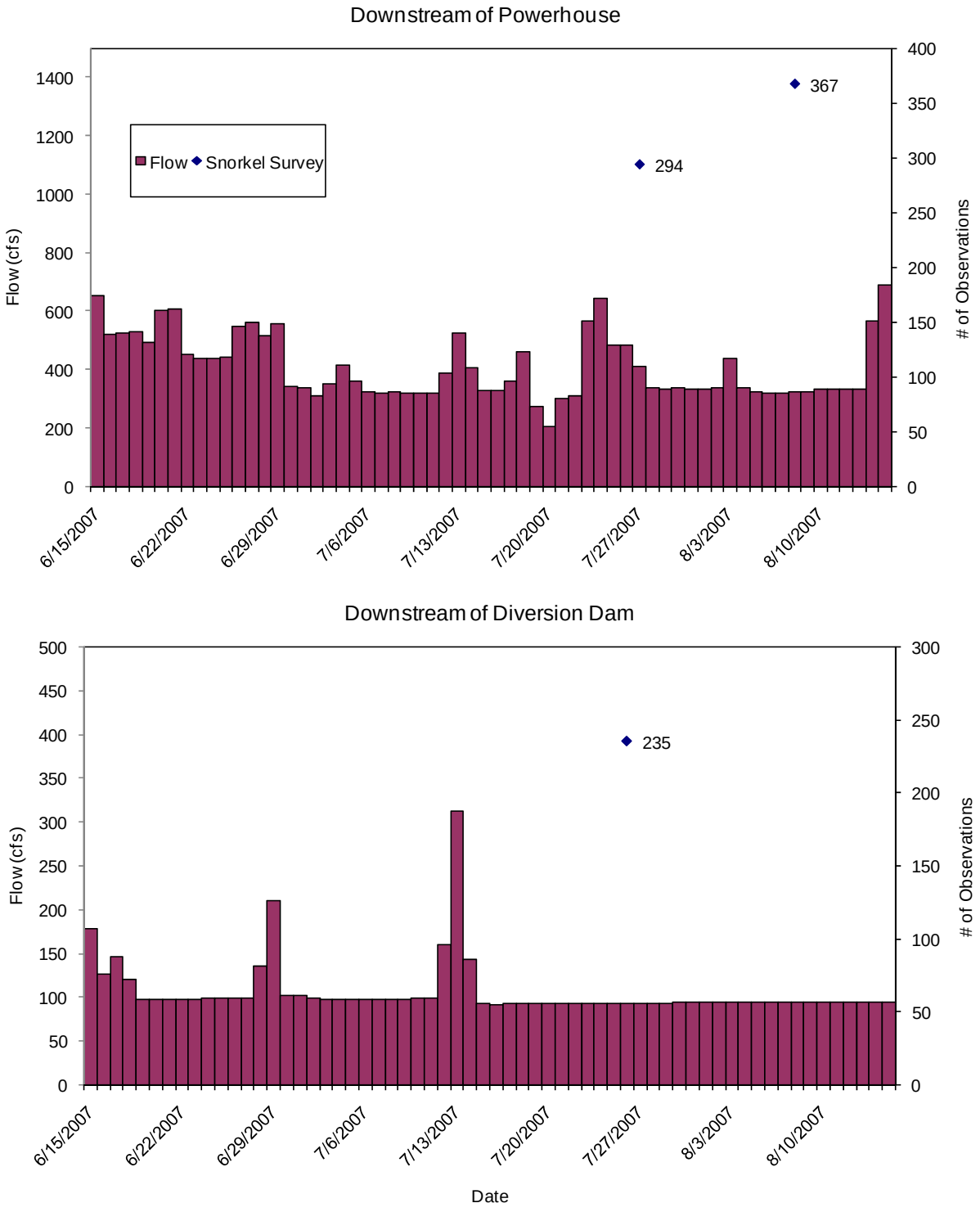


Figure 7. Average daily flows (2007) downstream of the powerhouse (top) and diversion dam (bottom) during summer rearing period (June 15 to August 15), Sultan River, Washington. Points indicate date and number of juvenile fish observations made during snorkel surveys.

6.4 COHO SALMON - JUVENILE

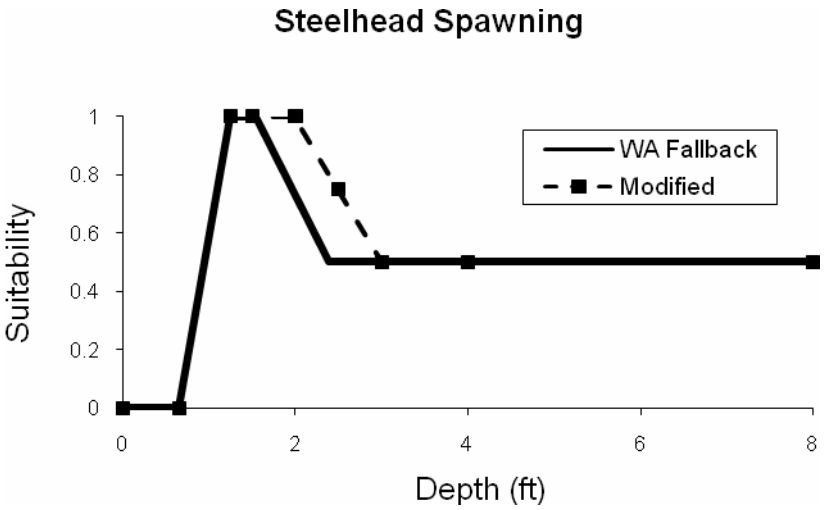
A total of 459 juvenile (>60mm < 100 mm length) coho salmon were observed in Reaches 1A and 2 during the two HSC surveys. Over 90 percent of the juvenile coho observed during the two surveys were located in Reach 1A, with only 42 of the total observations made in Reach 2. These fish were observed at depths between 0.35 and 4.0 feet, and at mean column velocities between 0.02 and 1.71 fps (Appendix B). Peak utilization for water depth occurred between 0.5 and 2.5 feet deep and 0.1 to 0.6 fps for mean column velocity. These fish used substrates ranging from gravel to boulders, with peak utilization observed in proximity to large gravel and cobble sized substrates. HSC curves for this species and life stage were derived from the utilization data and plotted with the State Fallback Curves for comparison.

6.5 STEELHEAD/RAINBOW TROUT - FRY

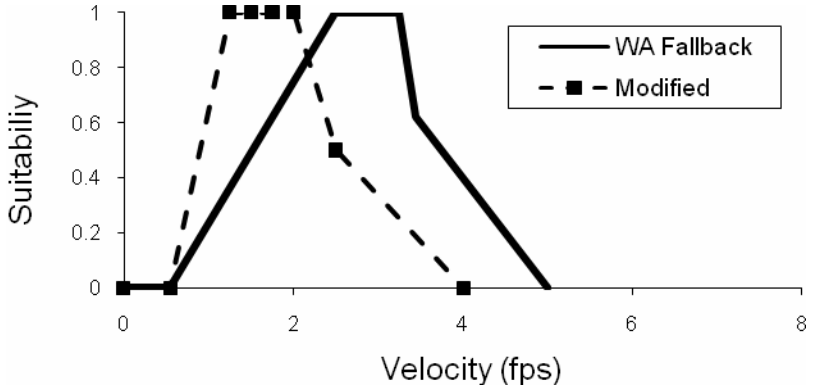
A total of 431 steelhead/rainbow trout fry (< 60 mm length) were observed in Reaches 1A and 2 during the two HSC surveys. The number of observations were nearly equally split between Reaches 1A and 2 with 238 and 193, respectively. These fish were observed at depths between 0.2 and 2.5 feet, and at mean column velocities between 0.0 and 2.03 fps (Appendix B). Peak utilization for water depth occurred between 0.5 and 0.8 feet deep and 0.1 to 0.6 fps for mean column velocity. Substrate utilization varied widely from sand to boulder with peak utilization observed in proximity to large gravel and cobble sized substrates. HSC curves for this species and life stage were derived from the utilization data and plotted with the State Fallback Curves for comparison.

7. RECOMMENDED HSC CURVES

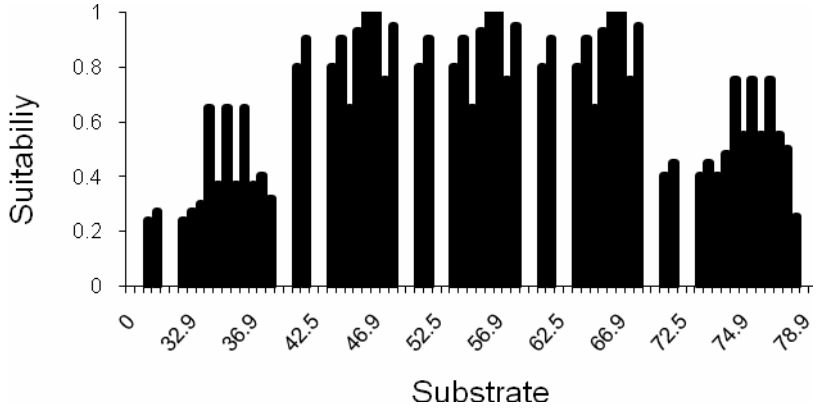
Site specific microhabitat utilization measurements were collected for four distinct species and life stages of fish in the Sultan River: spawning steelhead trout (n observations = 68), spawning Chinook salmon (n observations = 133), juvenile coho salmon (n observations = 459), and steelhead/rainbow trout fry (n observations = 431). For each of these species and life stages, HSC curves (depth and velocity) were developed using the site specific observations normalized to a suitability of 1.0. Plots of the resulting HSC utilization curves, State Fallback Curves, and for the spawning life stage of two species (steelhead trout and Chinook salmon spawning) and juvenile coho salmon the proposed modified curves, are presented in Figures 8 to 11. Because either no site specific data were collected or the data collected did not suggest modification, R2 proposes to utilize State Fallback Curves for the Species and Life stages noted in Table 3 and presented in Appendix C.



WA Fallback		Modified	
Depth	Util.	Depth	Util.
0	0	0	0.0
0.65	0	0.65	0.0
1.25	1	1.25	1.0
1.55	1	1.55	1.0
2.4	0.5	1.9	1.0
8	0.5	2.5	1.0
		3.0	0.5
		4.0	0.5
		8.0	0.5

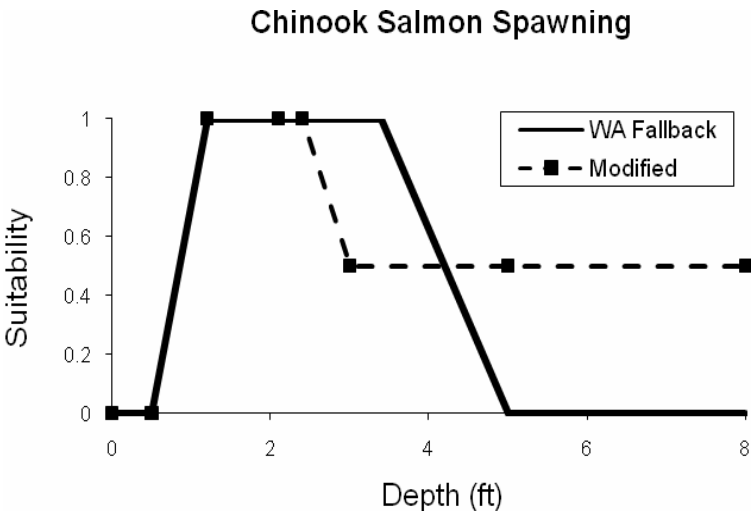


WA Fallback		Modified	
Velocity	Util.	Velocity	Util.
0	0	0	0
0.55	0	0.55	0.00
2.5	1	1.25	1.00
3.25	1	1.5	1.00
3.45	0.62	1.75	1.00
5	0	2.0	1.00
		2.5	0.5
		4.0	0

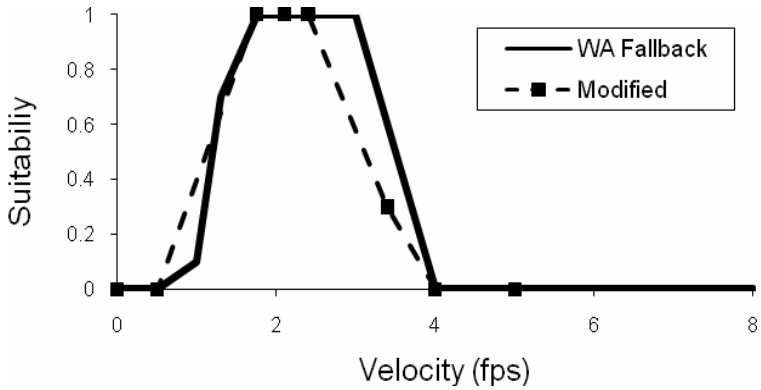


See reference for full list of coordinates

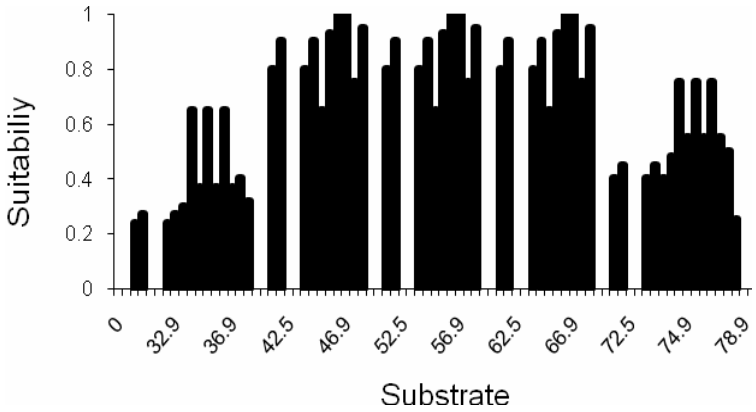
Figure 8. Steelhead spawning microhabitat suitability criteria curves including State Fallback Curves, site specific utilization curves, and recommended modified curves.



WA Fallback		Modified	
Depth	Util.	Depth	Util.
0	0	0	0
0.5	0	0.5	0
1.2	1	1.2	1
3.4	1	2.1	1.0
5	0	2.4	1.0
8	0	3.0	0.5
		5.0	0.5
		8.0	0.5

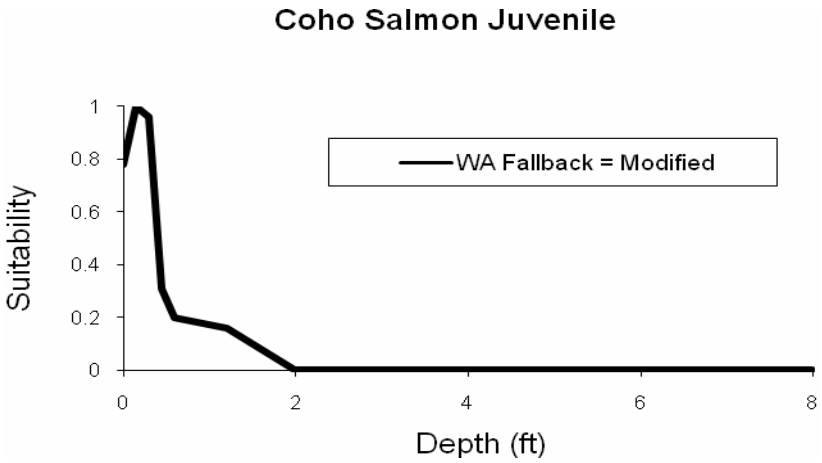


WA Fallback		Modified	
Velocity	Util.	Velocity	Util.
0	0	0.0	0.0
0.5	0	0.5	0.0
1	0.1	1.8	1.0
1.3	0.7	2.1	1.0
1.75	1	2.4	1.0
3	1	3.4	0.3
4	0	4.0	0.0
8	0	5.0	0.0

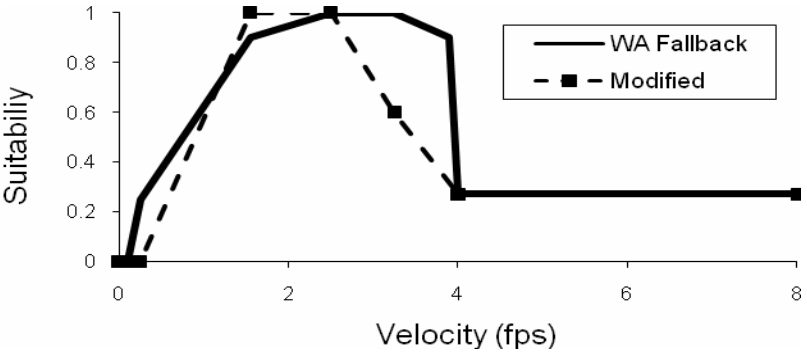


See reference for full list of coordinates

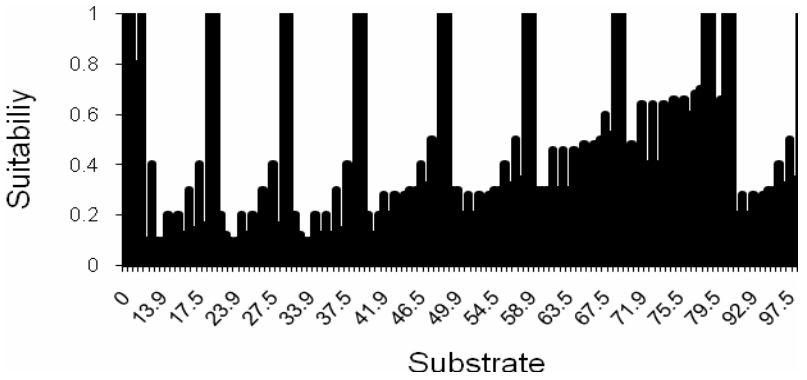
Figure 9. Chinook spawning microhabitat HSC curves including State Fallback, site specific utilization curves, and recommended modified curves.



Depth	Util.
0	0.78
0.15	1
0.3	0.96
0.45	0.31
0.6	0.2
1.2	0.16
2	0
8	0

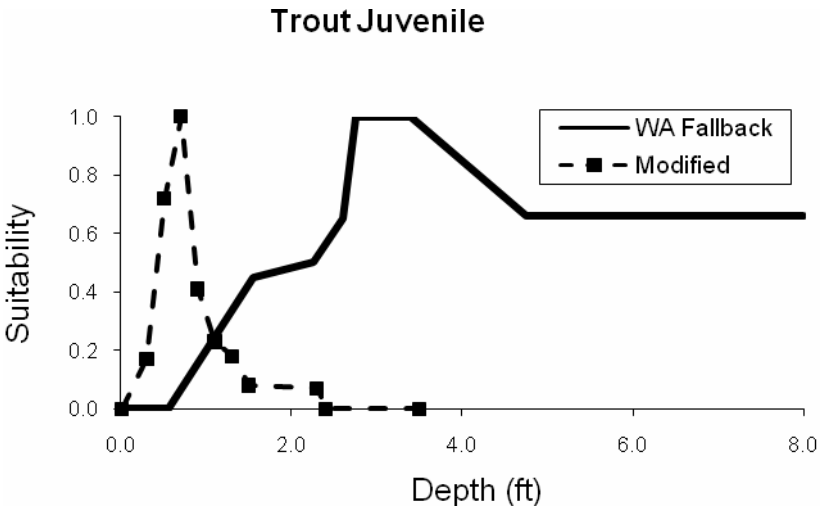


WA Fallback		Modified	
Velocity	Util.	Velocity	Util.
0	0	0	0
0.1	0	0.1	0
0.25	0.25	0.25	0
1.55	0.9	1.55	1
2.5	1	2.5	1
3.25	1	3.25	0.6
3.9	0.9	4	0.27
4	0.27	8	0.27
8	0.27		

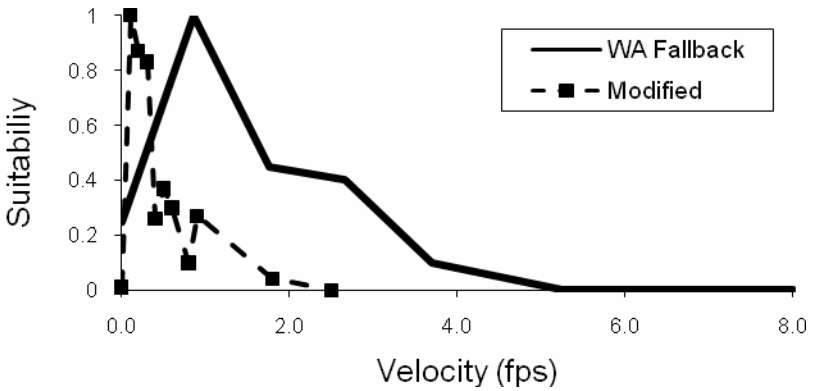


See reference for full list of coordinates

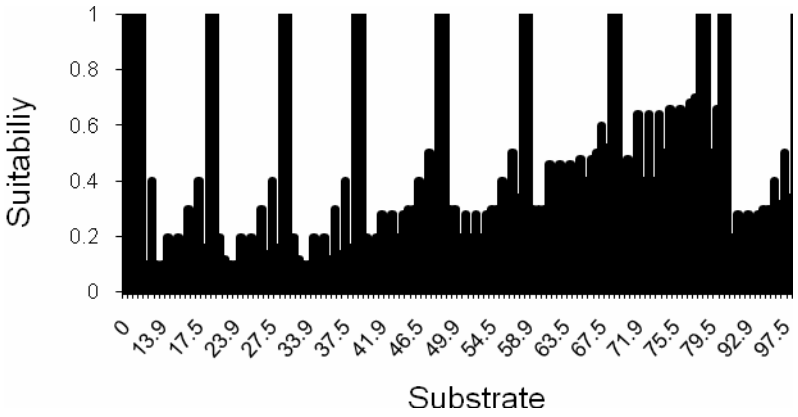
Figure 10. Juvenile coho salmon microhabitat suitability criteria curves including State Fallback Curves, site specific utilization curves, and recommended modified curves.



WA Fallback		Modified	
Depth	Util.	Depth	Util.
0.0	0.0	0.01	0
0.55	0.0	0.3	0.17
1.55	0.45	0.5	0.72
2.25	0.5	0.7	1.0
2.6	0.7	0.9	0.41
2.75	1	1.1	0.23
3.4	1	1.3	0.18
4.75	0.66	1.5	0.08
8	0.66	2.3	0.07
		2.4	0
		3.5	0



WA Fallback		Modified	
Velocity	Util.	Velocity	Util.
0.0	0.25	0	0.01
0.85	1	0.1	1.00
1.75	0.45	0.2	0.87
2.65	0.4	0.3	0.83
3.7	0.1	0.4	0.26
5.25	0	0.5	0.37
8.0	0	0.6	0.30
		0.8	0.10
		0.9	0.27
		1.8	0.04
		2.5	0.00



Substrate suitability for generic trout rearing. See reference for full list of coordinates

Figure 11. Juvenile trout microhabitat suitability criteria curves including State Fallback Curves, site specific utilization curves.

Table 3. Species and life stages for which State Fallback Curves will be applied on the Sultan River instream flow study, and rationale for use.

Species	Life Stage	Rationale for Using State Fallback Curves
Chinook salmon	Juvenile	insufficient observations to develop site specific criteria
Steelhead trout	Juvenile	no data collected; observations only made of fry life stage
Coho salmon	Juvenile	site specific data collected but Utilization Curve did not indicate modification warranted
Chum salmon	Spawning	no data collected
Chum salmon	Juvenile	no data collected
Pink salmon	Spawning	no data collected
Rainbow trout	Spawning	no data collected
Rainbow trout	Adult	no data collected
Rainbow trout	Juvenile	no data collected
Cutthroat trout	Spawning	no data collected
Cutthroat trout	Adult	no data collected
Cutthroat trout	Juvenile	no data collected

The two modified HSC curves for steelhead and Chinook spawning that are proposed for use on the Sultan River instream flow study, as well as the curves developed for juvenile coho and rainbow/steelhead fry that are not being proposed for use are discussed below.

7.1 STEELHEAD TROUT SPAWNING

Utilization curves for steelhead spawning were developed for both mean column velocity and water depth. The utilization curve for velocity begins at 0.5 fps (= 0) and is followed by a sharp increase to a single peak at 1.5 fps (= 1), a sharp decrease to 2.0 fps (= 0.57) and then gradually declining to 3.75 fps (= 0) (Figure 8). The State Fallback Curve for velocity begins similarly at 0.55 fps (=0), but then increases uniformly to a peak of 2.5 fps (= 1) that extends to 3.25 fps (= 1) before decreasing sharply to 3.45 fps (= 0.62) followed by a gradual decrease to 5 fps (= 0). Thus, the peaks of the two curves differ by1 fps at the lower end of the peak of the State Fallback Curve and by 1.75 fps at the upper end of the peak. Importantly, only 8 of the 66 measurements made over steelhead redds in the Sultan River were found in velocities of ≥ 3 fps suggesting that steelhead spawning in the Sultan River are generally using slower velocities than would be indicated by the upper end of the State Fallback Curve. As a result, R2 is proposing to modify the State Fallback Curve for velocity based on the site specific data. However, rather than simply recommending the utilization curve with its single sharp point, R2 has visually smoothed

and extended the curve to include a wider range of velocities as optimum (1.25 to 2 fps) before decreasing and following the descending limb to 3.75 fps (-0). The descending limb of the modified curve was specifically fit to match the relative shape and slope of the observed steelhead spawning utilization with a suitability of 0 for mean column velocities greater than 4.0 fps. Extending the suitable range of mean column velocity to a maximum of 4.0 fps covers the entire range of observed water velocities for all steelhead redd observations. In general, the peak and shape of the descending limb are similar in form to the State Fallback Curve, but offset lower by 1 to 1.25 fps (Figure 8).

For depth, the utilization data indicated that use began at 0.9 ft and then increased sharply as depth increased up to an optimum usage at 2 ft, a decrease to 2.5 ft, a sharp decrease to 3 ft and then a gradual decrease in use as depths increased above 3 ft. In contrast, the State Fallback Curves suggests no use at depths of ≤ 0.65 ft, optimum depths occurring from 1.25 to 1.55 ft, followed by a decrease in use once depths exceed 2.4 ft. The State Fallback Curve for depth does not intersect with zero but is maintained at the 0.5 level out through depths of 8 ft. Thus, it is velocity rather than depth that becomes the limiting parameter relative to defining spawning habitat. Based on the site specific data and a review of the State Fallback Curve, R2 is recommending adoption of the ascending limb of the State Fallback Curve up to 1.25 ft but extending the range of optimal depth to 2 ft before descending to 3 ft where suitability is maintained at 0.5 out to 8 ft (Figure 8). Similar to the velocity curve, the proposed descending limb is similar to the State Fallback Curve, but based on site specific data is offset by a depth that is about 0.5 ft greater.

Although substrate utilization observations were recorded at each of the surveyed steelhead spawning redds, the data generally match the State Fallback Curve and no modifications are proposed.

7.2 CHINOOK SALMON SPAWNING

Utilization curves were likewise developed for Chinook spawning for both mean column velocity and water depth. The utilization curve for velocity begins at 0.5 fps (= 0) followed by a relatively sharp steady increase to 2.1 fps, a single peak at 1.5 fps (= 1), followed by a sharp decrease to 1.8 fps (= 1.0), and then declining in a series of steps to 3.7 (= 0) (Figure 9). The State Fallback Curve for velocity begins similarly at 0.5 fps (= 0), but then increases steadily to a peak of 1.75 fps (= 1) that extends to 3 fps (= 1) before decreasing sharply to 4 fps (= 0). Thus, the peaks of the two curves differ by 0.25 fps at the lower end of the peak of the State Fallback Curve and by 1.5 fps at the upper end of the peak. For the measurements collected over Chinook redds, only 10 of 133 were found in velocities ≥ 3 fps suggesting that like steelhead, the Chinook spawning in the Sultan River tend to use slightly slower velocities than would be indicated by the

upper end of the State Fallback Curve. As a result, R2 is proposing to modify the State Fallback Curve for velocity based on the site specific data. As was done for steelhead, rather than recommending the utilization curve with its single sharp peak and multiple decreasing peaks, R2 visually smoothed and extended the curve to include a wider range of velocities as optimum (1.8 to 2.4 fps) before decreasing and following the descending limb to 4 fps (-0). The upper ¾ of the descending limb of the modified curve was fit about mid-way between the utilization curve and the State Fallback Curve.

For depth, the utilization data indicated that use began at 0.6 ft (= 0), increased sharply at depths of 1.3 to 1.6 ft (-0.53), followed by a sharp increase in use at depths of 2 ft (=1). Utilization then declined sharply as depths increased from 2.4 ft (= 0.7) to 3.8 ft (- 0). In contrast, the State Fallback Curves suggest no use at depths of ≤ 0.5 ft, optimum depths occurring from 1.2 to 3.4 ft, followed by no use once depths exceed 5 ft. Unlike the State Fallback Curve for steelhead depth, the State Fallback Curve for Chinook does intersect with zero at 5 ft. Based on the site specific data and a review of the State Fallback Curve, R2 is recommending a relatively minor adjustment to the ascending limb of the State Fallback Curve that essentially renders it as a single direct increase from 0.5 (= 0) to 1.8 ft. The range of optimal depths would extend to 2.4 ft which is 1 ft less than indicated by the State Fallback Curve. The descending limb then decreases sharply to 3 ft (= 0.5) and then is maintained at the 0.5 suitability level out to 8 ft. This differs from the State Fallback Curve that continues and intersects the x-axis at 5 ft (= 0). However, the modification pertaining to having depth non-limiting as proposed by R2 is consistent with the steelhead depth curve noted above and does not set an upper limit to the depth of water that may be utilized by spawning Chinook salmon.

As for steelhead, although substrate utilization observations were recorded at each of the surveyed Chinook spawning redds, the data appear to match the State Fallback Curve and so no modifications to the State Fallback Curve for Chinook spawning substrate suitability are recommended.

7.3 COHO JUVENILE

Both the ascending and descending limbs of the mean column water velocity utilization for juvenile coho salmon nearly identically matched the State Fallback Curve (Figure 10). The peak of the HSC utilization curve (suitability 1.0 = 0.15 cfs) and the maximum observed velocity utilization (2.0 cfs) match the State Fallback Curve. The additional data collected as part of this study essentially confirmed the applicability of the State Fallback Curves for use in the Sultan River, and as a result, R2 recommends use of the State Fallback Curve for juvenile coho salmon velocity.

The minimum water depth utilization observed during the 2007 snorkel surveys for juvenile coho was 0.4 feet. The ascending limb of the R2 modified juvenile coho salmon depth curve follows the shape of the utilization data to 1.5 ft (= 1). The range of water depth that provides a suitability of 1.0 extends from 1.5 ft to 2.5 ft. The frequency of utilization of water depth greater than 2.5 feet falls off considerably to a depth of 4.0 ft (Figure 10). The suitability of water depth greater than 4.0 ft was kept at a constant suitability of 0.27 which does not set an upper limit to the depth of water that may be utilized by juvenile coho salmon. Although these data support some modification to the State Fallback Curve for juvenile coho depth, R2 generally supports a "depth not limiting" concept when related to juvenile rearing habitats. The general premise is that the extent and range of habitats that will be used by juvenile fish will be limited by velocity, not by the depth of water. As a result, R2 recommends use of the State Fallback Curve for juvenile coho salmon depth, since it affords higher suitability to a wider range of depths than that suggested by the R2 data.

7.4 STEELHEAD/RAINBOW TROUT FRY

State Fallback Curves are not available for steelhead/rainbow trout fry. The HSC utilization curves presented in Figure 11 (Obs.) represent habitat usage by trout fry less than 60 millimeters in total length. The State Fallback Curves for Trout Juvenile appear to represent habitat suitability for much larger trout (Figure 11). Consequently, R2 is proposing to use the State Fallback Curves (depth, velocity, and substrate) for juvenile trout and not to include the steelhead/rainbow trout fry HSC curves as part of the instream flow study. However, if stakeholders request use of steelhead/rainbow trout fry HSC curves as part of the instream flow assessment, R2 recommends that the utilization curves presented in Figure 11 be used without modification.

8. TECHNICAL REVIEW MEETING

The District proposes to meet with agency and stakeholder representatives to present the results of this analysis and discuss the modified HSC curves proposed for use in the habitat modeling. The presentation will include a discussion of data collection and analysis techniques, other data sets reviewed, and the technical basis and rationale for each of the two modified curves. Comments from stakeholders and agencies will be solicited during the meeting on each of the curves, with the goal of reaching a consensus agreement on the final set of HSC curves to be used in the modeling.

Subsequent to the meeting, R2 will incorporate agency and stakeholder comments into a final draft report that will describe the process used in developing the HSC curves, including the comments received during the review meeting. This report will contain the final set of HSC

curves that will be used in the habitat-flow modeling, and will be appended as part of the instream flow study report.

9. REFERENCES

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Stillwater Sciences and Meridian Environmental. 2008b. Study Plan 18: riverine, riparian and wetland habitat assessment, technical report. Prepared for Snohomish County Public Utility District No. 1.

Sturges, H. A. 1926. The Choice of a Class Interval. J. Amer. Stat. Assoc. 21: 65-66.

Public Utility District No. 1 of Snohomish County and City of Everett. 2005. Pre-Application Document. Henry M. Jackson Hydroelectric Project, FERC 2157.

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APPENDIX A

Sultan River HSC Curve Observation Data: 2006 – 2008

Sultan River HSC Curve Observation Data: 2006 - 2008

Date	Reach	Species	Life Stage	# of Obs.	Depth (ft)	Velocity (fps)	Substrate (Dom.)	Substrate (Sub.)
7/7/2007	Reach 2	Steelhead	Spawning	1	0.88	1.46	MG	
7/7/2007	Reach 2	Steelhead	Spawning	1	1.19	1.44	MG	
7/7/2007	Reach 2	Steelhead	Spawning	1	1.20	1.64	MG	
7/7/2007	Reach 2	Steelhead	Spawning	1	0.95	0.78	MG	
7/7/2007	Reach 2	Steelhead	Spawning	1	1.70	3.08	MG	
7/7/2007	Reach 2	Steelhead	Spawning	1	1.40	2.69	MG	
7/7/2007	Reach 2	Steelhead	Spawning	1	1.68	2.59	MG	
7/7/2007	Reach 2	Steelhead	Spawning	1	1.32	1.90	MG	
7/7/2007	Reach 2	Steelhead	Spawning	1	2.40	1.70	MG	
7/7/2007	Reach 2	Steelhead	Spawning	1	1.80	2.19	MG	
7/7/2007	Reach 2	Steelhead	Spawning	1	1.14	2.49	MG	
7/7/2007	Reach 2	Steelhead	Spawning	1	2.00	1.55	MG	
7/7/2007	Reach 2	Steelhead	Spawning	1	2.40	1.52	MG	
7/7/2007	Reach 2	Steelhead	Spawning	1	2.21	1.54	MG	
7/7/2007	Reach 2	Steelhead	Spawning	1	2.10	1.49	MG	
7/7/2007	Reach 2	Steelhead	Spawning	1	0.95	0.79	SG	
7/7/2007	Reach 1A	Steelhead	Spawning	1	1.80	2.76	MG	
7/7/2007	Reach 1A	Steelhead	Spawning	1	1.85	2.78	LG	
7/7/2007	Reach 1A	Steelhead	Spawning	1	1.70	2.66	MG	
7/7/2007	Reach 1A	Steelhead	Spawning	1	1.45	2.46	MG	
7/7/2007	Reach 1A	Steelhead	Spawning	1	1.40	3.13	MG	
7/7/2007	Reach 1A	Steelhead	Spawning	1	1.75	3.41	MG	
7/13/2007	Reach 1A	Steelhead	Spawning	1	1.40	2.73	LG	
7/13/2007	Reach 1A	Steelhead	Spawning	1	1.50	2.77	LG	
7/13/2007	Reach 1A	Steelhead	Spawning	1	1.10	2.34	LG	
7/13/2007	Reach 1A	Steelhead	Spawning	1	1.10	1.95	LG	
7/13/2007	Reach 1A	Steelhead	Spawning	1	1.50	3.59	LG	
7/13/2007	Reach 1A	Steelhead	Spawning	1	1.60	1.54	LG	
7/13/2007	Reach 1A	Steelhead	Spawning	1	2.00	1.37	LG	
7/13/2007	Reach 1A	Steelhead	Spawning	1	1.50	1.61	SC	
7/13/2007	Reach 1A	Steelhead	Spawning	1	1.00	1.20	LG	

Sultan River HSC Curve Observation Data: 2006 - 2008

Date	Reach	Species	Life Stage	# of Obs.	Depth (ft)	Velocity (fps)	Substrate (Dom.)	Substrate (Sub.)
7/13/2007	Reach 1A	Steelhead	Spawning	1	1.70	2.40	LG	
7/13/2007	Reach 1A	Steelhead	Spawning	1	1.60	2.12	LG	
7/13/2007	Reach 1A	Steelhead	Spawning	1	1.50	2.14	SC	
4/23/2008	Reach 2	Steelhead	Spawning	1	2.35	2.91	SC	LG
4/23/2008	Reach 2	Steelhead	Spawning	1	1.9	3.34	SC	LG
4/23/2008	Reach 2	Steelhead	Spawning	1	2.25	1.9	LG	SC
4/23/2008	Reach 2	Steelhead	Spawning	1	1.4	3.2	LG	SC
4/23/2008	Reach 2	Steelhead	Spawning	1	1.9	1.77	LG	SC
4/23/2008	Reach 2	Steelhead	Spawning	1	1.75	1.94	LG	SC
4/23/2008	Reach 2	Steelhead	Spawning	1	2.55	2.09	LG	SG
4/23/2008	Reach 2	Steelhead	Spawning	1	1.8	1.96	LG	SG
4/23/2008	Reach 2	Steelhead	Spawning	1	1.8	2.34	LG	SG
4/23/2008	Reach 2	Steelhead	Spawning	1	1.3	1.59	LG	SG
4/23/2008	Reach 2	Steelhead	Spawning	1	1.6	1.92	LG	SG
4/23/2008	Reach 2	Steelhead	Spawning	1	2.3	1.9	LG	SG
4/23/2008	Reach 2	Steelhead	Spawning	1	2	1.63	LG	SG
4/23/2008	Reach 2	Steelhead	Spawning	1	2.55	1.255	LG	SG
4/23/2008	Reach 2	Steelhead	Spawning	1	3.15	1.22	LG	SG
4/23/2008	Reach 2	Steelhead	Spawning	1	1.3	1.14	SG	LG
4/23/2008	Reach 2	Steelhead	Spawning	1	2.5	1.375	SG	LG
4/23/2008	Reach 2	Steelhead	Spawning	1	2.15	1.62	SG	LG
5/6/2008	Reach 2	Steelhead	Spawning	1	1.3	3.24	SC	LG
5/6/2008	Reach 2	Steelhead	Spawning	1	1.8	2.51	SC	LG
5/6/2008	Reach 2	Steelhead	Spawning	1	1.15	1.96	SC	LG
5/6/2008	Reach 2	Steelhead	Spawning	1	2.65	1.89	SC	LG
5/6/2008	Reach 2	Steelhead	Spawning	1	2.35	2.68	LG	SC
5/6/2008	Reach 2	Steelhead	Spawning	1	3.5	2.38	LG	SC
5/6/2008	Reach 2	Steelhead	Spawning	1	1.5	1.54	LG	SC
5/6/2008	Reach 2	Steelhead	Spawning	1	2.65	2.47	LG	SG
5/6/2008	Reach 2	Steelhead	Spawning	1	2.5	1.36	LG	SG
5/6/2008	Reach 2	Steelhead	Spawning	1	2.4	2.31	LG	SG

Sultan River HSC Curve Observation Data: 2006 - 2008

Date	Reach	Species	Life Stage	# of Obs.	Depth (ft)	Velocity (fps)	Substrate (Dom.)	Substrate (Sub.)
5/6/2008	Reach 2	Steelhead	Spawning	1	1.35	1.42	LG	SG
5/6/2008	Reach 2	Steelhead	Spawning	1	2.15	1.33	LG	SG
5/6/2008	Reach 2	Steelhead	Spawning	1	2.2	1.62	LG	SG
5/6/2008	Reach 2	Steelhead	Spawning	1	1.25	2.1	LG	SG
5/6/2008	Reach 2	Steelhead	Spawning	1	1.7	1.58	LG	SG
10/2/2006	Reach 2	Chinook	Spawning	1	0.95	0.58	RB	CB
10/2/2006	Reach 2	Chinook	Spawning	1	2.20	1.26	CB	CG
10/2/2006	Reach 2	Chinook	Spawning	1	1.60	1.67	CG	CB
10/2/2006	Reach 2	Chinook	Spawning	1	1.45	1.97	FG	RB
10/2/2006	Reach 2	Chinook	Spawning	1	1.65	1.46	CG	CB
10/2/2006	Reach 2	Chinook	Spawning	1	1.85	1.97	RB	CB
10/2/2006	Reach 2	Chinook	Spawning	1	0.90	1.52	CB	CG
10/2/2006	Reach 2	Chinook	Spawning	1	2.10	1.54	RB	CB
10/2/2006	Reach 2	Chinook	Spawning	1	2.45	1.80	RB	CB
10/2/2006	Reach 2	Chinook	Spawning	1	2.45	1.39	CG	CB
10/2/2006	Reach 2	Chinook	Spawning	1	1.50	2.52	CG	CB
10/2/2006	Reach 2	Chinook	Spawning	1	1.70	1.93	CB	CG
10/2/2006	Reach 2	Chinook	Spawning	1	2.50	0.61	RB	CB
10/2/2006	Reach 2	Chinook	Spawning	1	1.90	1.40	CB	RB
10/2/2006	Reach 2	Chinook	Spawning	1	2.00	0.98	RB	CB
10/4/2006	Reach 1A	Chinook	Spawning	1	1.55	2.07	RB	CB
10/4/2006	Reach 1A	Chinook	Spawning	1	1.10	1.86	RB	CB
10/4/2006	Reach 1A	Chinook	Spawning	1	2.10	0.87	RB	CB
10/4/2006	Reach 1A	Chinook	Spawning	1	2.10	2.55	RB	CB
10/4/2006	Reach 1A	Chinook	Spawning	1	2.10	1.83	RB	CB
10/4/2006	Reach 1A	Chinook	Spawning	1	2.30	1.74	RB	CB
10/4/2006	Reach 1A	Chinook	Spawning	1	2.20	1.73	RB	CB
10/4/2006	Reach 1A	Chinook	Spawning	1	1.40	2.14	RB	CB
10/4/2006	Reach 1A	Chinook	Spawning	1	2.20	2.43	RB	CB
10/4/2006	Reach 1A	Chinook	Spawning	1	1.90	2.24	CB	RB
10/4/2006	Reach 1A	Chinook	Spawning	1	1.85	2.34	RB	CB

Sultan River HSC Curve Observation Data: 2006 - 2008

Date	Reach	Species	Life Stage	# of Obs.	Depth (ft)	Velocity (fps)	Substrate (Dom.)	Substrate (Sub.)
10/4/2006	Reach 1A	Chinook	Spawning	1	1.20	1.20	RB	BO
10/4/2006	Reach 1A	Chinook	Spawning	1	1.20	1.20	RB	BO
10/4/2006	Reach 1A	Chinook	Spawning	1	1.75	1.75	RB	CB
10/4/2006	Reach 1A	Chinook	Spawning	1	2.20	2.20	RB	CB
10/4/2006	Reach 1A	Chinook	Spawning	1	1.75	1.75	RB	CB
10/4/2006	Reach 1A	Chinook	Spawning	1	1.35	1.35	RB	BO
10/4/2006	Reach 1A	Chinook	Spawning	1	1.20	1.20	CG	CB
10/4/2006	Reach 1A	Chinook	Spawning	1	1.10	1.10	RB	BO
10/4/2006	Reach 1A	Chinook	Spawning	1	0.80	0.80	CB	RB
10/4/2006	Reach 1A	Chinook	Spawning	1	1.10	1.10	CB	RB
10/9/2006	Reach 1A	Chinook	Spawning	1	0.70	1.35	CB	RB
10/9/2006	Reach 1A	Chinook	Spawning	1	1.10	1.65	RB	CB
10/9/2006	Reach 1A	Chinook	Spawning	1	0.95	1.02	RB	CB
10/9/2006	Reach 1A	Chinook	Spawning	1	1.35	2.10	RB	BO
10/9/2006	Reach 1A	Chinook	Spawning	1	1.70	2.17	CG	RB
10/9/2006	Reach 1A	Chinook	Spawning	1	2.05	0.84	CG	CB
10/9/2006	Reach 1A	Chinook	Spawning	1	1.85	2.59	CB	RB
10/9/2006	Reach 1A	Chinook	Spawning	1	1.70	2.43	CB	RB
10/9/2006	Reach 1A	Chinook	Spawning	1	2.35	1.90	CB	RB
10/9/2006	Reach 1A	Chinook	Spawning	1	2.70	1.48	CB	CG
10/9/2006	Reach 1A	Chinook	Spawning	1	2.65	1.57	CB	RB
10/9/2006	Reach 1A	Chinook	Spawning	1	2.45	2.54	CB	RB
10/9/2006	Reach 1A	Chinook	Spawning	1	0.75	1.31	CG	CB
10/9/2006	Reach 1A	Chinook	Spawning	1	1.20	2.97	CB	RB
10/9/2006	Reach 1A	Chinook	Spawning	1	1.35	2.43	CG	CB
10/9/2006	Reach 1A	Chinook	Spawning	1	2.15	2.84	CB	CG
10/9/2006	Reach 1A	Chinook	Spawning	1	1.25	1.17	CB	RB
10/9/2006	Reach 1A	Chinook	Spawning	1	2.15	2.21	CG	CB
10/9/2006	Reach 1A	Chinook	Spawning	1	2.15	1.86	CG	CB
10/9/2006	Reach 1A	Chinook	Spawning	1	0.70	1.71	CB	CG
10/9/2006	Reach 1A	Chinook	Spawning	1	1.35	1.39	CB	CG

Sultan River HSC Curve Observation Data: 2006 - 2008

Date	Reach	Species	Life Stage	# of Obs.	Depth (ft)	Velocity (fps)	Substrate (Dom.)	Substrate (Sub.)
10/9/2006	Reach 1A	Chinook	Spawning	1	1.40	3.16	CG	CB
10/9/2006	Reach 1A	Chinook	Spawning	1	1.20	2.84	CB	CG
10/9/2006	Reach 1A	Chinook	Spawning	1	1.30	1.65	FG	CG
10/10/2006	Reach 2	Chinook	Spawning	1	3.60	0.76	CB	CG
10/10/2006	Reach 2	Chinook	Spawning	1	3.40	0.86	CG	FG
10/10/2006	Reach 2	Chinook	Spawning	1	1.90	1.30	FG	CG
10/10/2006	Reach 2	Chinook	Spawning	1	1.25	1.73	RB	CB
10/10/2006	Reach 2	Chinook	Spawning	1	1.80	2.15	CB	RB
10/10/2006	Reach 2	Chinook	Spawning	1	3.40	1.36	CG	RB
10/10/2006	Reach 2	Chinook	Spawning	1	1.70	3.19	RB	CB
10/10/2006	Reach 2	Chinook	Spawning	1	1.70	3.19	RB	CB
10/10/2006	Reach 2	Chinook	Spawning	1	1.70	3.19	RB	CB
10/10/2006	Reach 2	Chinook	Spawning	1	1.90	1.95	CB	CG
10/10/2006	Reach 2	Chinook	Spawning	1	2.10	1.95	CG	CB
10/10/2006	Reach 2	Chinook	Spawning	1	2.00	2.64	CG	CB
10/10/2006	Reach 2	Chinook	Spawning	1	2.45	1.78	CB	CG
10/10/2006	Reach 2	Chinook	Spawning	1	3.50	1.52	CG	CB
10/10/2006	Reach 2	Chinook	Spawning	1	2.30	2.28	CB	RB
9/24/2007	Reach 2	Chinook	Spawning	1	1.95	2.09	CG	RB
9/24/2007	Reach 2	Chinook	Spawning	1	2.80	2.52	FG	CG
9/24/2007	Reach 2	Chinook	Spawning	1	1.90	1.90	RB	FG
9/24/2007	Reach 2	Chinook	Spawning	1	1.90	1.90	RB	FG
9/24/2007	Reach 2	Chinook	Spawning	1	1.45	1.45	RB	FG
9/24/2007	Reach 2	Chinook	Spawning	1	1.75	1.75	CG	RB
9/24/2007	Reach 2	Chinook	Spawning	1	0.95	0.95	FG	CG
9/24/2007	Reach 2	Chinook	Spawning	1	0.70	0.70	FG	CG
9/24/2007	Reach 2	Chinook	Spawning	1	2.10	2.30	CG	FG
9/24/2007	Reach 2	Chinook	Spawning	1	2.10	1.36	CG	FG
9/24/2007	Reach 2	Chinook	Spawning	1	2.10	1.71	CG	CB
9/24/2007	Reach 2	Chinook	Spawning	1	2.30	0.96	CB	CG
9/24/2007	Reach 2	Chinook	Spawning	1	1.20	1.15	CG	CB

Sultan River HSC Curve Observation Data: 2006 - 2008

Date	Reach	Species	Life Stage	# of Obs.	Depth (ft)	Velocity (fps)	Substrate (Dom.)	Substrate (Sub.)
9/24/2007	Reach 2	Chinook	Spawning	1	2.10	1.72	RB	CB
9/24/2007	Reach 2	Chinook	Spawning	1	1.45	2.93	RB	CB
9/24/2007	Reach 2	Chinook	Spawning	1	1.75	2.61	RB	CB
9/24/2007	Reach 2	Chinook	Spawning	1	2.30	1.40	RB	CB
9/24/2007	Reach 2	Chinook	Spawning	1	2.90	1.58	RB	CB
9/24/2007	Reach 2	Chinook	Spawning	1	1.90	1.32	RB	CB
9/24/2007	Reach 2	Chinook	Spawning	1	2.10	0.96	CB	CG
9/24/2007	Reach 2	Chinook	Spawning	1	2.35	1.37	CG	CB
10/12/2007	Reach 2	Chinook	Spawning	1	1.15	1.27	CG	FG
10/12/2007	Reach 2	Chinook	Spawning	1	2.00	2.27	CB	CG
10/12/2007	Reach 2	Chinook	Spawning	1	2.05	2.79	CB	RB
10/12/2007	Reach 2	Chinook	Spawning	1	0.95	3.32	CB	CG
10/12/2007	Reach 2	Chinook	Spawning	1	1.00	0.67	RB	FG
10/12/2007	Reach 2	Chinook	Spawning	1	0.70	0.91	CG	CB
10/12/2007	Reach 2	Chinook	Spawning	1	1.00	1.55	CG	CB
10/12/2007	Reach 2	Chinook	Spawning	1	2.00	1.93	CG	CB
10/12/2007	Reach 2	Chinook	Spawning	1	2.40	1.73	CG	CB
10/12/2007	Reach 2	Chinook	Spawning	1	1.95	2.31	CG	CB
10/12/2007	Reach 2	Chinook	Spawning	1	1.25	2.36	CB	CG
10/12/2007	Reach 2	Chinook	Spawning	1	2.00	2.38	CB	CG
10/12/2007	Reach 2	Chinook	Spawning	1	0.90	2.21	CG	FG
10/12/2007	Reach 2	Chinook	Spawning	1	2.45	1.80	CB	CG
10/12/2007	Reach 2	Chinook	Spawning	1	1.75	1.62	CB	CG
10/12/2007	Reach 2	Chinook	Spawning	1	1.35	2.40	RB	CB
10/12/2007	Reach 2	Chinook	Spawning	1	1.65	2.25	RB	CB
10/12/2007	Reach 2	Chinook	Spawning	1	1.70	2.54	RB	CB
10/12/2007	Reach 2	Chinook	Spawning	1	1.45	2.50	RB	CB
10/12/2007	Reach 2	Chinook	Spawning	1	2.10	2.03	RB	CB
10/12/2007	Reach 2	Chinook	Spawning	1	1.10	1.09	RB	CB
10/12/2007	Reach 2	Chinook	Spawning	1	1.40	1.12	CB	FG
10/12/2007	Reach 2	Chinook	Spawning	1	1.75	2.77	RB	CB

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Date	Reach	Species	Life Stage	# of Obs.	Depth (ft)	Velocity (fps)	Substrate (Dom.)	Substrate (Sub.)
10/12/2007	Reach 2	Chinook	Spawning	1	1.60	1.80	RB	CB
10/12/2007	Reach 2	Chinook	Spawning	1	1.40	3.35	RB	CB
10/12/2007	Reach 2	Chinook	Spawning	1	1.75	2.31	RB	CB
10/12/2007	Reach 2	Chinook	Spawning	1	1.30	1.52	RB	CB
10/12/2007	Reach 2	Chinook	Spawning	1	0.70	3.27	RB	CB
10/12/2007	Reach 2	Chinook	Spawning	1	0.85	2.63	RB	CB
10/12/2007	Reach 2	Chinook	Spawning	1	2.60	1.13	CG	CB
10/12/2007	Reach 2	Chinook	Spawning	1	2.60	1.33	CG	CB
10/15/2007	Reach 1A	Chinook	Spawning	1	1.10	1.50	RB	CB
10/15/2007	Reach 1A	Chinook	Spawning	1	1.80	1.67	CB	CG
10/15/2007	Reach 1A	Chinook	Spawning	1	0.70	1.99	RB	CB
10/15/2007	Reach 1A	Chinook	Spawning	1	1.10	1.03	CB	CG
10/15/2007	Reach 1A	Chinook	Spawning	1	0.90	1.26	RB	CB
10/15/2007	Reach 1A	Chinook	Spawning	1	1.40	1.43	RB	CB
10/15/2007	Reach 1A	Chinook	Spawning	1	2.15	3.16	CB	CG
7/27/2007	Reach 1A	Trout	Fry	3	0.2	0.02	LC	SC
7/27/2007	Reach 1A	Trout	Fry	2	0.25	0.02	LC	SC
7/27/2007	Reach 1A	Trout	Fry	2	0.3	0.02	LC	SC
7/27/2007	Reach 1A	Trout	Fry	2	0.55	0.02	SC	SG
7/27/2007	Reach 1A	Trout	Fry	4	0.7	0.02	LC	SC
7/27/2007	Reach 1A	Trout	Fry	1	0.8	0.02	SC	LG
7/27/2007	Reach 1A	Trout	Fry	2	1.2	0.02	LC	SC
7/27/2007	Reach 1A	Trout	Fry	1	1.25	0.02	LG	LC
7/27/2007	Reach 1A	Trout	Fry	1	1.95	0.02	SC	LG
7/27/2007	Reach 1A	Trout	Fry	3	0.3	0.03	SC	LC
7/27/2007	Reach 1A	Trout	Fry	1	1	0.05	LC	SC
7/27/2007	Reach 1A	Trout	Fry	1	0.55	0.06	SC	LG
7/27/2007	Reach 1A	Trout	Fry	1	0.50	0.10	SC	LC
7/27/2007	Reach 1A	Trout	Fry	5	0.6	0.10	SC	LG
7/27/2007	Reach 1A	Trout	Fry	1	1.40	0.10	B	LC
7/27/2007	Reach 1A	Trout	Fry	20	0.60	0.12	SC	LC

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Date	Reach	Species	Life Stage	# of Obs.	Depth (ft)	Velocity (fps)	Substrate (Dom.)	Substrate (Sub.)
7/27/2007	Reach 1A	Trout	Fry	2	0.55	0.13	SC	LC
7/27/2007	Reach 1A	Trout	Fry	2	0.6	0.13	SC	LG
7/27/2007	Reach 1A	Trout	Fry	2	0.45	0.20	SC	LC
7/27/2007	Reach 1A	Trout	Fry	1	0.7	0.21	SC	LC
7/27/2007	Reach 1A	Trout	Fry	2	0.5	0.23	SC	LC
7/27/2007	Reach 1A	Trout	Fry	4	0.4	0.24	LG	LC
7/27/2007	Reach 1A	Trout	Fry	5	0.5	0.27	SC	LG
7/27/2007	Reach 1A	Trout	Fry	6	0.65	0.28	SC	LC
7/27/2007	Reach 1A	Trout	Fry	5	0.80	0.34	SC	LC
7/27/2007	Reach 1A	Trout	Fry	1	0.50	0.35	SC	LG
7/27/2007	Reach 1A	Trout	Fry	3	0.85	0.42	SC	LG
7/27/2007	Reach 1A	Trout	Fry	1	0.9	0.43	SC	LC
7/27/2007	Reach 1A	Trout	Fry	3	0.7	0.47	SC	LG
7/27/2007	Reach 1A	Trout	Fry	1	0.60	0.50	SC	LC
7/27/2007	Reach 1A	Trout	Fry	1	0.95	0.51	SC	LG
7/27/2007	Reach 1A	Trout	Fry	3	0.95	0.58	SC	LG
7/27/2007	Reach 1A	Trout	Fry	1	1.8	0.81	SC	LG
7/27/2007	Reach 1A	Trout	Fry	20	0.60	0.83	SC	LC
7/27/2007	Reach 1A	Trout	Fry	1	0.70	0.83	SC	LC
7/27/2007	Reach 2	Trout	Fry	1	2.15	0.00	B	LC
7/27/2007	Reach 2	Trout	Fry	1	0.45	0.01	LC	LG
7/27/2007	Reach 2	Trout	Fry	1	0.70	0.02	B	LC
7/27/2007	Reach 2	Trout	Fry	2	0.80	0.02	LC	LG
7/27/2007	Reach 2	Trout	Fry	1	1.40	0.02	B	LC
7/27/2007	Reach 2	Trout	Fry	3	0.60	0.03	B	LG
7/27/2007	Reach 2	Trout	Fry	30	0.75	0.03	LG	B
7/27/2007	Reach 2	Trout	Fry	10	0.45	0.05	SC	LC
7/27/2007	Reach 2	Trout	Fry	6	1.05	0.05	LC	LG
7/27/2007	Reach 2	Trout	Fry	6	0.55	0.06	LC	LG
7/27/2007	Reach 2	Trout	Fry	5	1.30	0.06	B	SC
7/27/2007	Reach 2	Trout	Fry	1	0.35	0.08	LC	LG

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Date	Reach	Species	Life Stage	# of Obs.	Depth (ft)	Velocity (fps)	Substrate (Dom.)	Substrate (Sub.)
7/27/2007	Reach 2	Trout	Fry	6	0.65	0.11	SC	MG
7/27/2007	Reach 2	Trout	Fry	1	0.95	0.11	SND	SG
7/27/2007	Reach 2	Trout	Fry	2	2.30	0.11	B	LC
7/27/2007	Reach 2	Trout	Fry	4	0.25	0.12	MG	LG
7/27/2007	Reach 2	Trout	Fry	3	0.45	0.12	LC	LG
7/27/2007	Reach 2	Trout	Fry	1	1.25	0.12	B	MG
7/27/2007	Reach 2	Trout	Fry	4	0.40	0.14	LC	MG
7/27/2007	Reach 2	Trout	Fry	15	0.65	0.15	B	LG
7/27/2007	Reach 2	Trout	Fry	2	1.40	0.19	SC	LG
7/27/2007	Reach 2	Trout	Fry	1	0.75	0.20	B	MG
7/27/2007	Reach 2	Trout	Fry	4	0.70	0.21	SC	LG
7/27/2007	Reach 2	Trout	Fry	1	1.50	0.21	LC	B
7/27/2007	Reach 2	Trout	Fry	1	0.55	0.23	LG	LC
7/27/2007	Reach 2	Trout	Fry	2	0.85	0.23	LC	LG
7/27/2007	Reach 2	Trout	Fry	1	1.60	0.27	B	SG
7/27/2007	Reach 2	Trout	Fry	3	0.95	0.29	LG	SC
7/27/2007	Reach 2	Trout	Fry	30	0.55	0.30	LG	B
7/27/2007	Reach 2	Trout	Fry	3	0.40	0.40	LC	LG
7/27/2007	Reach 2	Trout	Fry	1	1.30	0.41	SND	SG
7/27/2007	Reach 2	Trout	Fry	1	0.70	0.45	B	MG
7/27/2007	Reach 2	Trout	Fry	5	1.00	0.49	LC	SG
7/27/2007	Reach 2	Trout	Fry	6	0.65	0.50	LC	LG
7/27/2007	Reach 2	Trout	Fry	1	0.40	0.52	LG	B
7/27/2007	Reach 2	Trout	Fry	15	0.50	0.58	SC	LC
7/27/2007	Reach 2	Trout	Fry	3	0.55	0.58	SG	LG
7/27/2007	Reach 2	Trout	Fry	2	1.10	0.60	LG	B
7/27/2007	Reach 2	Trout	Fry	2	0.85	0.69	LG	B
7/27/2007	Reach 2	Trout	Fry	2	0.55	0.75	SC	LC
7/27/2007	Reach 2	Trout	Fry	1	1.05	1.09	LG	LC
7/27/2007	Reach 2	Trout	Fry	1	1.15	1.72	LC	LG
7/27/2007	Reach 2	Trout	Fry	1	1.45	2.01	MG	LG

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Date	Reach	Species	Life Stage	# of Obs.	Depth (ft)	Velocity (fps)	Substrate (Dom.)	Substrate (Sub.)
7/27/2007	Reach 2	Trout	Fry	1	1.50	2.03	LG	LC
8/8/2007	Reach 1A	Trout	Fry	1	0.4	0.02	LG	SC
8/8/2007	Reach 1A	Trout	Fry	3	0.5	0.03	SC	LG
8/8/2007	Reach 1A	Trout	Fry	1	0.5	0.06	SC	LG
8/8/2007	Reach 1A	Trout	Fry	3	0.3	0.08	SC	LG
8/8/2007	Reach 1A	Trout	Fry	1	0.4	0.08	LG	SC
8/8/2007	Reach 1A	Trout	Fry	3	0.7	0.19	SC	LC
8/8/2007	Reach 1A	Trout	Fry	1	0.55	0.22	LG	SC
8/8/2007	Reach 1A	Trout	Fry	3	0.5	0.25	SC	LG
8/8/2007	Reach 1A	Trout	Fry	1	1	0.25	SC	LC
8/8/2007	Reach 1A	Trout	Fry	2	0.3	0.27	LG	SND
8/8/2007	Reach 1A	Trout	Fry	1	0.5	0.30	SC	LC
8/8/2007	Reach 1A	Trout	Fry	3	0.5	0.30	SC	LG
8/8/2007	Reach 1A	Trout	Fry	1	0.95	0.33	SC	LG
8/8/2007	Reach 1A	Trout	Fry	1	0.75	0.72	LG	SND
8/8/2007	Reach 1A	Trout	Fry	1	0.5	0.02	LG	MG
8/8/2007	Reach 1A	Trout	Fry	3	0.5	0.07	LG	SC
8/8/2007	Reach 1A	Trout	Fry	1	0.5	0.15	SC	LC
8/8/2007	Reach 1A	Trout	Fry	1	0.45	0.20	LG	SC
8/8/2007	Reach 1A	Trout	Fry	1	0.75	0.22	SC	LG
8/8/2007	Reach 1A	Trout	Fry	2	0.45	0.27	LG	SC
8/8/2007	Reach 1A	Trout	Fry	3	0.85	0.28	LC	SC
8/8/2007	Reach 1A	Trout	Fry	1	0.6	0.30	LG	SC
8/8/2007	Reach 1A	Trout	Fry	1	0.5	0.35	LG	SC
8/8/2007	Reach 1A	Trout	Fry	4	0.5	0.40	LG	MG
8/8/2007	Reach 1A	Trout	Fry	6	0.4	0.02	SC	LG
8/8/2007	Reach 1A	Trout	Fry	1	1.2	0.03	SC	LG
8/8/2007	Reach 1A	Trout	Fry	1	0.75	0.11	SC	LG
8/8/2007	Reach 1A	Trout	Fry	1	0.3	0.15	SC	LG
8/8/2007	Reach 1A	Trout	Fry	1	0.6	0.32	SC	LG
8/8/2007	Reach 1A	Trout	Fry	1	0.9	0.74	SC	LG

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Date	Reach	Species	Life Stage	# of Obs.	Depth (ft)	Velocity (fps)	Substrate (Dom.)	Substrate (Sub.)
8/8/2007	Reach 1A	Trout	Fry	1	0.5	0.85	SC	LG
8/8/2007	Reach 1A	Trout	Fry	1	1.25	0.08	B	SC
8/8/2007	Reach 1A	Trout	Fry	1	0.3	0.13	LG	SC
8/8/2007	Reach 1A	Trout	Fry	1	0.7	0.15	B	SC
8/8/2007	Reach 1A	Trout	Fry	1	0.45	0.17	SC	LG
8/8/2007	Reach 1A	Trout	Fry	1	0.4	0.19	LG	SC
8/8/2007	Reach 1A	Trout	Fry	1	0.35	0.23	LG	MG
8/8/2007	Reach 1A	Trout	Fry	1	0.45	0.26	LG	SC
8/8/2007	Reach 1A	Trout	Fry	2	1.3	0.36	SC	MG
8/8/2007	Reach 1A	Trout	Fry	1	0.5	0.54	LG	MG
8/8/2007	Reach 1A	Trout	Fry	1	2.5	0.59	SC	LC
8/8/2007	Reach 1A	Trout	Fry	1	2.5	0.66	B	SC
8/8/2007	Reach 1A	Trout	Fry	1	0.45	0.86	LG	SC
8/8/2007	Reach 1A	Trout	Fry	1	0.5	0.89	LG	LC
8/8/2007	Reach 1A	Trout	Fry	1	1.1	1.10	SC	LC
8/8/2007	Reach 1A	Trout	Fry	1	1.4	1.18	SC	LG
8/8/2007	Reach 1A	Trout	Fry	1	1.5	1.24	SC	LG
8/8/2007	Reach 1A	Trout	Fry	1	1.45	1.49	SC	LG
8/8/2007	Reach 1A	Trout	Fry	1	1.5	1.96	B	LC
8/8/2007	Reach 1A	Trout	Fry	1	1.75	0.18	B	LC
8/8/2007	Reach 1A	Trout	Fry	1	0.8	0.05	LC	SC
8/8/2007	Reach 1A	Trout	Fry	1	1.4	0.08	LC	SC
8/8/2007	Reach 1A	Trout	Fry	2	0.5	0.29	LC	SC
8/8/2007	Reach 1A	Trout	Fry	2	0.6	0.40	SC	LG
8/8/2007	Reach 1A	Trout	Fry	2	1.2	0.42	LC	LG
8/8/2007	Reach 1A	Trout	Fry	1	0.6	0.05	LC	SC
8/8/2007	Reach 1A	Trout	Fry	1	0.6	0.06	LC	SC
8/8/2007	Reach 1A	Trout	Fry	1	0.5	0.24	LC	SC
8/8/2007	Reach 1A	Trout	Fry	1	0.6	0.33	LC	SC
8/8/2007	Reach 1A	Trout	Fry	1	0.5	0.70	LC	SC
8/8/2007	Reach 1A	Trout	Fry	1	1.2	0.20	SC	LC

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Date	Reach	Species	Life Stage	# of Obs.	Depth (ft)	Velocity (fps)	Substrate (Dom.)	Substrate (Sub.)
8/8/2007	Reach 1A	Trout	Fry	1	1	0.23	SC	LC
8/8/2007	Reach 1A	Trout	Fry	1	1	0.27	SC	LC
8/8/2007	Reach 1A	Trout	Fry	1	1.1	0.48	SC	LC
8/8/2007	Reach 1A	Trout	Fry	1	1.2	0.59	BR	SC
8/8/2007	Reach 1A	Trout	Fry	5	0.7	0.02	SC	LC
8/8/2007	Reach 1A	Trout	Fry	2	1.2	0.02	LC	SC
8/8/2007	Reach 1A	Trout	Fry	4	0.7	0.04	SC	LG
8/8/2007	Reach 1A	Trout	Fry	5	0.4	0.11	SC	B
8/8/2007	Reach 1A	Trout	Fry	1	1.3	0.12	LC	SC
8/8/2007	Reach 1A	Trout	Fry	3	0.5	0.13	LC	SC
8/8/2007	Reach 1A	Trout	Fry	2	0.6	0.14	LC	SC
8/8/2007	Reach 1A	Trout	Fry	1	1	0.14	SC	LG
8/8/2007	Reach 1A	Trout	Fry	2	0.8	0.38	LC	SC
8/8/2007	Reach 1A	Trout	Fry	12	0.6	0.50	SC	B
7/27/2007	Reach 1A	Coho	Juvenile	1	0.80	0.02	LG	SLT
7/27/2007	Reach 1A	Coho	Juvenile	1	1.25	0.02	LG	LC
7/27/2007	Reach 1A	Coho	Juvenile	1	1.70	0.02	B	LC
7/27/2007	Reach 1A	Coho	Juvenile	10	1.7	0.02	SC	LG
7/27/2007	Reach 1A	Coho	Juvenile	10	1.9	0.02	SC	LG
7/27/2007	Reach 1A	Coho	Juvenile	20	2.2	0.02	SC	LG
7/27/2007	Reach 1A	Coho	Juvenile	20	1.5	0.06	LC	LG
7/27/2007	Reach 1A	Coho	Juvenile	20	1.9	0.06	SC	LG
7/27/2007	Reach 1A	Coho	Juvenile	12	1.55	0.07	SC	LG
7/27/2007	Reach 1A	Coho	Juvenile	1	1.45	0.08	LC	SND
7/27/2007	Reach 1A	Coho	Juvenile	12	1.1	0.09	SC	LG
7/27/2007	Reach 1A	Coho	Juvenile	20	1.8	0.10	SC	LG
7/27/2007	Reach 1A	Coho	Juvenile	10	0.60	0.12	SC	LC
7/27/2007	Reach 1A	Coho	Juvenile	6	1.25	0.19	LG	LC
7/27/2007	Reach 1A	Coho	Juvenile	20	1.95	0.20	LC	LG
7/27/2007	Reach 1A	Coho	Juvenile	1	0.75	0.24	SC	LG
7/27/2007	Reach 1A	Coho	Juvenile	1	0.90	0.30	SC	LG

Sultan River HSC Curve Observation Data: 2006 - 2008

Date	Reach	Species	Life Stage	# of Obs.	Depth (ft)	Velocity (fps)	Substrate (Dom.)	Substrate (Sub.)
7/27/2007	Reach 1A	Coho	Juvenile	4	1.3	0.63	LC	LG
7/27/2007	Reach 1A	Coho	Juvenile	10	0.60	0.83	SC	LC
7/27/2007	Reach 2	Coho	Juvenile	3	0.80	0.02	B	MG
7/27/2007	Reach 2	Coho	Juvenile	1	1.25	0.02	B	MG
7/27/2007	Reach 2	Coho	Juvenile	2	1.95	0.04	B	LC
7/27/2007	Reach 2	Coho	Juvenile	3	1.05	0.05	LC	LG
7/27/2007	Reach 2	Coho	Juvenile	1	0.65	0.15	B	LG
7/27/2007	Reach 2	Coho	Juvenile	1	1.40	0.22	SC	LG
7/27/2007	Reach 2	Coho	Juvenile	8	1.35	0.40	B	SG
7/27/2007	Reach 2	Coho	Juvenile	8	1.55	0.41	B	SG
7/27/2007	Reach 2	Coho	Juvenile	3	0.40	0.49	LC	MG
7/27/2007	Reach 2	Coho	Juvenile	1	0.60	0.50	LG	SC
7/27/2007	Reach 2	Coho	Juvenile	3	1.10	0.60	LG	B
7/27/2007	Reach 2	Coho	Juvenile	8	1.35	0.76	B	SG
8/8/2007	Reach 1A	Coho	Juvenile	1	0.55	0.26	SC	SG
8/8/2007	Reach 1A	Coho	Juvenile	2	0.65	0.32	LG	MG
8/8/2007	Reach 1A	Coho	Juvenile	3	0.7	0.34	LG	MG
8/8/2007	Reach 1A	Coho	Juvenile	1	0.55	0.38	LG	MG
8/8/2007	Reach 1A	Coho	Juvenile	3	0.65	0.40	LG	MG
8/8/2007	Reach 1A	Coho	Juvenile	3	0.45	0.15	LG	SC
8/8/2007	Reach 1A	Coho	Juvenile	3	0.75	0.23	LG	LC
8/8/2007	Reach 1A	Coho	Juvenile	1	1.35	0.40	LG	SC
8/8/2007	Reach 1A	Coho	Juvenile	2	1.3	0.66	LG	SC
8/8/2007	Reach 1A	Coho	Juvenile	10	1.5	0.02	B	LC
8/8/2007	Reach 1A	Coho	Juvenile	10	1.7	0.09	B	LC
8/8/2007	Reach 1A	Coho	Juvenile	8	1.9	0.14	SC	LC
8/8/2007	Reach 1A	Coho	Juvenile	1	0.35	0.23	LG	MG
8/8/2007	Reach 1A	Coho	Juvenile	5	1.7	0.23	SC	LC
8/8/2007	Reach 1A	Coho	Juvenile	1	2.1	0.25	SC	LC
8/8/2007	Reach 1A	Coho	Juvenile	1	2.8	0.28	B	SC
8/8/2007	Reach 1A	Coho	Juvenile	1	3.3	0.32	B	LC

Sultan River HSC Curve Observation Data: 2006 - 2008

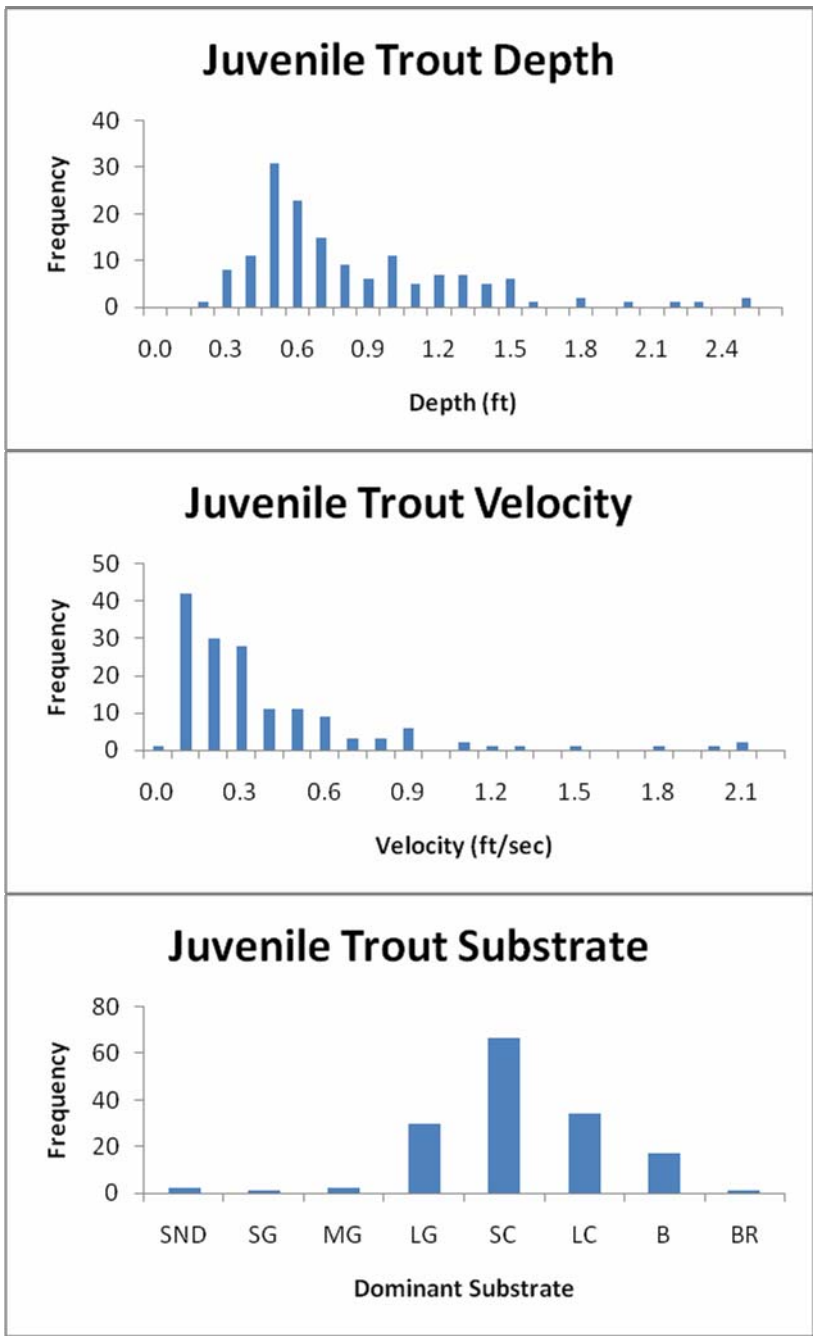
Date	Reach	Species	Life Stage	# of Obs.	Depth (ft)	Velocity (fps)	Substrate (Dom.)	Substrate (Sub.)
8/8/2007	Reach 1A	Coho	Juvenile	1	2.9	0.42	SC	LC
8/8/2007	Reach 1A	Coho	Juvenile	1	3	0.43	SC	LC
8/8/2007	Reach 1A	Coho	Juvenile	1	3	0.47	SC	LC
8/8/2007	Reach 1A	Coho	Juvenile	1	2.8	0.48	SC	LC
8/8/2007	Reach 1A	Coho	Juvenile	1	2.6	0.51	SC	LC
8/8/2007	Reach 1A	Coho	Juvenile	1	1.4	0.58	SC	LG
8/8/2007	Reach 1A	Coho	Juvenile	1	1.45	0.60	SC	LG
8/8/2007	Reach 1A	Coho	Juvenile	3	1.5	0.69	SC	LG
8/8/2007	Reach 1A	Coho	Juvenile	1	1.1	0.75	SC	LC
8/8/2007	Reach 1A	Coho	Juvenile	1	2.6	0.83	SC	LC
8/8/2007	Reach 1A	Coho	Juvenile	1	2.8	0.84	B	LC
8/8/2007	Reach 1A	Coho	Juvenile	1	2.4	1.52	SC	LC
8/8/2007	Reach 1A	Coho	Juvenile	1	2.5	1.71	SC	LC
8/8/2007	Reach 1A	Coho	Juvenile	2	0.8	0.06	LC	SC
8/8/2007	Reach 1A	Coho	Juvenile	6	3.4	0.19	LC	SC
8/8/2007	Reach 1A	Coho	Juvenile	8	3	0.20	LC	SC
8/8/2007	Reach 1A	Coho	Juvenile	8	3.1	0.26	LC	SC
8/8/2007	Reach 1A	Coho	Juvenile	4	3.95	0.28	LC	SC
8/8/2007	Reach 1A	Coho	Juvenile	8	3.6	0.32	LC	SC
8/8/2007	Reach 1A	Coho	Juvenile	8	3.6	0.38	LC	SC
8/8/2007	Reach 1A	Coho	Juvenile	13	0.95	0.02	LC	B
8/8/2007	Reach 1A	Coho	Juvenile	13	1.15	0.02	LC	B
8/8/2007	Reach 1A	Coho	Juvenile	13	1.35	0.02	LC	B
8/8/2007	Reach 1A	Coho	Juvenile	1	1.4	0.08	LC	SC
8/8/2007	Reach 1A	Coho	Juvenile	1	1.6	0.30	LC	SC
8/8/2007	Reach 1A	Coho	Juvenile	1	1.1	0.39	LC	SC
8/8/2007	Reach 1A	Coho	Juvenile	2	0.6	0.04	LC	SC
8/8/2007	Reach 1A	Coho	Juvenile	1	0.6	0.05	LC	SC
8/8/2007	Reach 1A	Coho	Juvenile	10	2.7	0.05	BR	SC
8/8/2007	Reach 1A	Coho	Juvenile	4	1	0.17	SC	LC
8/8/2007	Reach 1A	Coho	Juvenile	10	3.25	0.21	BR	SC

Sultan River HSC Curve Observation Data: 2006 - 2008

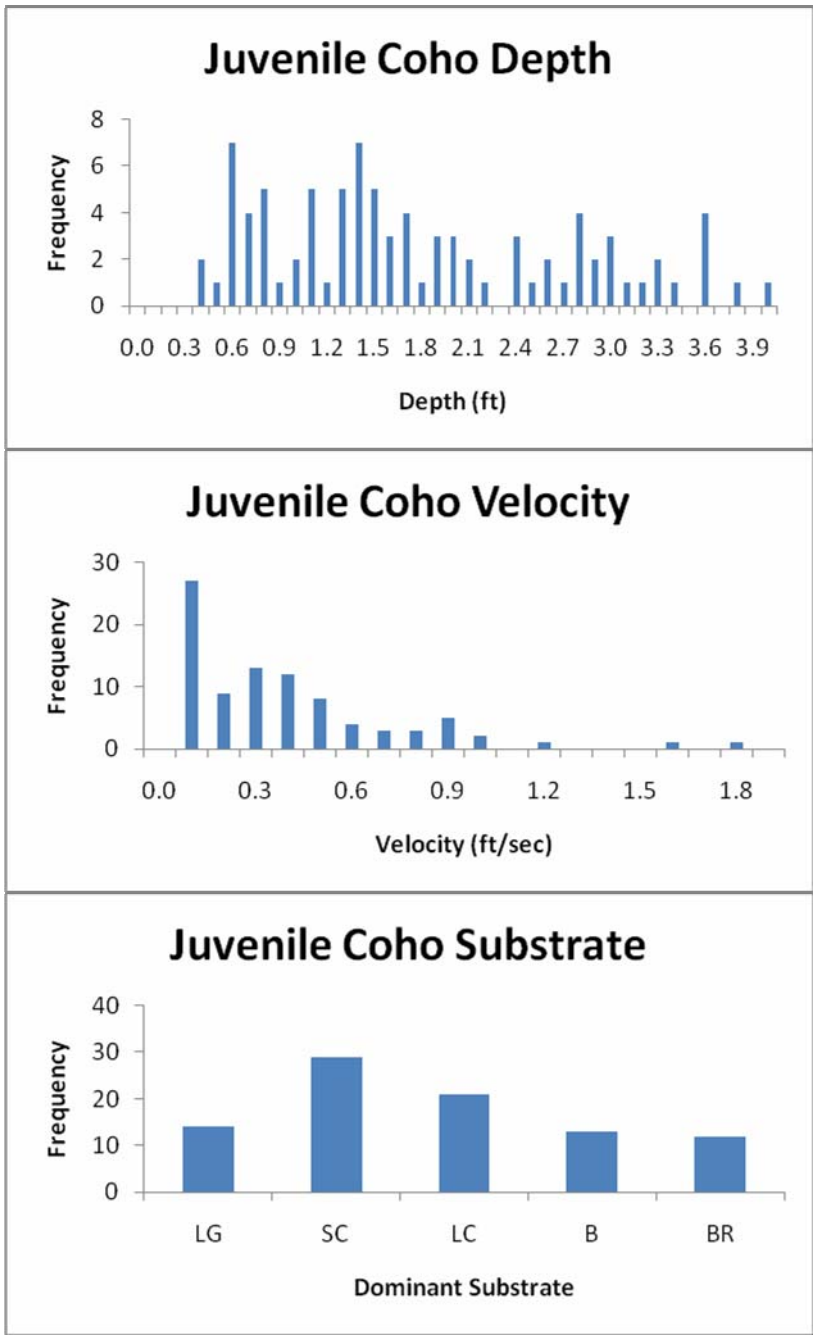
Date	Reach	Species	Life Stage	# of Obs.	Depth (ft)	Velocity (fps)	Substrate (Dom.)	Substrate (Sub.)
8/8/2007	Reach 1A	Coho	Juvenile	10	3.6	0.36	BR	SC
8/8/2007	Reach 1A	Coho	Juvenile	10	3.6	0.40	BR	SC
8/8/2007	Reach 1A	Coho	Juvenile	10	3.8	0.44	BR	SC
8/8/2007	Reach 1A	Coho	Juvenile	3	2.1	0.78	BR	SC
8/8/2007	Reach 1A	Coho	Juvenile	3	2.4	0.82	BR	SC
8/8/2007	Reach 1A	Coho	Juvenile	6	3.2	0.86	BR	SC
8/8/2007	Reach 1A	Coho	Juvenile	4	2.8	0.91	BR	SC
8/8/2007	Reach 1A	Coho	Juvenile	2	2.4	0.94	BR	SC
8/8/2007	Reach 1A	Coho	Juvenile	4	2.9	1.14	BR	SC
8/8/2007	Reach 1A	Coho	Juvenile	1	2	0.05	BR	SC

APPENDIX B

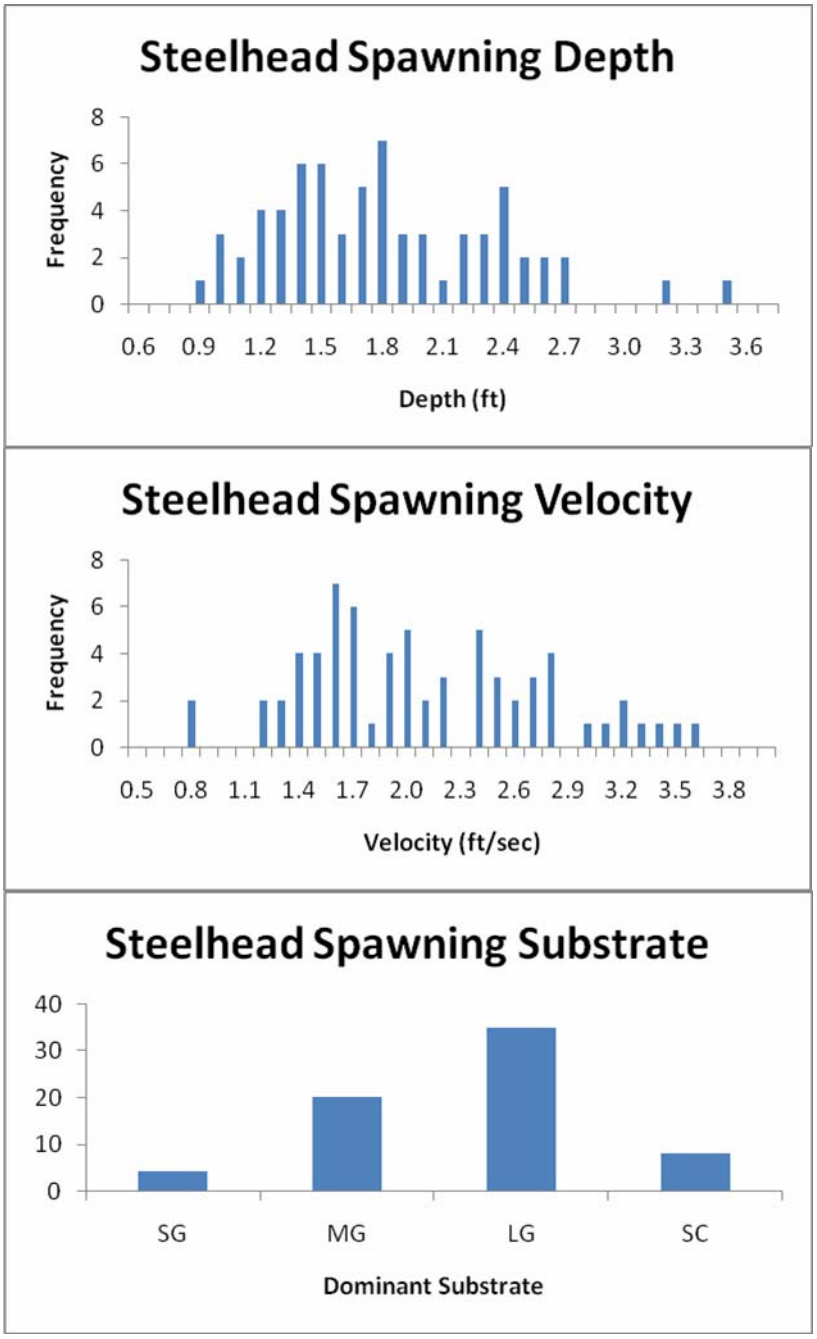
Frequency Distribution of HSC Curve Data Collected on the Sultan River, Washington



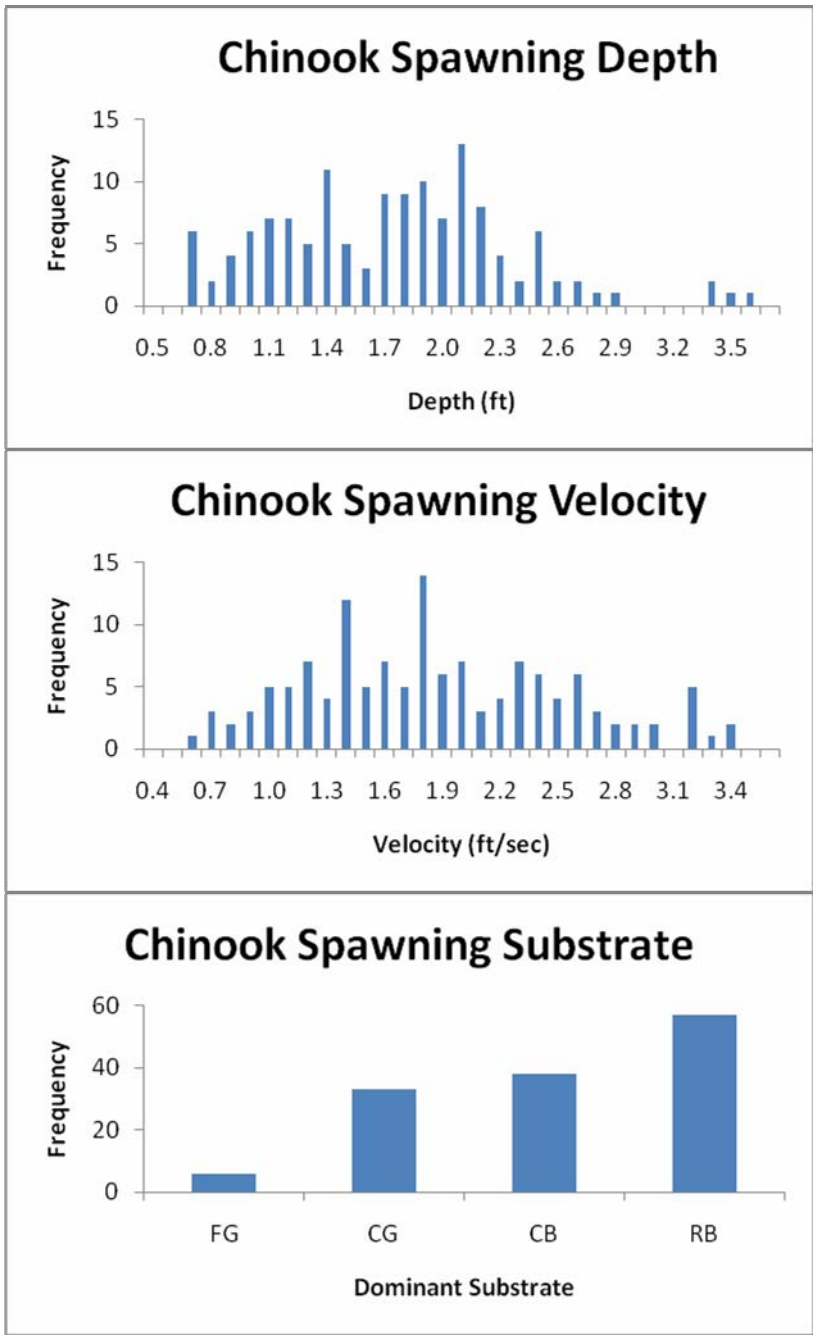
Juvenile trout microhabitat utilization (July/August 2007), Sultan River, Washington.



Juvenile coho microhabitat utilization (July/August 2007), Sultan River, Washington.



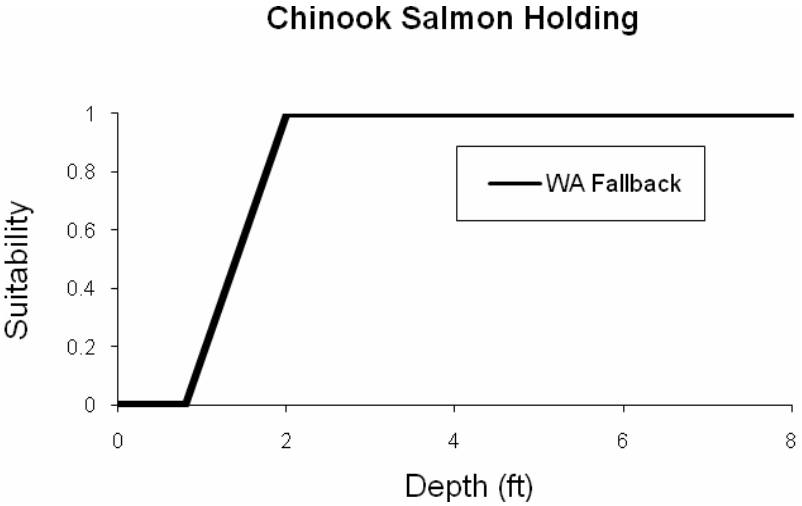
Steelhead spawning microhabitat utilization (July 2007 and April/May 2008), Sultan River, Washington.



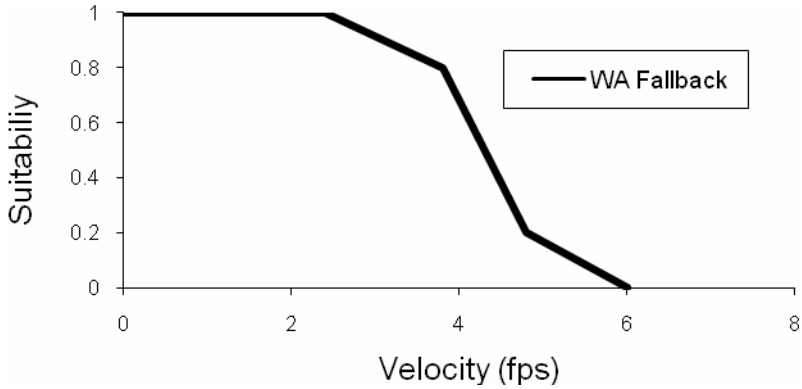
Chinook spawning microhabitat utilization (September/October 2006 and 2007), Sultan River, Washington.

APPENDIX C

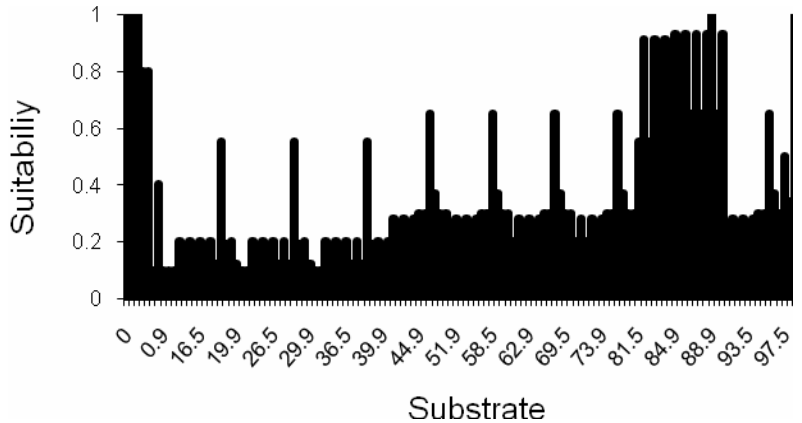
Habitat Suitability Criteria



Depth	Util.
0	0
0.8	0
2	1
6.5	1
100	1

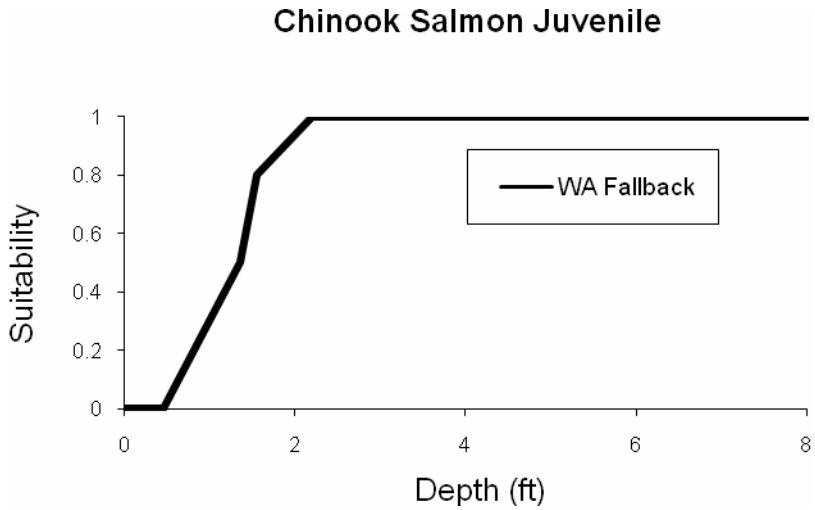


Velocity	Util.
0	1
2.4	1
3.8	0.8
4.8	0.2
6	0

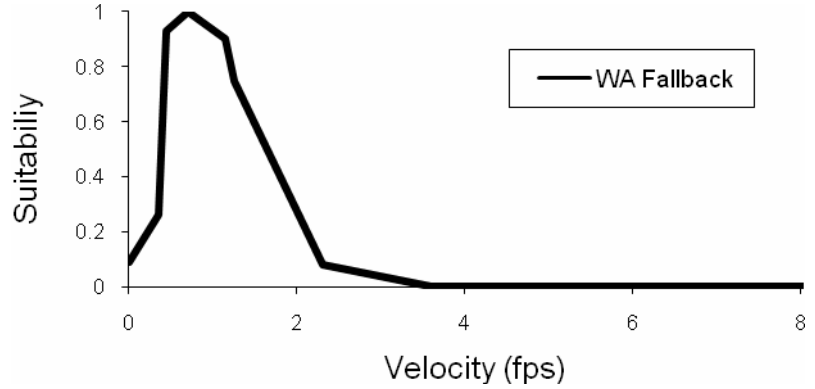


See reference for full list of coordinates

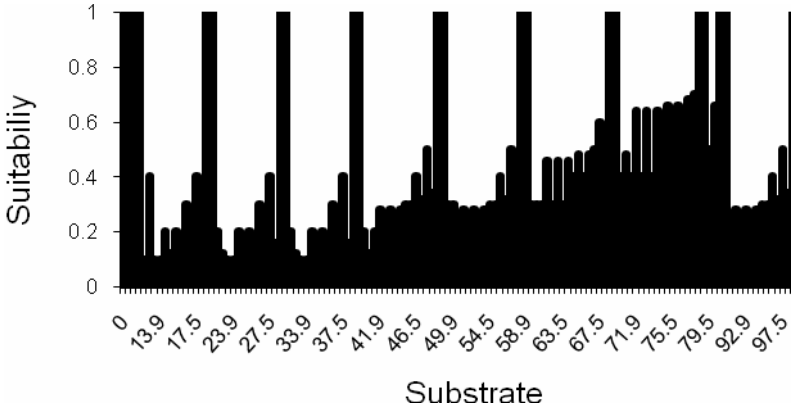
Figure C-1. Chinook holding microhabitat suitability criteria.



Depth	Util.
0	0
0.45	0
1.35	0.5
1.55	0.8
2.2	1
100	1

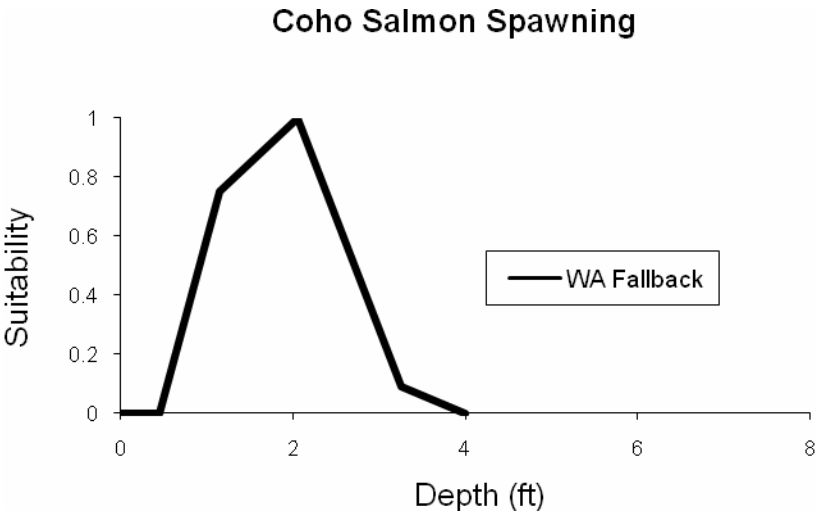


Velocity	Util.
0	0.09
0.35	0.26
0.45	0.93
0.7	1
1.15	0.9
1.25	0.75
2.3	0.08
3.6	0
100	0

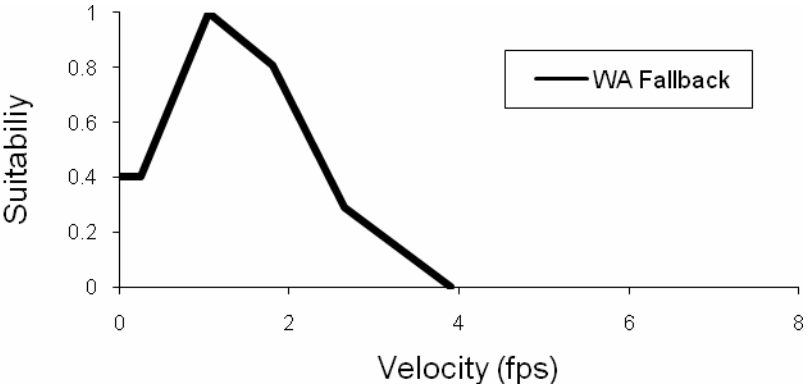


See reference for full list of coordinates

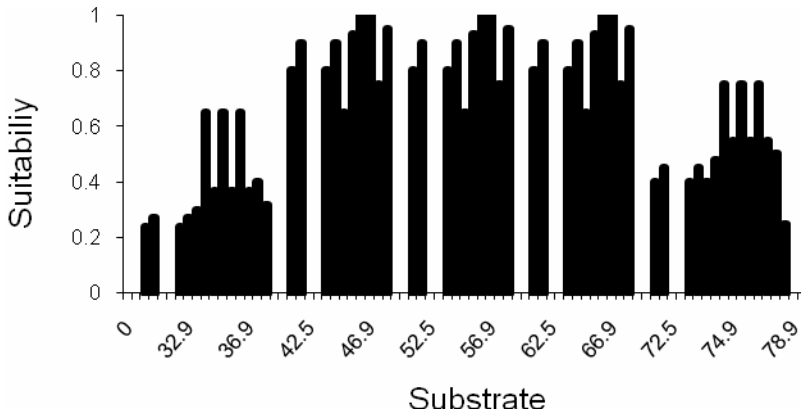
Figure C-2. Juvenile Chinook microhabitat suitability criteria.



Depth	Util.
0	0
0.45	0
1.15	0.75
2.05	1
3.25	0.09
4	0
100	0

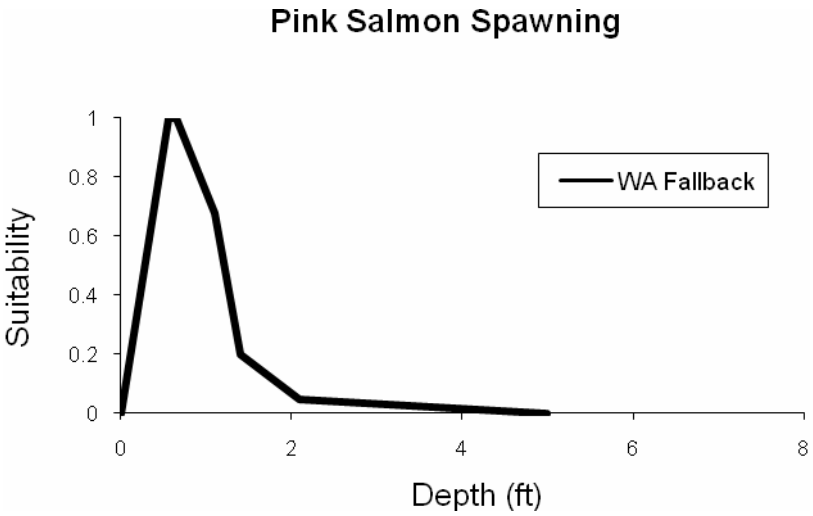


Velocity	Util.
0	0.4
0.25	0.4
1.05	1
1.8	0.81
2.65	0.29
3.9	0
100	0

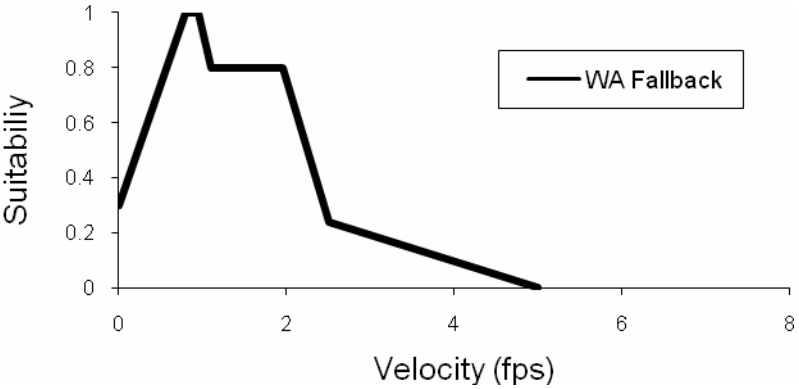


See reference for full list of coordinates

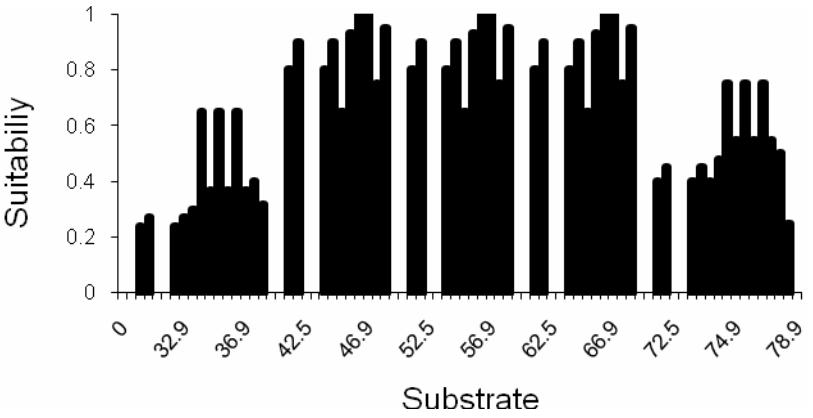
Figure C-3. Coho salmon spawning microhabitat suitability criteria.



Depth	Util.
0	0
0.55	1
0.65	1
1.1	0.68
1.4	0.2
2.1	0.05
5	0

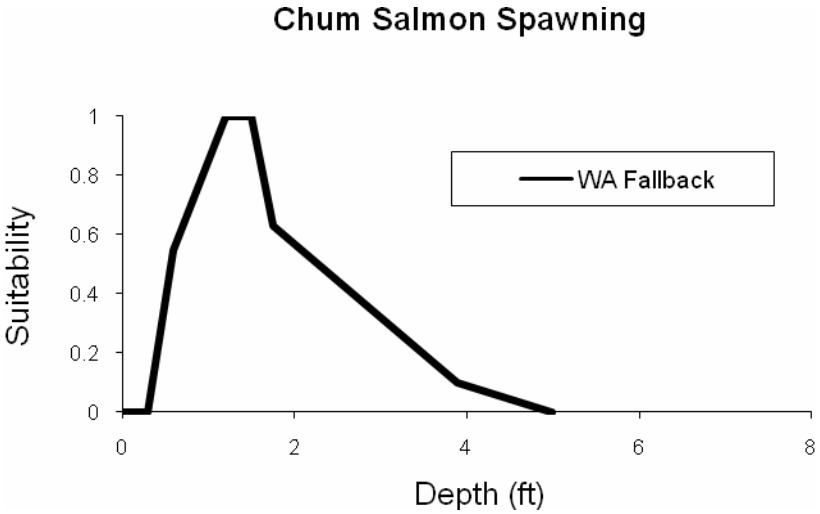


Velocity	Util.
0	0.3
0.8	1
0.95	1
1.1	0.8
1.95	0.8
2.5	0.24
5	0

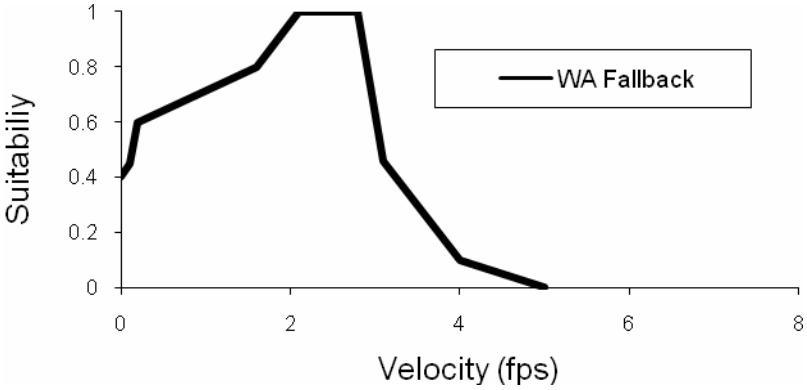


See reference for full list of coordinates

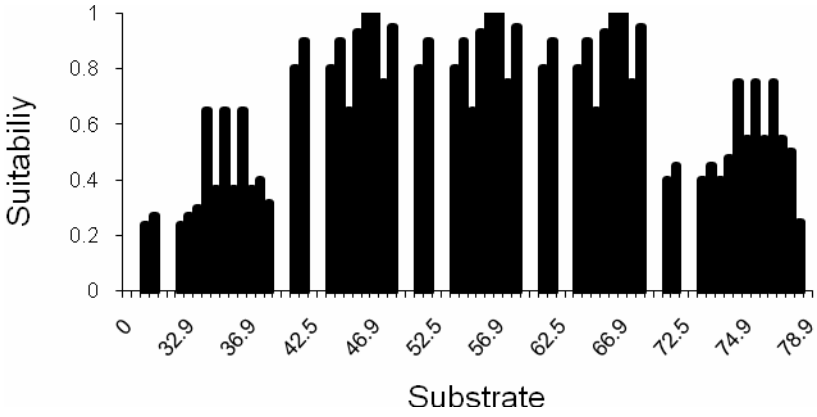
Figure C-4. Pink salmon spawning microhabitat suitability criteria.



Depth	Util.
0	0
0.3	0
0.6	0.55
1.2	1
1.5	1
1.75	0.63
3.9	0.1
5	0
100	0.05

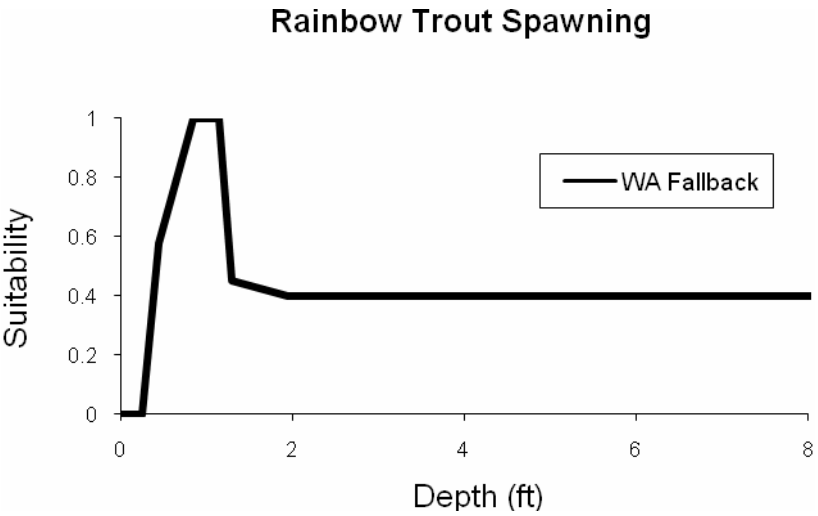


Velocity	Util.
0	0.4
0.1	0.45
0.2	0.6
1.6	0.8
2.1	1
2.8	1
3.1	0.46
4	0.1
5	0

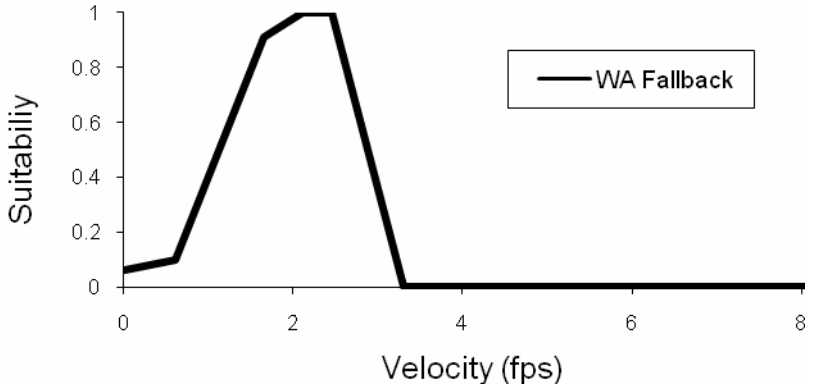


See reference for full list of coordinates

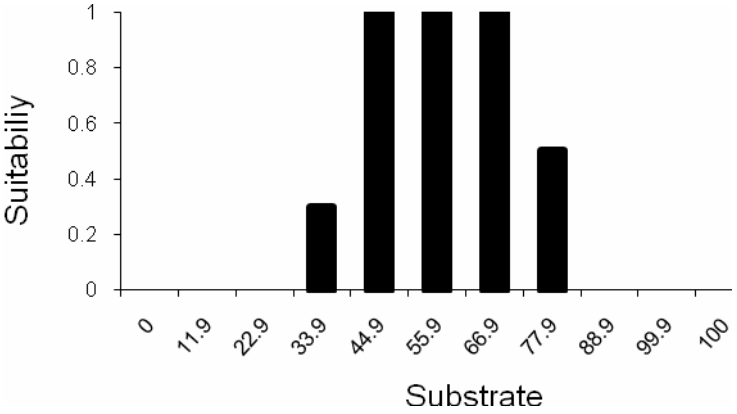
Figure C-5. Chum salmon spawning microhabitat suitability criteria.



Depth	Util.
0	0
0.25	0
0.45	0.58
0.85	1
1.15	1
1.3	0.45
1.95	0.40
2.5	0.4
100	0.4

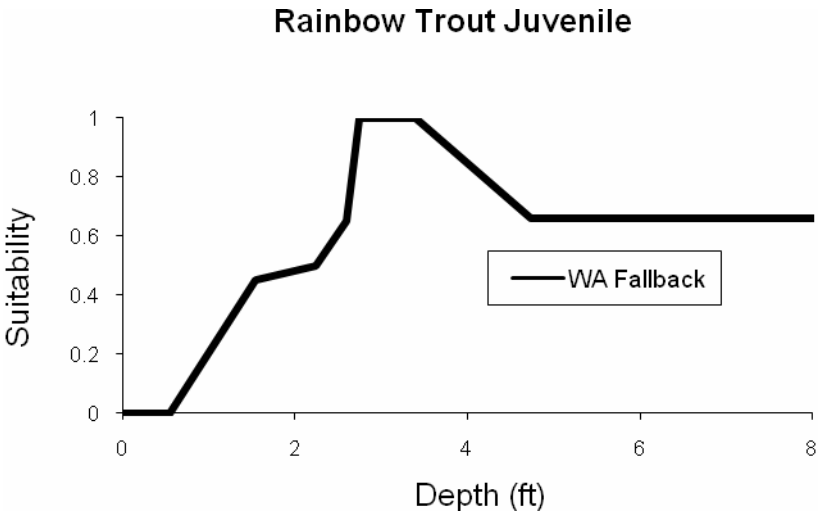


Velocity	Util.
0	0.06
0.6	0.1
1.65	0.91
2.1	1
2.45	1
3.3	0
100	0

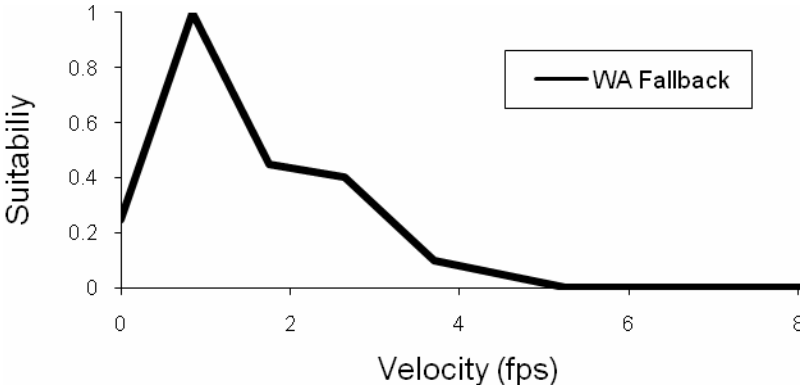


See reference for full list of coordinates

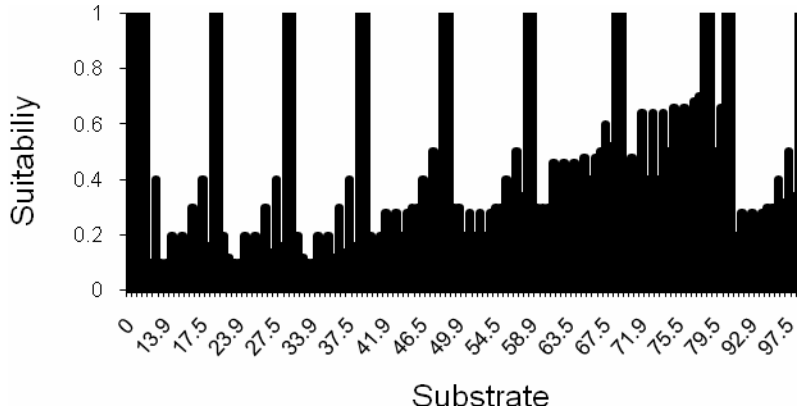
Figure C-6. Rainbow trout spawning microhabitat suitability criteria.



Depth	Util.
0	0
0.55	0
1.55	0.45
2.25	0.5
2.6	0.65
2.75	1
3.4	1
4.75	0.66
100	0.66

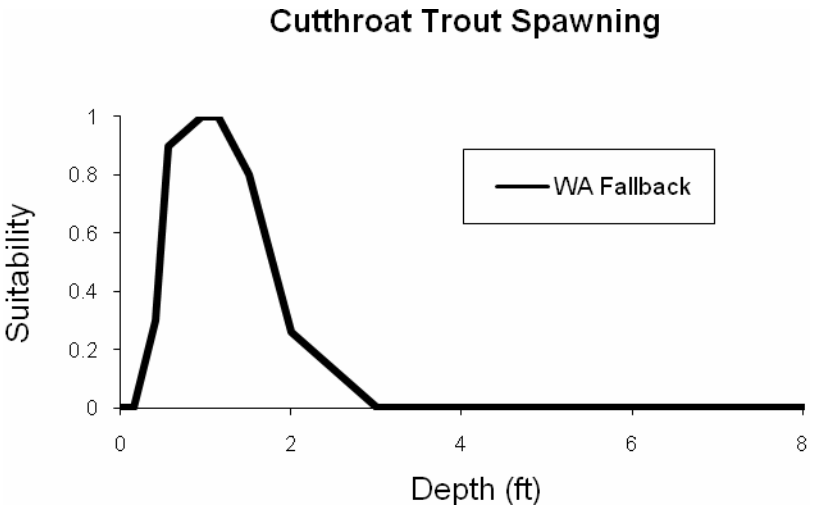


Velocity	Util.
0	0.25
0.85	1
1.75	0.45
2.65	0.4
3.7	0.1
5.25	0
100	0

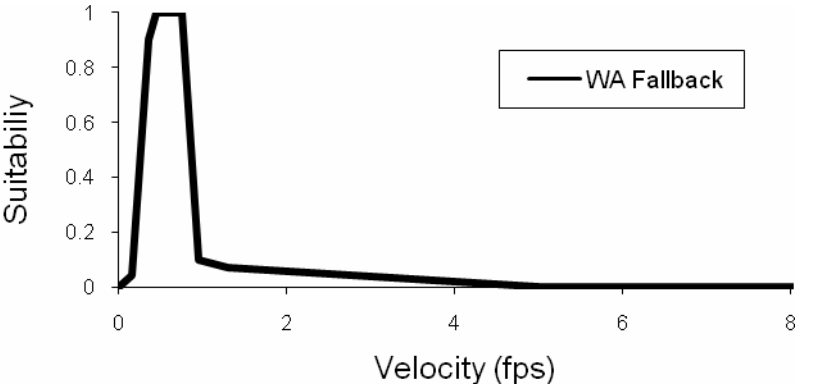


See reference for full list of coordinates

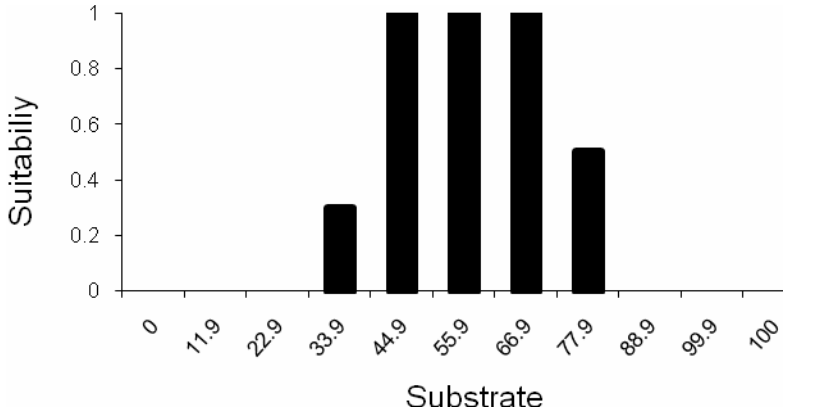
Figure C-7. Juvenile rainbow trout microhabitat suitability criteria.



Depth	Util.
0	0
0.15	0
0.4	0.3
0.55	0.9
0.95	1
1.15	1
1.5	0.8
2	0.26
3	0
100	0



Velocity	Util.
0	0
0.15	0.04
0.35	0.9
0.45	1
0.75	1
0.95	0.1
1.3	0.07
5	0
100	0



Size	Util.
0	0
11.9	0
22.9	0
33.9	0.3
44.9	1
55.9	1
66.9	1
77.9	0.5
88.9	0
99.9	0
100	0

Figure C-8. Cutthroat trout spawning microhabitat suitability criteria.

APPENDIX C2

**Technical Memorandum: Sultan River Instream Flow Study –
HSC Preference Analysis and Revised Steelhead and Chinook Curves,
July 31, 2008**

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Technical Memorandum

Date: July 31, 2008 Project Number: 1628.05/MM102

To: Keith Binkley – Snohomish County PUD

cc: Aquatic Resources Working Group

From: Dudley Reiser/Chiming Huang – R2 Resource Consultants

Subject: Sultan River Instream Flow Study – HSC Preference Analysis and Revised Steelhead and Chinook Curves

This technical memorandum (TM) presents and summarizes the results of additional analysis completed subsequent to the July 22, 2008 Habitat Suitability Curve review meeting. During that meeting, R2 (D. Reiser) presented the results of the HSC curve development process as described in R2 (2008), and discussed specific HSC curves proposed for use in the PHABSIM (Physical Habitat Simulation) modeling for the Sultan River instream flow study. There were three action items defined for R2 as a result of the meeting. These included:

1. Review and update curves for steelhead and Chinook based on adjusting the utilization data for availability following Washington Department of Fish and Wildlife and Washington Department of Ecology guidelines (WDFW/WDOE 2004).
2. Review and present other published curve sets related to steelhead velocity.
3. Provide data/notes regarding substrate and cover collected during microhabitat surveys.

This TM addresses these three action items.

As noted in the Meeting Summary, R2 had collected HSC data of several life stages of target fish species of interest in the Sultan River Instream Flow Study, including steelhead and Chinook salmon spawning, coho juvenile, and steelhead/trout fry. These data were subsequently used for developing habitat suitability curves which were based on habitat utilization. Because the resulting coho juvenile curves closely resembled the Washington State Fallback Curves (WDFW/WDOE 2004), and no data had been collected for a number of other species (i.e., chum and pink spawning, Chinook juvenile, steelhead juvenile), R2 proposed to use the Fallback curves of those species for the habitat-flow modeling.

Although deriving HSC curves from utilization data as was done by R2 for developing the proposed steelhead and Chinook spawning curves is a generally accepted approach (see Bovee 1986) and has been applied in other instream flow assessments (see attached list of HSC curves), the State of Washington requires consideration be given to adjusting such data based on availability. A preliminary evaluation of availability was presented by R2 during the July 22, 2008 meeting, for which utilization data collected from 33 redds from Reach 2 were displayed along with a frequency distribution of depths and velocities as predicted at 170 cfs, as well as measured during field surveys in which flows were 120 cfs and 240 cfs. The preliminary results indicated that some, albeit relatively few, velocities and depths greater than or equal to those measured over the redds would be available within the channel. This prompted both WDFW and WDOE representatives at the meeting (Hal Beecher and Jim Pacheco) to request further analysis of the utilization data to account for availability, thereby developing preference curves. This was to be done following the WDFW/WDOE Instream Flow Study Guidelines (Guidelines) as presented in the WDFW/WDOE (2004; revised 2008) report. This TM provides the results of that analysis for both steelhead and Chinook.

Action Item 1 – Review and update curves for steelhead and Chinook based on adjusting the utilization data for availability following Washington Department of Fish and Wildlife and Washington Department of Ecology (WDFW/WDOE 2004) guidelines.

This write-up summarizes the steps used in development of velocity and depth preference curves for 49 steelhead redds and 81 Chinook redds measured in Reach 2 of the Sultan River, WA, following the procedures outlined in the Guidelines. An additional 16 steelhead redds (above the 33 analyzed for the June 22 meeting) were included in this analysis to capture redds from both the upper and lower segments of Reach 2. The results are compared to the State Fallback curves, which for steelhead were derived from 25 redds measured in the Cedar River, Washington, and for Chinook were derived from 46 redds measured during two studies (rivers not named). The procedures are first described in detail for steelhead; the same procedures were used for the Chinook data, the results of which immediately follow the steelhead analysis.

For discussion purposes, it is noted that the Sultan River is divided into three operational reaches: Reach 1 – from the Skykomish River confluence to the Powerhouse; Reach 2 – from the Powerhouse to Diversion Dam; and Reach 3 – from the Diversion Dam to Culmback Dam. The analysis of both the steelhead and Chinook redds focused on two segments of Reach 2, an upper segment just below the Diversion Dam (RM 7.3-7.6), and a lower segment located about 0.5 miles above the powerhouse (RM 4.5-5.2). The lower segment of Reach 2 encompasses six of

the PHABSIM transects measured as part of the instream flow study. The District and WDFW have cooperatively conducted steelhead spawning surveys in this segment since 1993 in the Sultan River, ranking this section as heavily utilized by spawning steelhead each year. An average of about 25% of the steelhead spawning in the Sultan River reportedly occurs in this reach. (Pers. comm. K. Binkley – District 7/23/08). The upper segment is located just below the Diversion Dam and encompasses seven of the PHABSIM transects. The analysis of redd data was limited to Reach 2 because the flows in this reach were relatively stable during redd construction and measurement, whereas flows in Reach 1were more variable as influenced by hydroelectric project operations. No anadromous fish are present in Reach 3.

Redd Surveys

Surveys to locate and measure steelhead and Chinook redds were conducted during the respective 2006, 2007, and 2008 spawning seasons within the upper and lower segments of Reach 2. The dates, numbers of redds measured, and locations of the surveys are summarized as follows.

Steelhead spawning surveys – total of 49 redds measured:

(1) 6/7/2007: 1 redd in upper segment (RM 7.3-7.6)
(2) 6/7/2007: 15 redds in lower segment (RM 4.5-5.2)
(3) 4/23/2008: 18 redds in lower segment (RM 4.5-5.2)
(4) 5/6/2008: 15 redds in lower segment (RM 4.5-5.2)

Chinook spawning surveys – total of 81 redds measured:

(1) 10/2/2006: 15 redds in lower segment (RM 4.5-5.2)
(2) 10/10/06: 15 redds in upper segment (RM 7.3-7.6)
(3) 9/24/2007: 20 redds in lower segment (RM 4.5-5.2)
(4) 10/12/2007: 31 redds in lower segment (RM 4.5-5.2)

Flow Estimates at Redd Locations

In general, most redds can still be detected for about 14 days after fish spawn. However, knowing the actual flow at the time the fish spawned is difficult unless the stream is gaged and even then, it can be difficult if flows are variable during the spawning period. However, if flows have remained relatively stable throughout the spawning period, than using the average flow of the 14 days prior to the redd observation and measurement as the surrogate to the flow at the time the redd was created, should be reasonable for evaluating habitat availability.

Steelhead Spawning Flows

For steelhead spawning, the USGS records indicated flows released from the Diversion Dam were held relatively constant at about 180 cfs for periods of time longer than 14 days prior to each survey date. Therefore, Q=180 cfs would represent a reasonable estimate of flows at the Diversion Dam for all three surveys.

Accretion flow and tributary inflow from Marsh and Chaplain creeks results in an increase in flow in a downstream direction. Based on daily flows provided by the District, R2 estimated average flows for the 14 days prior to the three steelhead spawning surveys in the lower segment of Reach 2 as follows:

(1) Survey date: 6/7/2007 – estimated flow = 271cfs
(2) Survey date: 4/23/2008 – estimated flow = 321cfs
(3) Survey date: 5/6/2008 – estimated flow = 300cfs

Because the average of the three flows is 297 cfs (i.e., ≈ 300 cfs), and the variations of the flows are within ±10% of the average, R2 considered this as a representative flow for the lower site. Since redds were found in both the upper and lower segment of Reach 2, for purposes of computing the hydraulic characteristics (depths and velocities) available during steelhead spawning, R2 averaged the upper (180 cfs) and lower (300 cfs) flows. Thus, 240 cfs was used for defining the frequency of various depth and velocity intervals available across the 13 transects measured in the two segments. The distribution of depths and velocities from redd measurements taken at this flow was presented in one of the frequency distributions during the July 22, 2008 HSC review meeting.

Chinook Spawning Flows

For Chinook spawning, USGS records indicated that flows below the Diversion Dam ranged between 140 cfs and 180 cfs during the spawning seasons in 2006 and 2007. The average flows for the 14 days prior to the spawning redd surveys were:

(1) Survey date: 10/2/2006 – estimated flow = 160cfs
(2) Survey date: 10/10/06 – estimated flow = 162cfs
(3) Survey date: 9/24/2007 – estimated flow = 143cfs
(4) Survey date: 10/12/2007 – estimated flow = 173cfs

As for steelhead, accretion and tributary inflow results in an increase in flow in the lower portions of Reach 2. The District estimated daily flows at the lower segment by subtracting the

flow released from the Powerhouse from the flows at the USGS gage just below the Powerhouse. Accordingly, the average flows for the 14 days prior to the spawning redd surveys were estimated as follows:

(1) Survey date: 10/2/2006 – estimated flow = 206 cfs
(2) Survey date: 10/10/06 – estimated flow = 194 cfs
(3) Survey date: 9/24/2007 – estimated flow = 203 cfs
(4) Survey date: 10/12/2007 – estimated flow = 255 cfs

Since redds were measured in both the upper and lower segments of Reach 2, R2 applied the same averaging approach as used for steelhead for identifying the flow to be used for defining the availability of hydraulic characteristics during the period of spawning. Thus, the upper and lower flows were averaged for each of the four survey periods resulting in the following four flow estimates: 183 cfs (survey date 10/2/08, average of 160 cfs and 206 cfs); 178 cfs (survey date 10/10/08, average of 162 cfs and 194 cfs); 173 cfs (survey date 9/24/08, average of 143 cfs and 203 cfs); and 214 cfs (survey date 10/12/08, average of 173 cfs and 255 cfs). The average of these four flows (Q=187 cfs) was then used to define the hydraulics related to the Chinook redd surveys.

Data Analysis

Tables 1a and 1b and 2a and 2b summarize the hydraulics of all 13 transects in Reach 2 as determined for flows of 240 cfs for steelhead and 187 cfs for Chinook. The hydraulics (availability of depths and velocities) for 240 cfs were taken directly from the data surveyed under a measured flow at 238 cfs, while the hydraulics for 187 cfs were derived from the hydraulic modeling output. The hydraulic data were sorted and placed in bins with 0.1ft increments for depth and 0.1ft/s increments for velocity. The range of the bin size is shown in the first two columns (Column 1 and 2) of the tables.

Column 3 (Freq) is the number of verticals (i.e., velocity and depth measuring stations) of all 13 transects with hydraulics falling within the bin range. Column 4 shows the percentage of the total wetted surface area in Reach 2 for the verticals in Column 3. Table 3 lists the weighting factors for each of the 13 transects in Reach 2 that includes 6 in the lower Study site and 7 in the upper Study site. A weighting factor is the ratio of stream length the transect represents (based on habitat mapping completed by Stillwater Sciences [2008]) to the total stream length in Reach 2. The stream length a transect represents is the total stream length multiplied by the weighting factor. For example, Transect 5 in the lower segment of Reach 2 has a weighting factor of 14.8%, which would translate to a stream length of 5 miles × 14.8% = 0.74 mile, where 5 miles

is the total stream length in Reach 2. The wetted surface area each vertical represents is the width of the vertical multiplied by the weighted length of the transect.

Utilization (Col 5) shows the number of redd observations in each bin range, which total 49 for steelhead and 81 for Chinook. The data indicate that steelhead spawn in water depths between 0.8 ft and 3.5 ft, and in velocities between 0.7 ft/s and 3.4 ft/s. For Chinook, the spawning depth ranges between 0.7ft and 3.7 ft and velocity ranges from 0.5 ft/s to 3.4 ft/s. The last column, Column 6 (E) is the Expected number of redd depth or velocity measurements that would be found within each of the bins if the distribution of redds was proportional to the frequency with which depths and velocities occur. The Expected number is the product of Area % and Utilization.

Preference Curve Development

R2 followed the recommended Guidelines for calculating preference curves, which states that the bins be combined using the criterion that the combined Expected values be at least 5. Tables 4 and 5 show the velocity and depth preference curve calculations for steelhead and Chinook, respectively. The first two columns in each table are the ranges of each of the combined E (Expected) values, and the third and fourth columns are, respectively, the combined E values and the actual number of redd observations O. The last two columns show the ratio of O to E and the normalized value of O/E by the maximum value of O/E.

Steelhead Analysis

For steelhead, the normalized values in Table 4 are plotted in Figures 1 and 2 as the calculated (a) line for velocity and depth preferences, respectively; the proposed steelhead spawning velocity and depth Preference curves are depicted as the (b) line. The plots show optimal velocity ranges between 1.25 ft/s and 2 ft/s and optimal depths between 1.25ft and 2.5ft. Figures 3(a) and 3(b) compare the State Fallback curves and the proposed preference curves; Figures 4(a) and 4(b) compare the proposed preference curve with the original modified curve based on utilization data alone that was originally proposed and presented during the agency meeting on 7/22/08. The coordinates of the State Fallback curve, original modified curve, and proposed Preference curve are listed in Table 6(a) for velocity and Table 6(b) for depth.

Overall, the ascending limb and plateau of the proposed velocity Preference curve are identical to those of the original modified curve (Figure 4[a]). However, the descending limb of the Preference curve now encompasses a slightly wider range of velocities, with the zero intersection at 5 fps, rather than 4 fps as was indicated under the original modified curves. This change was

warranted based on the calculated velocity preference curve as noted in Figure 1a. Analysis of HSC depth data adjusted for availability resulted in a Preference curve that matched the original proposed modified curve based on utilization data (Figure 4[b]), and it remains as the suggested curve for use in the habitat-flow modeling.

Chinook Analysis

The normalized values for the Chinook data in Table 5 are plotted in Figure 5 and Figure 6 as the calculated (a) line for velocity and depth preferences, respectively. Figures 5(b) and 6(b) are the proposed preference curves for velocity and depth are depicted as the (b) line. The plots indicate optimal velocity ranges between 1.2 ft/s and 2.5 ft/s and optimal depths between 1.2 ft and 2.4 ft. Figures 7(a) and 7(b) compare the State Fallback curves with the proposed Preference curves for Chinook. Figures 8(a) and 8(b) compare the proposed curve with the original modified curve based on utilization data alone that was originally proposed and presented during the agency meeting on 7/22/08. The coordinates of the State fallback curve, original modified curve, and proposed Preference curves are listed in Table 7(a) for velocity and Table 7(b) for depth.

The resulting velocity Preference analysis resulted in a curve that encompassed a slightly wider range of velocities on the ascending limb of the curve compared with the original proposed modified, and a descending portion of the curve that was just slightly wider than the original proposed modified curve (Figure 8a) and slightly narrower than the Fallback curve (Figure 7a). The depth Preference curve closely matched the original proposed modified curve (Figure 8b) but differs from the Fallback curve in having both a narrower optimal depth range as well as depth non-limiting (suitability = 0.5) at depths ≥ 2.7 ft (Figure 6b).

Proposed HSC Curves

Based on the above analysis of utilization and availability, R2 suggests adoption of the steelhead and Chinook spawning Preference curves for both velocity and depth (Figures 1 and 2, and 5 and 6) for use in the habitat – flow modeling of the instream flow study for the Sultan River. These curves would be used along with those depicted by the State Fallback curves for other species and life stages of interest, as noted during the July 22, 2008 ARWG meeting.

Action Item 2 – Review and present other published curve sets related to steelhead velocity

For comparative purposes, R2 compiled HSC velocity curves for steelhead spawning that have been used in a number of other instream flow studies (see Attachment A). These curve sets included Category 1 (Literature), Category 2 (Utilization), and Category 3 (Preference) type curve sets, as defined by Bovee (1986). For display purposes, the curve sets are divided into two

classes – those for which the optimum velocity range extended up to 3 fps, and those for which the range was greater than 3 fps. Coordinates for each of these curves and source references are also included.

Action Item 3 – Provide data/notes regarding substrate and cover collected during microhabitat surveys

Data and notes pertaining to depths, velocities, substrate composition and adjoining cover types that were collected during the spawning and juvenile HSC surveys are provided in Attachment B. Copies of field data are provided in Attachment C.

Literature Cited

Bovee, K. D. 1986. Development and evaluation of habitat suitability criteria for use in the instream flow incremental methodology. U.S. Geological Survey, Fort Collins Science Center. 235 pp.

R2 Resource Consultants, Inc. 2008. Proposed Habitat Suitability Criteria (HSC) Curves for Application in Habitat – Flow Modeling for the Sultan River Instream Flow Study – RSP 3. Prepared for Public Utility District No. 1 of Snohomish County, and City of Everett, Washington.

Stillwater Sciences and Meridian Environmental. 2008a. Study Plan 18: riverine, riparian and wetland habitat assessment, technical report. Prepared for Snohomish County Public Utility District No. 1.

Washington Department of Fish and Wildlife and Washington State Department of Ecology. 2004. Instream flow study guidelines: technical and habitat suitability issues, Updated, February 2, 2008.

Table 1(a). Summary of velocity availability and utilization for steelhead spawning at Q=240 cfs in the Sultan River. (N=49).

(1)	(2)	(3)	(4)	(5)	(6)
Velocity Bin Range			Area %		E
Lower	Upper	Freq	(A)	Utilization	(=N A)
0	0.09	21	5.5%	0	2.70
0.1	0.19	15	3.9%	0	1.91
0.2	0.29	18	4.7%	0	2.30
0.3	0.39	16	4.2%	0	2.06
0.4	0.49	22	5.7%	0	2.79
0.5	0.59	11	2.9%	0	1.42
0.6	0.69	13	3.4%	0	1.67
0.7	0.79	16	4.2%	2	2.06
0.8	0.89	12	3.2%	0	1.57
0.9	0.99	13	3.4%	0	1.67
1	1.09	13	3.4%	0	1.67
1.1	1.19	11	2.8%	1	1.37
1.2	1.29	22	5.7%	2	2.79
1.3	1.39	6	1.6%	3	0.78
1.4	1.49	4	1.0%	4	0.49
1.5	1.59	8	2.1%	6	1.03
1.6	1.69	8	2.1%	4	1.03
1.7	1.79	12	3.1%	2	1.52
1.8	1.89	11	2.8%	1	1.37
1.9	1.99	6	1.6%	7	0.78
2	2.09	9	2.3%	1	1.13
2.1	2.19	10	2.6%	2	1.27
2.2	2.29	7	1.8%	0	0.88
2.3	2.39	9	2.3%	3	1.13
2.4	2.49	8	2.1%	2	1.03
2.5	2.59	6	1.6%	2	0.78
2.6	2.69	10	2.6%	2	1.27
2.7	2.79	6	1.6%	0	0.78
2.8	2.89	4	1.0%	0	0.49

Table 1(a). Summary of velocity availability and utilization for steelhead spawning at Q=240 cfs in the Sultan River. (N=49).

(1)	(2)	(3)	(4)	(5)	(6)
Velocity Bin Range			Area %		E
Lower	Upper	Freq	(A)	Utilization	(=N A)
2.9	2.99	2	0.5%	1	0.25
3	3.09	5	1.3%	1	0.64
3.1	3.19	6	1.5%	0	0.74
3.2	3.29	4	1.0%	2	0.49
3.3	3.39	7	1.8%	1	0.88
3.4	3.49	5	1.3%	0	0.64
3.5	3.59	3	0.8%	0	0.39
3.6	3.69	3	0.8%	0	0.39
3.7	3.79	8	2.0%	0	0.98
3.8	3.89	3	0.8%	0	0.39
3.9	3.99	2	0.5%	0	0.25
4	4.09	2	0.5%	0	0.25
4.1	4.19	1	0.3%	0	0.15
4.2	4.29	2	0.5%	0	0.25
4.3	4.39	1	0.3%		0.15
4.4	4.49	1	0.3%		0.15
4.5	4.59	0	0.0%		0.00
4.6	4.69	1	0.3%		0.15
4.7	4.79	1	0.3%		0.15
4.8	4.89	0	0.0%		0.00
4.9	4.99	0	0.0%		0.00
5	5.09	0	0.0%		0.00
5.1	5.19	1	0.3%		0.15
5.2	5.29	0	0.0%		0.00
5.3	5.39	0	0.0%		0.00
5.4	5.49	0	0.0%		0.00
5.5	5.59	0	0.0%		0.00

Table 1(b). Summary of depth availability and utilization for steelhead spawning at Q=240 cfs in the Sultan River. (N=49)

(1)	(2)	(3)	(4)	(5)	(6)
Depth Bin Range			Area %		E
Lower	Upper	Freq	(A)	Utilization	(=N A)
0	0.09	3	0.8%		0.39
0.1	0.19	7	1.9%		0.93
0.2	0.29	5	1.3%		0.64
0.3	0.39	8	2.1%		1.03
0.4	0.49	11	2.9%		1.42
0.5	0.59	15	3.9%		1.91
0.6	0.69	9	2.4%	0	1.18
0.7	0.79	16	4.2%	0	2.06
0.8	0.89	11	2.9%	1	1.42
0.9	0.99	20	5.3%	2	2.60
1	1.09	11	2.9%	0	1.42
1.1	1.19	18	4.7%	3	2.30
1.2	1.29	14	3.6%	2	1.76
1.3	1.39	14	3.7%	5	1.81
1.4	1.49	13	3.4%	2	1.67
1.5	1.59	15	3.9%	1	1.91
1.6	1.69	11	2.8%	2	1.37
1.7	1.79	15	3.9%	3	1.91
1.8	1.89	10	2.6%	4	1.27
1.9	1.99	8	2.1%	2	1.03
2	2.09	11	2.8%	2	1.37
2.1	2.19	12	3.1%	3	1.52
2.2	2.29	9	2.3%	3	1.13
2.3	2.39	7	1.8%	3	0.88
2.4	2.49	14	3.6%	3	1.76
2.5	2.59	15	3.9%	4	1.91
2.6	2.69	16	4.1%	2	2.01
2.7	2.79	15	3.8%	0	1.86
2.8	2.89	1	0.3%	0	0.15

Table 1(b). Summary of depth availability and utilization for steelhead spawning at Q=240 cfs in the Sultan River. (N=49)

(1)	(2)	(3)	(4)	(5)	(6)
Depth Bin Range			Area %		E
Lower	Upper	Freq	(A)	Utilization	(=N A)
2.9	2.99	5	1.3%	0	0.64
3	3.09	13	3.3%	0	1.62
3.1	3.19	3	0.8%	1	0.39
3.2	3.29	5	1.3%	0	0.64
3.3	3.39	3	0.8%	0	0.39
3.4	3.49	6	1.5%	0	0.74
3.5	3.59	2	0.5%	1	0.25
3.6	3.69	0	0.0%	0	0.00
3.7	3.79	3	0.8%	0	0.39
3.8	3.89	1	0.3%	0	0.15
3.9	3.99	0	0.0%	0	0.00
4	4.09	1	0.3%	0	0.15
4.1	4.19	1	0.3%	0	0.15
4.2	4.29	0	0.0%	0	0.00
4.3	4.39	0	0.0%	0	0.00
4.4	4.49	3	0.8%	0	0.39
4.5	4.59	0	0.0%	0	0.00
4.6	4.69	0	0.0%	0	0.00
4.7	4.79	1	0.3%	0	0.15
4.8	4.89	1	0.3%	0	0.15
4.9	4.99	0	0.0%	0	0.00
5	5.09	0	0.0%	0	0.00
5.1	5.19	0	0.0%	0	0.00
5.2	5.29	2	0.5%		0.25
5.3	5.39	0	0.0%		0.00
5.4	5.49	0	0.0%		0.00
5.5	5.59	1	0.3%		0.15

Table 2(a). Summary of velocity availability and utilization for Chinook spawning at Q=187 cfs in the Sultan River. (N=81)

(1)	(2)	(3)	(4)	(5)	(6)
Velocity Bin Range			Area %		E
Lower	Upper	Freq	(A)	Utilization	(=N A)
0	0.09	17	4.5%	0	3.65
0.1	0.19	19	5.1%	0	4.13
0.2	0.29	17	4.5%	0	3.65
0.3	0.39	22	5.8%	0	4.70
0.4	0.49	14	3.7%	0	3.00
0.5	0.59	20	5.2%	1	4.21
0.6	0.69	15	4.0%	2	3.24
0.7	0.79	14	3.7%	2	3.00
0.8	0.89	18	4.7%	1	3.81
0.9	0.99	16	4.2%	5	3.40
1	1.09	19	5.0%	1	4.05
1.1	1.19	14	3.7%	3	3.00
1.2	1.29	7	1.8%	2	1.46
1.3	1.39	10	2.6%	7	2.11
1.4	1.49	6	1.6%	4	1.30
1.5	1.59	11	2.9%	6	2.35
1.6	1.69	14	3.6%	2	2.92
1.7	1.79	12	3.2%	6	2.59
1.8	1.89	11	2.9%	3	2.35
1.9	1.99	10	2.6%	8	2.11
2	2.09	15	3.9%	1	3.16
2.1	2.19	7	1.8%	1	1.46
2.2	2.29	6	1.6%	4	1.30
2.3	2.39	4	1.1%	5	0.89
2.4	2.49	9	2.4%	1	1.94
2.5	2.59	11	2.9%	4	2.35
2.6	2.69	7	1.8%	3	1.46
2.7	2.79	5	1.3%	2	1.05
2.8	2.89	7	1.8%	0	1.46

Table 2(a). Summary of velocity availability and utilization for Chinook spawning at Q=187 cfs in the Sultan River. (N=81)

(1)	(2)	(3)	(4)	(5)	(6)
Velocity Bin Range			Area %		E
Lower	Upper	Freq	(A)	Utilization	(=N A)
2.9	2.99	6	1.6%	1	1.30
3	3.09	1	0.3%	0	0.24
3.1	3.19	4	1.0%	3	0.81
3.2	3.29	0	0.0%	1	0.00
3.3	3.39	1	0.3%	2	0.24
3.4	3.49	1	0.3%	0	0.24
3.5	3.59	2	0.5%	0	0.41
3.6	3.69	2	0.5%	0	0.41
3.7	3.79	1	0.3%	0	0.24
3.8	3.89	1	0.3%	0	0.24
3.9	3.99	0	0.0%	0	0.00
4	4.09	1	0.3%	0	0.24
4.1	4.19	1	0.3%	0	0.24
4.2	4.29	0	0.0%	0	0.00
4.3	4.39	0	0.0%	0	0.00
4.4	4.49	1	0.3%	0	0.24
4.5	4.59	0	0.0%	0	0.00
4.6	4.69	0	0.0%	0	0.00
4.7	4.79	0	0.0%	0	0.00
4.8	4.89	0	0.0%	0	0.00
4.9	4.99	1	0.3%	0	0.24
5	5.09	0	0.0%	0	0.00
5.1	5.19	0	0.0%	0	0.00

Table 2(b). Summary of depth availability and utilization for Chinook spawning at Q=187 cfs in the Sultan River. (N=81)

(1)	(2)	(3)	(4)	(5)	(6)
Depth Bin Range			Area %		E
Lower	Upper	Freq	(A)	Utilization	(=N A)
0	0.09	3	0.8%	0	0.65
0.1	0.19	12	3.2%	0	2.59
0.2	0.29	11	2.9%	0	2.35
0.3	0.39	10	2.7%	0	2.19
0.4	0.49	15	4.0%	0	3.24
0.5	0.59	12	3.2%	0	2.59
0.6	0.69	17	4.5%	0	3.65
0.7	0.79	9	2.4%	3	1.94
0.8	0.89	10	2.7%	1	2.19
0.9	0.99	26	6.9%	5	5.59
1	1.09	15	4.0%	2	3.24
1.1	1.19	12	3.2%	2	2.59
1.2	1.29	18	4.7%	3	3.81
1.3	1.39	16	4.3%	2	3.48
1.4	1.49	11	2.9%	6	2.35
1.5	1.59	17	4.5%	1	3.65
1.6	1.69	10	2.6%	4	2.11
1.7	1.79	12	3.1%	10	2.51
1.8	1.89	14	3.7%	2	3.00
1.9	1.99	12	3.2%	7	2.59
2	2.09	11	2.9%	6	2.35
2.1	2.19	10	2.6%	8	2.11
2.2	2.29	7	1.8%	1	1.46
2.3	2.39	19	5.0%	4	4.05
2.4	2.49	9	2.3%	5	1.86
2.5	2.59	7	1.8%	1	1.46
2.6	2.69	8	2.1%	2	1.70
2.7	2.79	6	1.5%	0	1.22
2.8	2.89	9	2.3%	1	1.86

Table 2(b). Summary of depth availability and utilization for Chinook spawning at Q=187 cfs in the Sultan River. (N=81)

(1)	(2)	(3)	(4)	(5)	(6)
Depth Bin Range			Area %		E
Lower	Upper	Freq	(A)	Utilization	(=N A)
2.9	2.99	7	1.8%	1	1.46
3	3.09	6	1.6%	0	1.30
3.1	3.19	3	0.8%	0	0.65
3.2	3.29	2	0.5%	0	0.41
3.3	3.39	2	0.5%	0	0.41
3.4	3.49	0	0.0%	2	0.00
3.5	3.59	2	0.5%	1	0.41
3.6	3.69	1	0.3%	1	0.24
3.7	3.79	1	0.3%	0	0.24
3.8	3.89	0	0.0%	0	0.00
3.9	3.99	0	0.0%	0	0.00
4	4.09	1	0.3%	0	0.24
4.1	4.19	0	0.0%	0	0.00
4.2	4.29	1	0.3%	0	0.24
4.3	4.39	2	0.5%	0	0.41
4.4	4.49	0	0.0%	0	0.00
4.5	4.59	0	0.0%	0	0.00
4.6	4.69	0	0.0%	0	0.00
4.7	4.79	1	0.3%	0	0.24
4.8	4.89	1	0.3%	0	0.24
4.9	4.99	0	0.0%	0	0.00
5	5.09	0	0.0%	0	0.00
5.1	5.19	2	0.5%	0	0.41

Table 3. Transect weighting factors are determined from habitat mapping (Stillwater Sciences 2008).

Transect Number	Weighting Factor
Lower TR-1	1.3%
Lower TR-2	5.9%
Lower TR-3	1.3%
Lower TR-4	15.3%
Lower TR-5	14.8%
Lower TR-6	15.3%
Upper TR-1	19.2%
Upper TR-2	10.3%
Upper TR-3	2.4%
Upper TR-4	2.4%
Upper TR-5	7.0%
Upper TR-6	2.4%
Upper TR-7	2.4%

Table 4(a). Velocity preference calculation for steelhead spawning.

Velocity Range		Combined	Observations		Normalized
Lower	Upper	E	O	O/E	O/E
0	0.29	6.91	0	0.00	0.00
0.3	0.59	6.27	0	0.00	0.00
0.6	0.89	5.29	2	0.38	0.12
0.9	1.29	7.5	3	0.40	0.12
1.3	1.89	6.22	20	3.22	1.00
1.9	2.39	5.19	13	2.50	0.78
2.4	3.09	5.24	8	1.53	0.47
3.1	3.99	5.15	3	0.58	0.18
>4		1.39	0	0.00	0.00

Table 4(b). Depth preference calculation for steelhead spawning.

Depth Range		Combined	Observations		Normalized
Lower	Upper	E	O	O/E	O/E
0	0.59	6.32	0	0.00	0.00
0.6	0.99	7.25	3	0.41	0.20
1	1.29	5.49	5	0.91	0.43
1.3	1.59	5.39	8	1.48	0.71
1.6	1.99	5.59	11	1.97	0.94
2	2.49	6.66	14	2.10	1.00
2.5	2.79	5.78	6	1.04	0.49
2.8	3.79	5.19	2	0.39	0.18
>3.8		1.52	0	0.00	0.00

Table 5(a). Velocity preference calculation for Chinook spawning.

Velocity Range		Combined	Observations		Normalized
Lower	Upper	E	O	O/E	O/E
0	0.19	7.78	0	0.00	0.00
0.2	0.39	8.34	0	0.00	0.00
0.4	0.59	7.21	1	0.14	0.05
0.6	0.79	6.24	4	0.64	0.24
0.8	0.99	7.21	6	0.83	0.32
1	1.19	7.05	4	0.57	0.22
1.2	1.59	7.21	19	2.64	1.00
1.6	1.79	5.51	8	1.45	0.55
1.8	2.09	7.61	12	1.58	0.60
2.1	2.49	5.59	11	1.97	0.75
2.5	2.79	6.32	9	1.42	0.54
2.8	4.99	5.1	7	1.37	0.52
>5		0	0	0.00	0.00

Table 5(b). Depth preference calculation for Chinook spawning.

Depth Range		Combined	Observations		Normalized
Lower	Upper	E	O	O/E	O/E
0	0.29	5.59	0	0.00	0.00
0.3	0.49	5.43	0	0.00	0.00
0.5	0.69	6.24	0	0.00	0.00
0.7	0.99	9.72	9	0.93	0.31
1	1.19	5.83	4	0.69	0.23
1.2	1.39	7.29	5	0.69	0.23
1.4	1.59	5.99	7	1.17	0.39
1.6	1.89	7.61	16	2.10	0.71
1.9	2.19	7.05	21	2.98	1.00
2.2	2.39	5.51	5	0.91	0.30
2.4	2.69	5.02	8	1.59	0.54
2.7	3.09	5.83	2	0.34	0.12
>3.1		4.13	4	0.97	0.33

Table 6(a). Coordinates of State Fallback curve, original modified curve, and proposed curve for steelhead spawning velocity preference.

WA Fallback		Original Modified		Proposed	
V(ft/s)	Preference	V(ft/s)	Preference	V(ft/s)	Preference
0.00	0.00	0.00	0.00	0.00	0.00
0.55	0.00	0.55	0.00	0.55	0.00
2.50	1.00	1.25	1.00	1.25	1.00
3.25	1.00	1.50	1.00	1.50	1.00
3.45	0.62	1.75	1.00	1.75	1.00
5.00	0.00	2.00	1.00	2.00	1.00
		2.50	0.50	2.70	0.50
		4.00	0.00	5.00	0.00

Table 6(b). Coordinates of State Fallback curve, original modified curve, and proposed curve for steelhead spawning depth preference.

WA Fallback		Original Modified		Proposed	
Depth (ft)	Preference	Depth (ft)	Preference	Depth (ft)	Preference
0.00	0.00	0.00	0.00	0.00	0.00
0.65	0.00	0.65	0.00	0.65	0.00
1.25	1.00	1.25	1.00	1.25	1.00
1.55	1.00	1.55	1.00	1.55	1.00
2.40	0.50	1.90	1.00	1.90	1.00
8.00	0.50	2.50	1.00	2.50	1.00
		3.00	0.50	3.00	0.50
		4.00	0.50	4.00	0.50
		8.00	0.50	8.00	0.50

Table 7(a). Coordinates of State Fallback curve, original modified curve, and proposed curve for Chinook spawning velocity preference.

WA Fallback		Original Modified		Proposed	
V(ft/s)	Preference	V(ft/s)	Preference	V(ft/s)	Preference
0.00	0.00	0.00	0.00	0.00	0.00
0.50	0.00	0.50	0.00	0.55	0.00
1.00	0.50	1.80	1.00	1.20	1.00
1.75	1.00	2.10	1.00	1.50	1.00
3.00	1.00	2.40	1.00	1.75	1.00
4.00	0.00	3.40	0.30	2.50	1.00
10.00	0.00	4.00	0.00	4.00	0.00
		10.00	0.00		

Table 7(b). Coordinates of State Fallback curve, original modified curve, and proposed curve for Chinook spawning depth preference.

WA Fallback		Original Modified		Proposed	
Depth (ft)	Preference	Depth (ft)	Preference	Depth (ft)	Preference
0.00	0.00	0.00	0.00	0.00	0.00
0.30	0.00	0.50	0.00	0.50	0.00
0.50	0.50	1.20	1.00	1.20	1.00
0.85	1.00	2.10	1.00	1.55	1.00
3.40	1.00	2.40	1.00	1.90	1.00
5.00	0.00	3.00	0.50	2.40	1.00
10.00	0.00	5.00	0.50	2.70	0.50
		8.00	0.50	4.00	0.50
		8.00	0.50	8.00	0.50

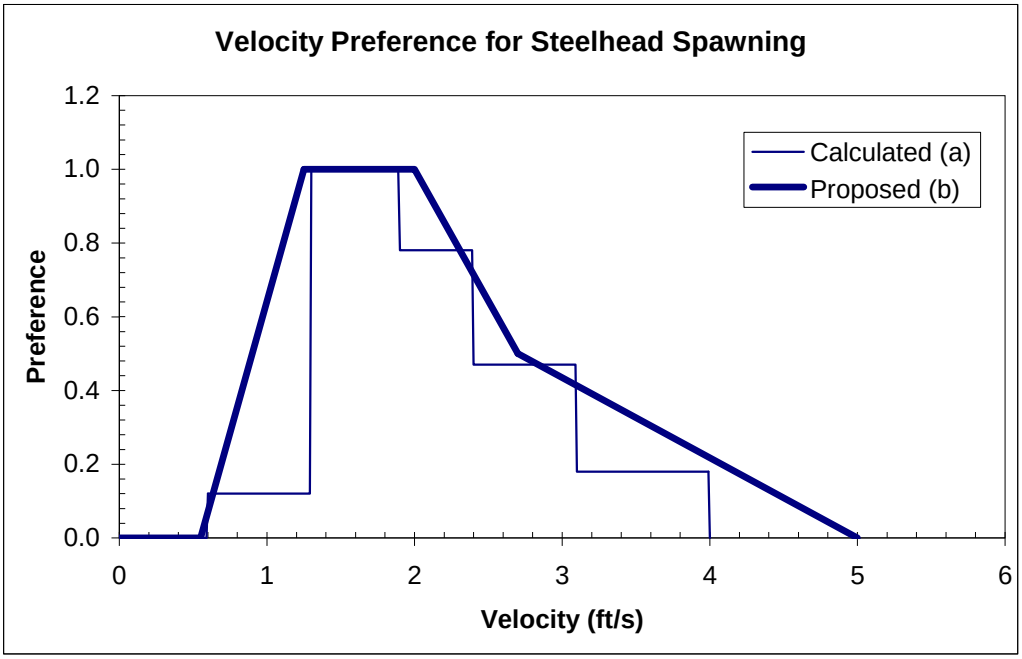


Figure 1. Calculated (a) and proposed (b) steelhead spawning velocity preference curves (N=49).

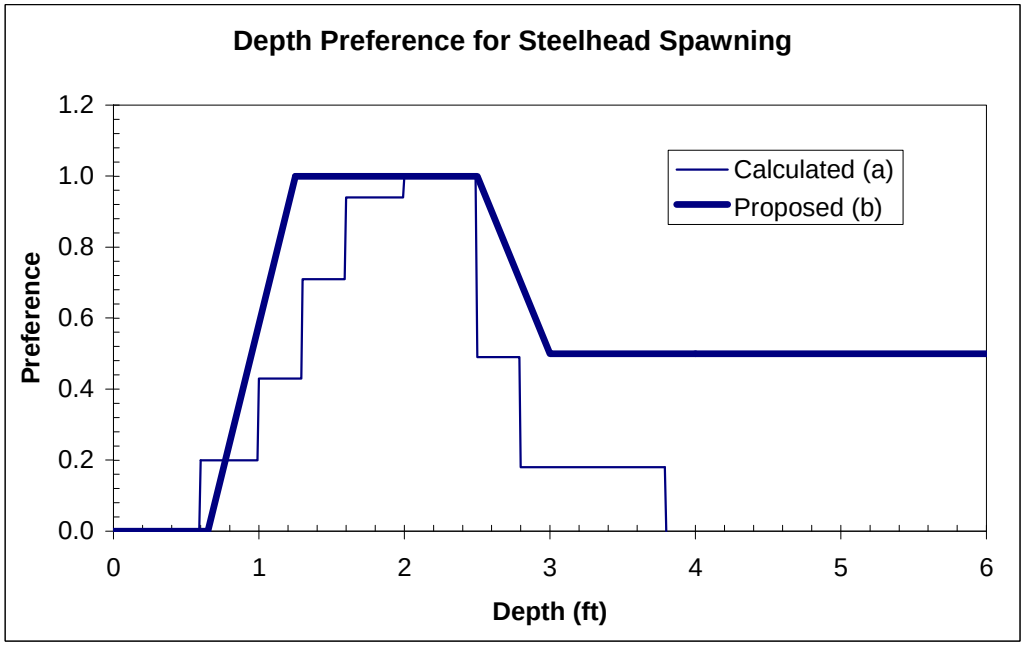


Figure 2. Calculated (a) proposed (b) steelhead spawning depth preference curves (N=49).

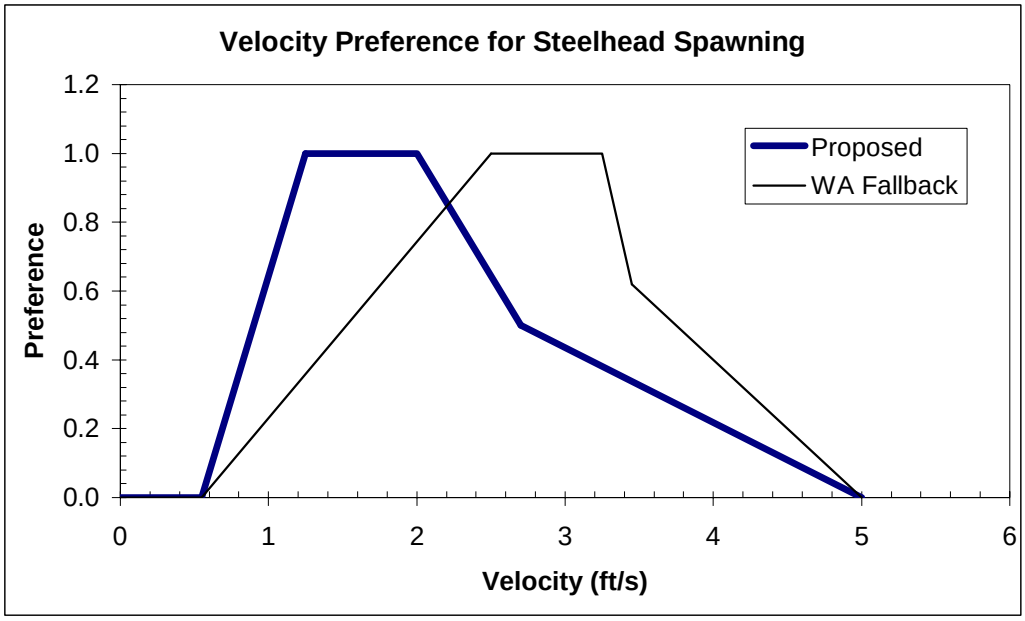


Figure 3(a). Comparison of proposed and State Fallback Preference curves for steelhead spawning velocity criteria.

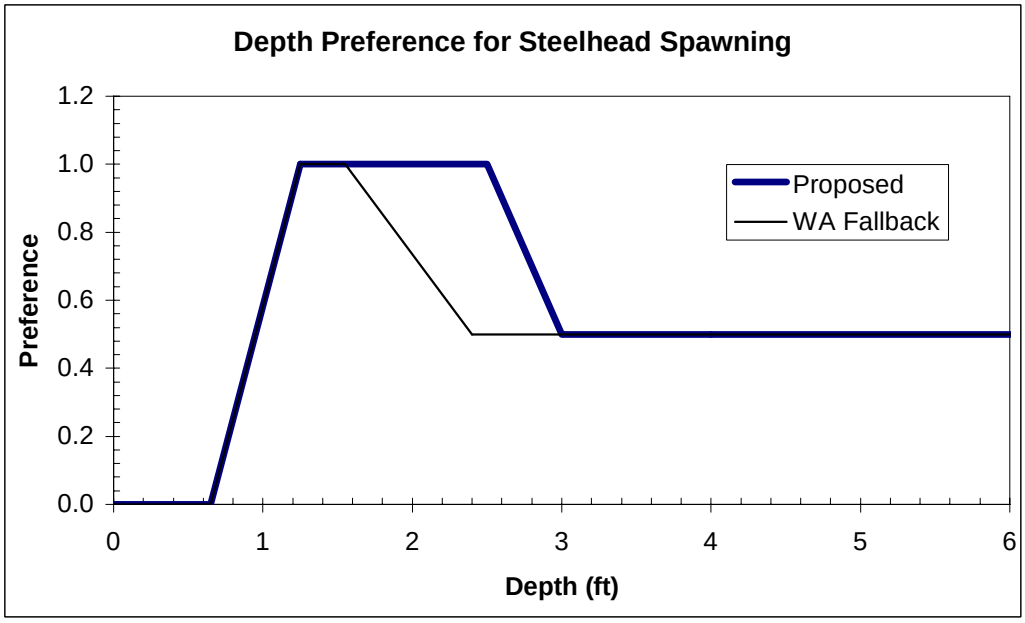


Figure 3(b). Comparison of proposed and State Fallback Preference curves for steelhead spawning depth criteria.

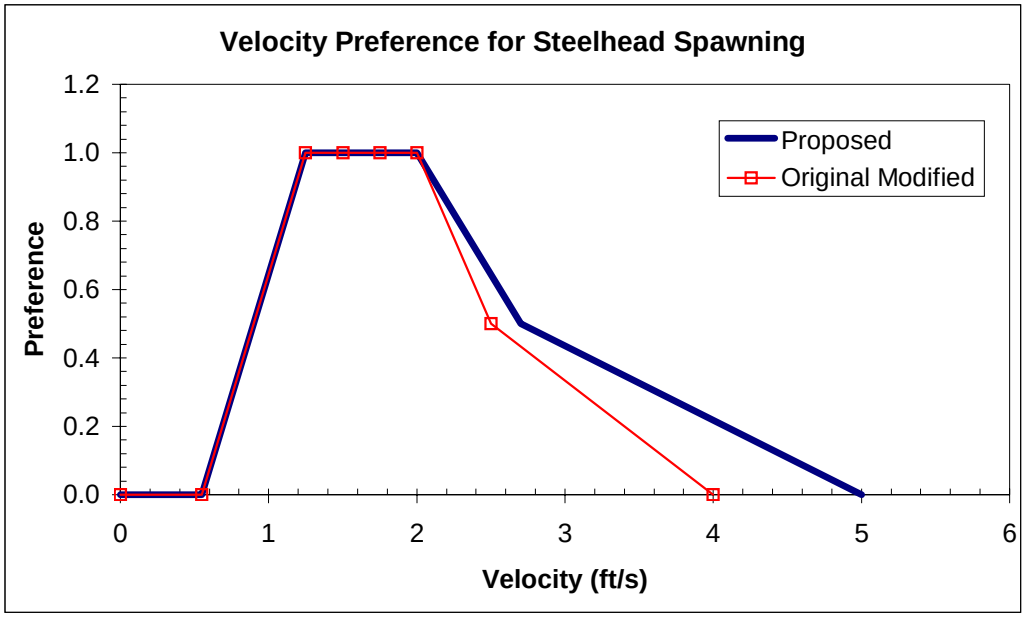


Figure 4(a). Comparison of proposed preference and original modified utilization steelhead spawning velocity curves.

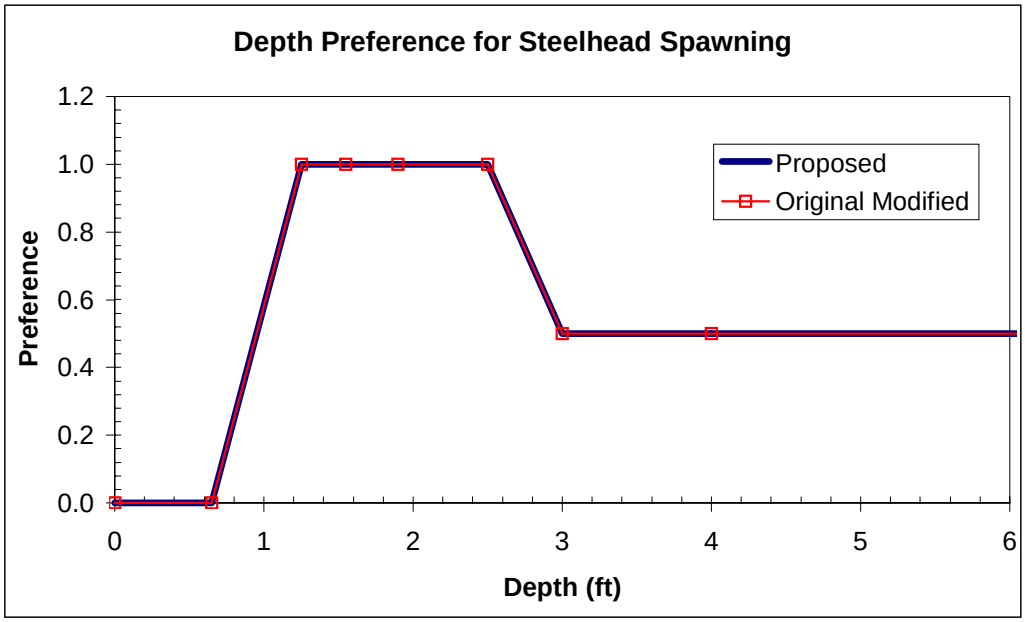


Figure 4(b). Comparison of proposed preference and original modified utilization steelhead spawning depth curves.

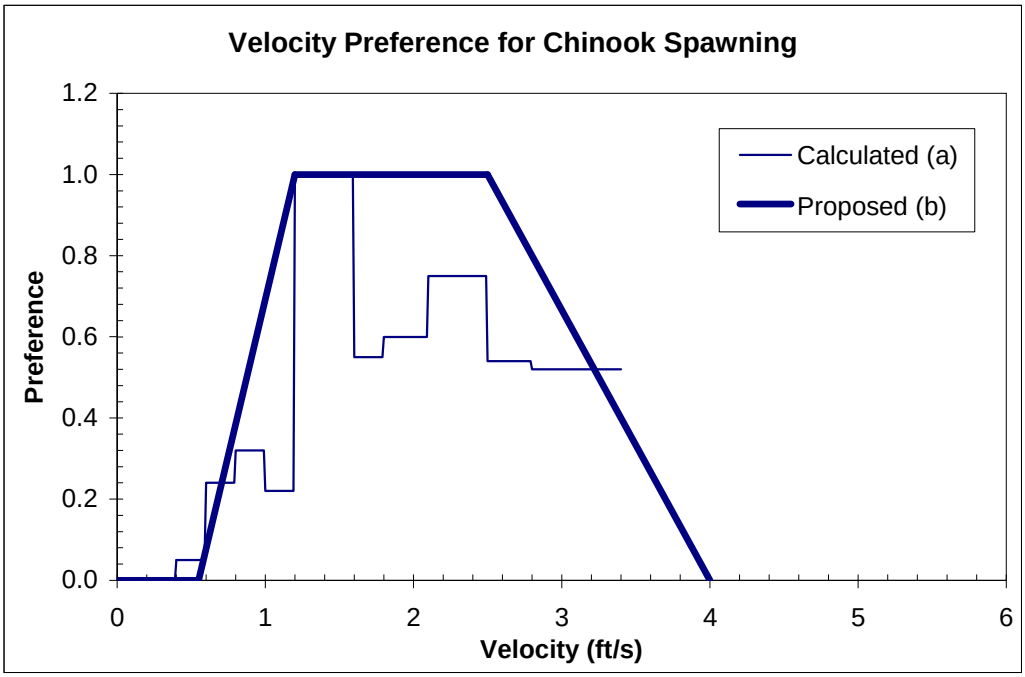


Figure 5. Chinook spawning velocity preference (a) calculated (b) proposed.

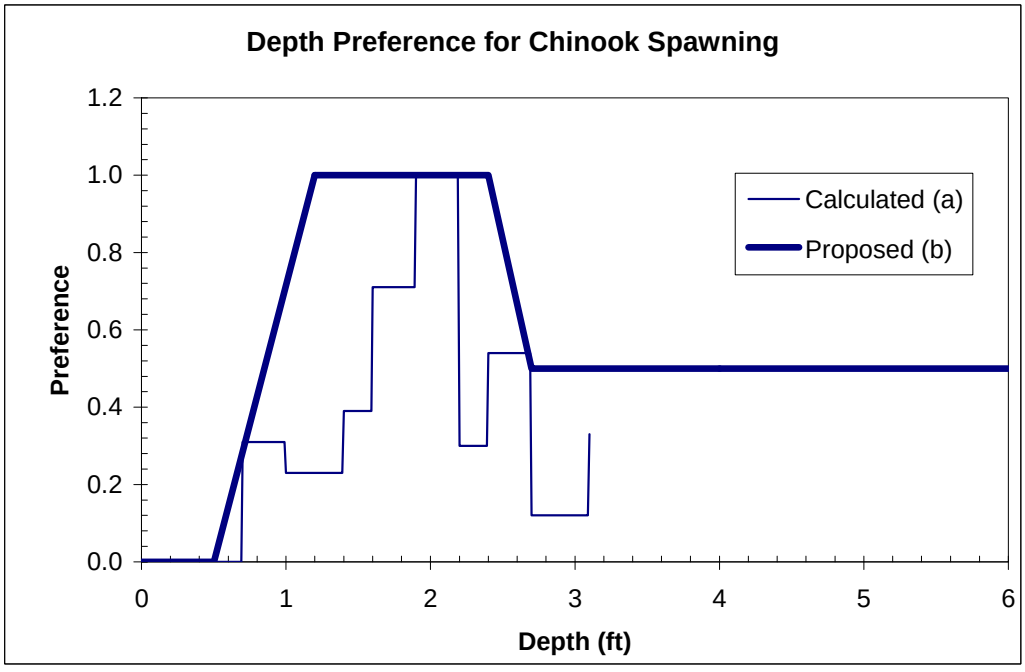


Figure 6. Chinook spawning depth preference (a) calculated (b) proposed.

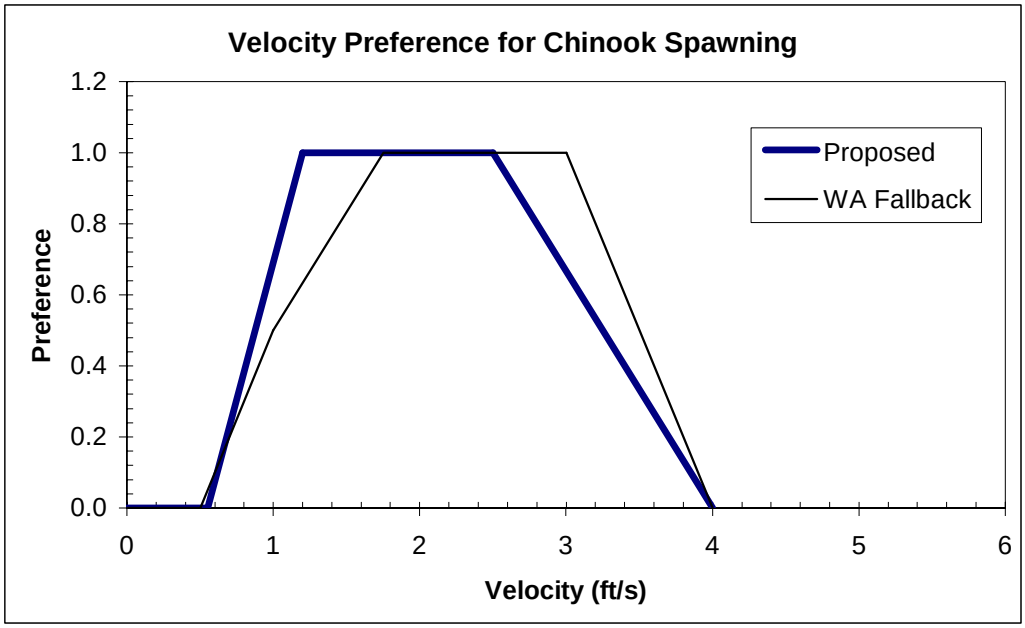


Figure 7(a). Comparison of proposed and State Fallback Preference curves for Chinook spawning velocity criteria.

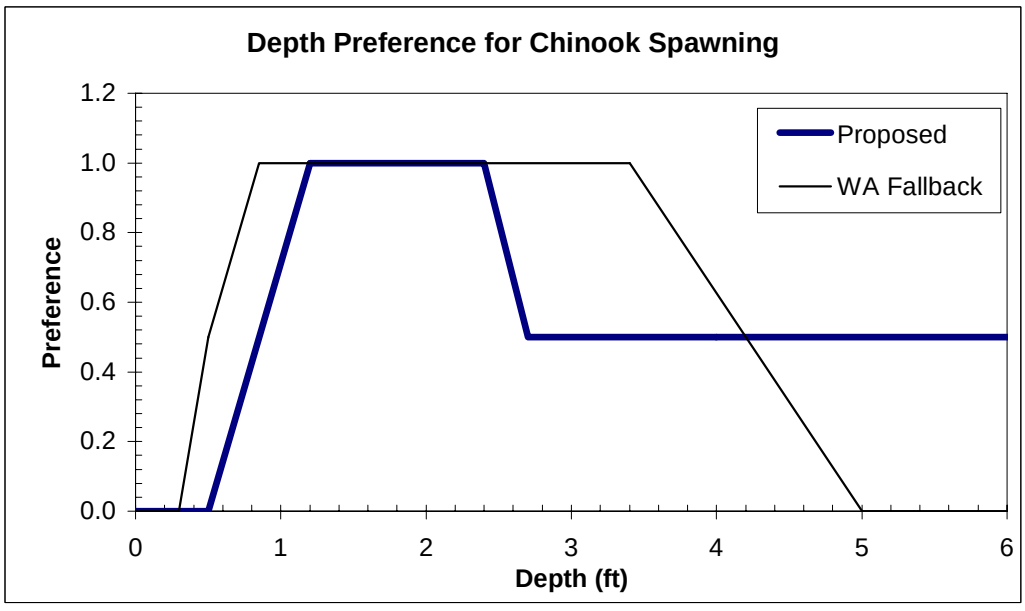


Figure 7(b). Comparison of proposed and State Fallback Preference curves for Chinook spawning depth criteria.

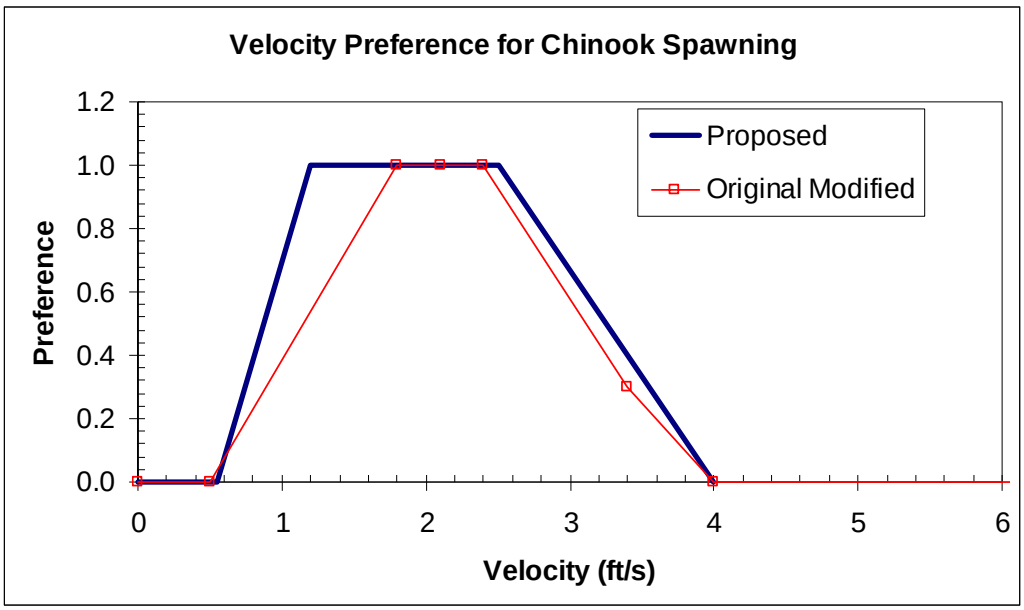


Figure 8(a). Comparison of proposed preference and original modified utilization Chinook spawning velocity curves.

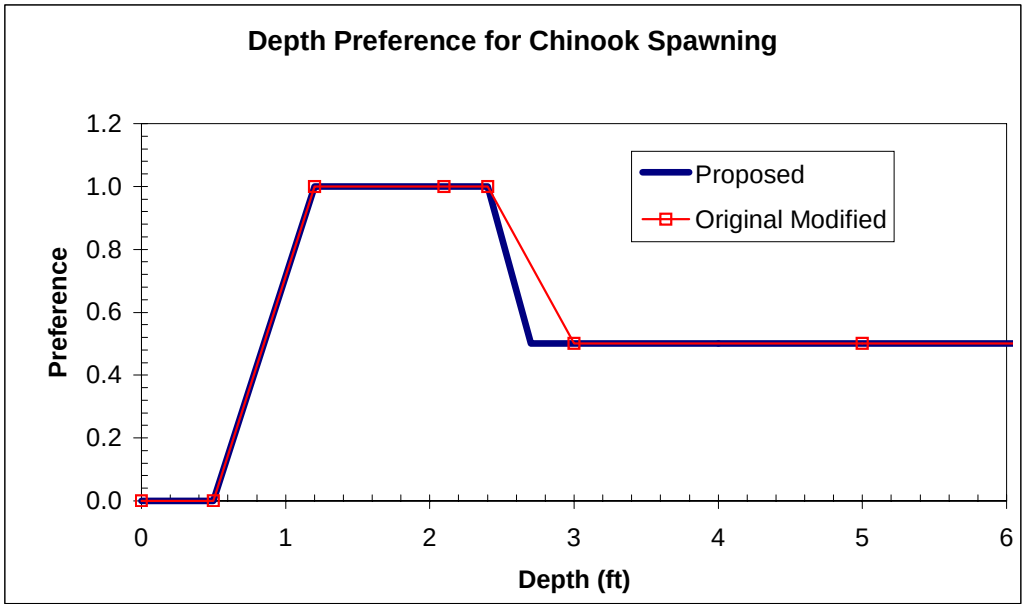
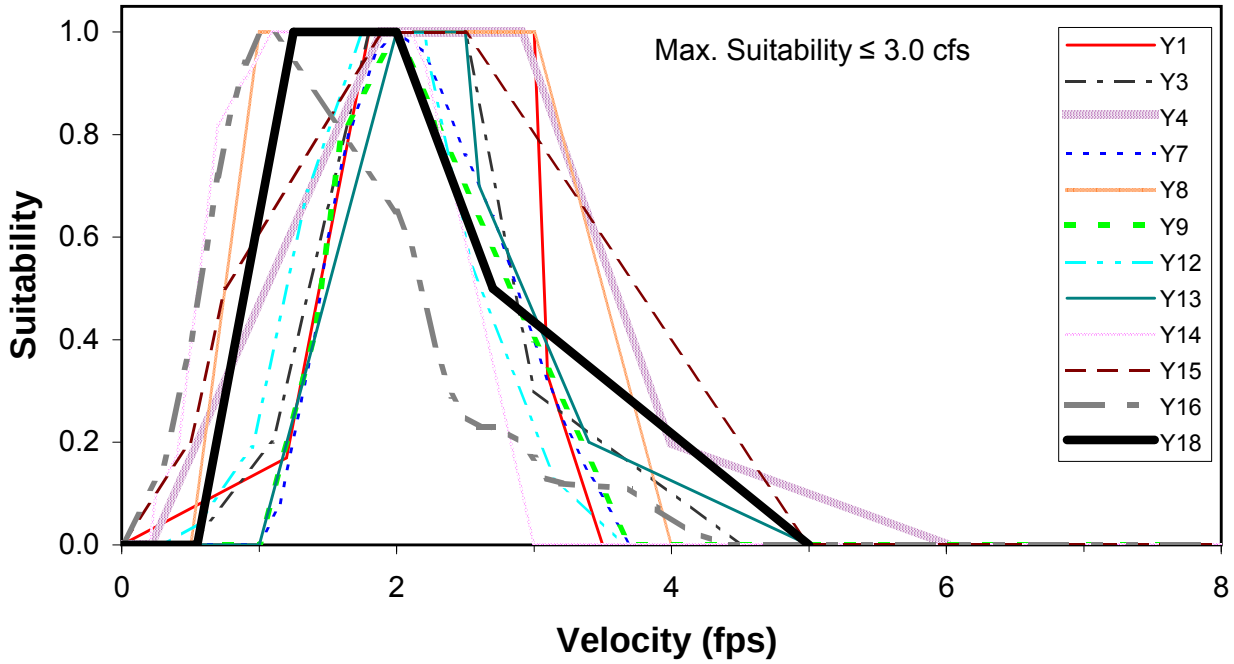


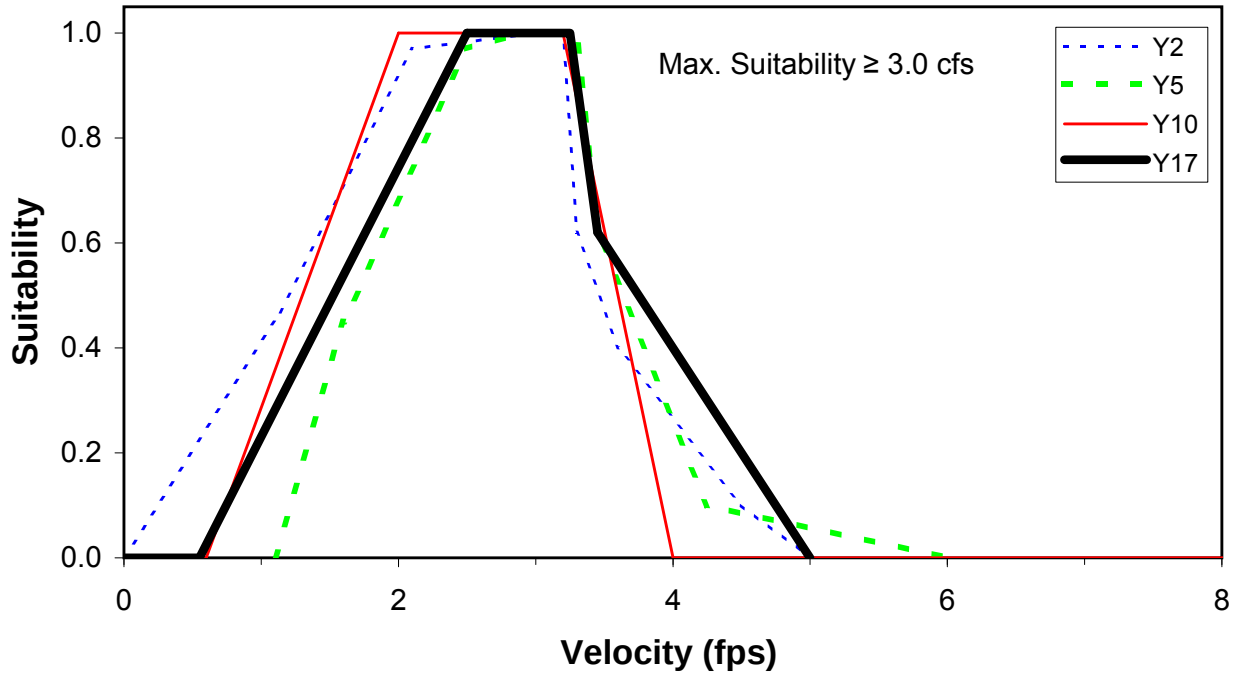
Figure 8(b). Comparison of proposed preference and original modified utilization Chinook spawning depth curves.

ATTACHMENT 1

Steelhead Spawning Velocity Curves

Steelhead Spawning Velocity Curves





Source:	Y1 -	Sams and Pearson 1963
	Y2 -	DES 1999
	Y3 -	Hosey 1986
	Y4 -	R2 Resource Consultants 1998
	Y5 -	WDFW 1996
	Y6 -	Hampton 1988
	Y7 --	Beak Consultants 1985; Bovee 1978; USFWS 1987
	Y8 -	Idaho USGS
	Y9 -	USFS 1989
	Y10-	R2 Resource Consultants
	Y11-	Sitka Electric Dept 2005
	Y12	Reiser 1986; Reiser et al 1988
	Y13	Hosey & Associates 1986
	Y14	Hampton 1988
	Y15	WDFW 1987
	Y16	Hampton 1997
	Y17	WDFW, WDOE 2004, 2008
	Y18	R2 Resource Consultants 2008

Location:	Y1 -	Oregon
	Y2 -	Skagit River, WA
	Y3 -	White River, WA
	Y4 -	Lostine River, Oregon; Ward Creek, AK
	Y5 -	Fallback curves, Cedar R., WA
	Y6 -	California, Utilization Cat. II
	Y7 -	Sandy River, Oregon
	Y8 -	Upper Salmon Basin, ID
	Y9 -	Western U.S., GAWS, Cat. II
	Y10-	Newhalem Creek, WA
	Y11-	proposed curve, Sawmill Creek, AK
	Y12	Idaho
	Y13	Washington, Suitability, Cat. I
	Y14	California, Pref. Cat. III
	Y15	Washington, Preference, Cat. III
	Y16	Lower Trinity River
	Y17	Washington State
	Y18	Sultan River, WA

Steelhead Spawning Suitability Scores for Velocity

X	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18
0.00	0.00	0.00		0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.20				0.00										0.00				
0.25											0.18			0.10				
0.30						0.16						0.00				0.15		
0.40														0.17				
0.50			0.00					0.00							0.20	0.39		
0.55												0.04					0.00	0.00
0.60										0.00						0.55		
0.63											0.36							
0.70														0.82		0.72		
0.75											0.64				0.50			
0.80						0.87										0.85		
0.90														0.91		0.94		
0.95												0.19						
1.00						0.98	0.00	1.00	0.00				0.00			0.99		
1.10		0.45	0.20		0.00	1.00								1.00		1.00		
1.15							0.08											
1.20	0.17																	
1.25											1.00							1.00
1.35												0.69						
1.40							0.40		0.40									
1.50							0.60											1.00
1.60					0.45		0.74		0.80									
1.65							0.80											
1.75												1.00						1.00
1.80	1.00		1.00															
1.85							0.96											
1.90				1.00											1.00			
2.00							1.00		1.00	1.00			1.00			0.65		1.00
2.10		0.97	1.00			0.58								1.00		0.59		
2.20							0.96					1.00		0.94		0.48		
2.25												0.92						
2.30							0.90									0.37		
2.40						0.28										0.29		
2.50			1.00		0.97	0.25	0.76						1.00		1.00	0.25	1.00	
2.55												0.54						
2.60													0.70			0.23		
2.70							0.64									0.23		0.50
2.75						0.23												
2.80																0.22		
2.9				1.00	1.00											0.20		
3.00	1.00	1.00	0.30					1.00	0.40		0.30			0.00		0.17		
3.10	0.33						0.32									0.13		
3.15												0.13						
3.20		1.00				0.14				1.00						0.12		
3.25							0.22										1.00	
3.30		0.62			1.00													
3.40							0.14						0.20					
3.45					0.62												0.62	
3.50	0.00										0.00							
3.60		0.40				0.14												
3.65												0.00						
3.70							0.00		0.00							0.11		
3.90																0.07		
4.00				0.20				0.00		0.00								
4.10																0.03		
4.25					0.10													
4.40						0.00										0.00		
4.50		0.10	0.00															
5.00		0.00											0.00		0.00		0.00	0.00
6.00				0.00	0.00													
8.00						0.00	0.00	0.00	0.00			0.00	0.00	0.00	0.00			
100.00								0.00		0.00						0.00		

ATTACHMENT 2

HSC Raw Data

Sultan River HSC Curve Observation Data: Spawning Observations

Date	Reach	Species	# of Obs.	Redd Width (ft)	Redd Length (ft)	Water Depth (ft)	Mean Column Velocity (ft/s)	Dom Sub.	Subdom. Sub.
6/7/2007	Reach 1A	Steelhead	1	2.5	7	1.80	2.76	MG	
6/7/2007	Reach 1A	Steelhead	1	2.5	6	1.85	2.78	LG	
6/7/2007	Reach 1A	Steelhead	1	2.6	6	1.70	2.66	MG	
6/7/2007	Reach 1A	Steelhead	1	2.4	6.5	1.45	2.46	MG	
6/7/2007	Reach 1A	Steelhead	1	2.6	6.5	1.40	3.13	MG	
6/7/2007	Reach 1A	Steelhead	1	2.5	5.5	1.75	3.41	MG	
6/13/2007	Reach 1A	Steelhead	1	5	10	1.40	2.73	LG	
6/13/2007	Reach 1A	Steelhead	1	6	8	1.50	2.77	LG	
6/13/2007	Reach 1A	Steelhead	1	10	14	1.10	2.34	LG	
6/13/2007	Reach 1A	Steelhead	1	8	12	1.10	1.95	LG	
6/13/2007	Reach 1A	Steelhead	1	6	8	1.50	3.59	LG	
6/13/2007	Reach 1A	Steelhead	1	3	6	1.60	1.54	LG	
6/13/2007	Reach 1A	Steelhead	1	3	8	2.00	1.37	LG	
6/13/2007	Reach 1A	Steelhead	1	3	8	1.50	1.61	SC	
6/13/2007	Reach 1A	Steelhead	1	4	10	1.00	1.20	LG	
6/13/2007	Reach 1A	Steelhead	1	8	12	1.70	2.40	LG	
6/13/2007	Reach 1A	Steelhead	1	6	8	1.60	2.12	LG	
6/13/2007	Reach 1A	Steelhead	1	4	7	1.50	2.14	SC	
6/7/2007	Reach 2	Steelhead	1	3.7	8.5	0.88	1.46	MG	
6/7/2007	Reach 2	Steelhead	1	3	6	1.19	1.44	MG	
6/7/2007	Reach 2	Steelhead	1	3.5	7	1.20	1.64	MG	
6/7/2007	Reach 2	Steelhead	1	2.5	5.5	0.95	0.78	MG	

Sultan River HSC Curve Observation Data: Spawning Observations

Date	Reach	Species	# of Obs.	Redd Width (ft)	Redd Length (ft)	Water Depth (ft)	Mean Column Velocity (ft/s)	Dom Sub.	Subdom. Sub.
6/7/2007	Reach 2	Steelhead	1	3	6.5	1.70	3.08	MG	
6/7/2007	Reach 2	Steelhead	1	3	7.5	1.40	2.69	MG	
6/7/2007	Reach 2	Steelhead	1	3.5	7	1.68	2.59	MG	
6/7/2007	Reach 2	Steelhead	1	3	6.5	1.32	1.90	MG	
6/7/2007	Reach 2	Steelhead	1	3	6	2.40	1.70	MG	
6/7/2007	Reach 2	Steelhead	1	3	6	1.80	2.19	MG	
6/7/2007	Reach 2	Steelhead	1	3	6.5	1.14	2.49	MG	
6/7/2007	Reach 2	Steelhead	1	2.75	5.5	2.00	1.55	MG	
6/7/2007	Reach 2	Steelhead	1	2.5	3.5	2.40	1.52	MG	
6/7/2007	Reach 2	Steelhead	1	3	3	2.21	1.54	MG	
6/7/2007	Reach 2	Steelhead	1	2.5	3	2.10	1.49	MG	
6/7/2007	Reach 2	Steelhead	1	2.75	6.5	0.95	0.79	SG	
4/23/2008	Reach 2	Steelhead	1			2.35	2.91	SC	LG
4/23/2008	Reach 2	Steelhead	1			1.9	3.34	SC	LG
4/23/2008	Reach 2	Steelhead	1			2.25	1.9	LG	SC
4/23/2008	Reach 2	Steelhead	1			1.4	3.2	LG	SC
4/23/2008	Reach 2	Steelhead	1			1.9	1.77	LG	SC
4/23/2008	Reach 2	Steelhead	1			1.75	1.94	LG	SC
4/23/2008	Reach 2	Steelhead	1			2.55	2.09	LG	SG
4/23/2008	Reach 2	Steelhead	1			1.8	1.96	LG	SG
4/23/2008	Reach 2	Steelhead	1			1.8	2.34	LG	SG
4/23/2008	Reach 2	Steelhead	1			1.3	1.59	LG	SG

Sultan River HSC Curve Observation Data: Spawning Observations

Date	Reach	Species	# of Obs.	Redd Width (ft)	Redd Length (ft)	Water Depth (ft)	Mean Column Velocity (ft/s)	Dom Sub.	Subdom. Sub.
4/23/2008	Reach 2	Steelhead	1			1.6	1.92	LG	SG
4/23/2008	Reach 2	Steelhead	1			2.3	1.9	LG	SG
4/23/2008	Reach 2	Steelhead	1			2	1.63	LG	SG
4/23/2008	Reach 2	Steelhead	1			2.55	1.255	LG	SG
4/23/2008	Reach 2	Steelhead	1			3.15	1.22	LG	SG
4/23/2008	Reach 2	Steelhead	1			1.3	1.14	SG	LG
4/23/2008	Reach 2	Steelhead	1			2.5	1.375	SG	LG
4/23/2008	Reach 2	Steelhead	1			2.15	1.62	SG	LG
5/6/2008	Reach 2	Steelhead	1			1.3	3.24	SC	LG
5/6/2008	Reach 2	Steelhead	1			1.8	2.51	SC	LG
5/6/2008	Reach 2	Steelhead	1			1.15	1.96	SC	LG
5/6/2008	Reach 2	Steelhead	1			2.65	1.89	SC	LG
5/6/2008	Reach 2	Steelhead	1			2.35	2.68	LG	SC
5/6/2008	Reach 2	Steelhead	1			3.5	2.38	LG	SC
5/6/2008	Reach 2	Steelhead	1			1.5	1.54	LG	SC
5/6/2008	Reach 2	Steelhead	1			2.65	2.47	LG	SG
5/6/2008	Reach 2	Steelhead	1			2.5	1.36	LG	SG
5/6/2008	Reach 2	Steelhead	1			2.4	2.31	LG	SG
5/6/2008	Reach 2	Steelhead	1			1.35	1.42	LG	SG
5/6/2008	Reach 2	Steelhead	1			2.15	1.33	LG	SG
5/6/2008	Reach 2	Steelhead	1			2.2	1.62	LG	SG
5/6/2008	Reach 2	Steelhead	1			1.25	2.1	LG	SG

Sultan River HSC Curve Observation Data: Spawning Observations

Date	Reach	Species	# of Obs.	Redd Width (ft)	Redd Length (ft)	Water Depth (ft)	Mean Column Velocity (ft/s)	Dom Sub.	Subdom. Sub.
5/6/2008	Reach 2	Steelhead	1			1.7	1.58	LG	SG
10/4/2006	Reach 1A	Chinook	1			1.55	2.07	RB	CB
10/4/2006	Reach 1A	Chinook	1			1.10	1.86	RB	CB
10/4/2006	Reach 1A	Chinook	1			2.10	0.87	RB	CB
10/4/2006	Reach 1A	Chinook	1			2.10	2.55	RB	CB
10/4/2006	Reach 1A	Chinook	1			2.10	1.83	RB	CB
10/4/2006	Reach 1A	Chinook	1			2.30	1.74	RB	CB
10/4/2006	Reach 1A	Chinook	1			2.20	1.73	RB	CB
10/4/2006	Reach 1A	Chinook	1			1.40	2.14	RB	CB
10/4/2006	Reach 1A	Chinook	1			2.20	2.43	RB	CB
10/4/2006	Reach 1A	Chinook	1			1.90	2.24	CB	RB
10/4/2006	Reach 1A	Chinook	1			1.85	2.34	RB	CB
10/4/2006	Reach 1A	Chinook	1			1.20	1.20	RB	BO
10/4/2006	Reach 1A	Chinook	1			1.20	1.20	RB	BO
10/4/2006	Reach 1A	Chinook	1			1.75	1.75	RB	CB
10/4/2006	Reach 1A	Chinook	1			2.20	2.20	RB	CB
10/4/2006	Reach 1A	Chinook	1			1.75	1.75	RB	CB
10/4/2006	Reach 1A	Chinook	1			1.35	1.35	RB	BO
10/4/2006	Reach 1A	Chinook	1			1.20	1.20	CG	CB
10/4/2006	Reach 1A	Chinook	1			1.10	1.10	RB	BO
10/4/2006	Reach 1A	Chinook	1			0.80	0.80	CB	RB
10/4/2006	Reach 1A	Chinook	1			1.10	1.10	CB	RB

Sultan River HSC Curve Observation Data: Spawning Observations

Date	Reach	Species	# of Obs.	Redd Width (ft)	Redd Length (ft)	Water Depth (ft)	Mean Column Velocity (ft/s)	Dom Sub.	Subdom. Sub.
10/9/2006	Reach 1A	Chinook	1			0.70	1.35	CB	RB
10/9/2006	Reach 1A	Chinook	1			1.10	1.65	RB	CB
10/9/2006	Reach 1A	Chinook	1			0.95	1.02	RB	CB
10/9/2006	Reach 1A	Chinook	1			1.35	2.10	RB	BO
10/9/2006	Reach 1A	Chinook	1			1.70	2.17	CG	RB
10/9/2006	Reach 1A	Chinook	1			2.05	0.84	CG	CB
10/9/2006	Reach 1A	Chinook	1			1.85	2.59	CB	RB
10/9/2006	Reach 1A	Chinook	1			1.70	2.43	CB	RB
10/9/2006	Reach 1A	Chinook	1			2.35	1.90	CB	RB
10/9/2006	Reach 1A	Chinook	1			2.70	1.48	CB	CG
10/9/2006	Reach 1A	Chinook	1			2.65	1.57	CB	RB
10/9/2006	Reach 1A	Chinook	1			2.45	2.54	CB	RB
10/9/2006	Reach 1A	Chinook	1			0.75	1.31	CG	CB
10/9/2006	Reach 1A	Chinook	1			1.20	2.97	CB	RB
10/9/2006	Reach 1A	Chinook	1			1.35	2.43	CG	CB
10/9/2006	Reach 1A	Chinook	1			2.15	2.84	CB	CG
10/9/2006	Reach 1A	Chinook	1			1.25	1.17	CB	RB
10/9/2006	Reach 1A	Chinook	1			2.15	2.21	CG	CB
10/9/2006	Reach 1A	Chinook	1			2.15	1.86	CG	CB
10/9/2006	Reach 1A	Chinook	1			0.70	1.71	CB	CG
10/9/2006	Reach 1A	Chinook	1			1.35	1.39	CB	CG
10/9/2006	Reach 1A	Chinook	1			1.40	3.16	CG	CB

Sultan River HSC Curve Observation Data: Spawning Observations

Date	Reach	Species	# of Obs.	Redd Width (ft)	Redd Length (ft)	Water Depth (ft)	Mean Column Velocity (ft/s)	Dom Sub.	Subdom. Sub.
10/9/2006	Reach 1A	Chinook	1			1.20	2.84	CB	CG
10/9/2006	Reach 1A	Chinook	1			1.30	1.65	FG	CG
10/15/2007	Reach 1A	Chinook	1			1.10	1.50	RB	CB
10/15/2007	Reach 1A	Chinook	1			1.80	1.67	CB	CG
10/15/2007	Reach 1A	Chinook	1			0.70	1.99	RB	CB
10/15/2007	Reach 1A	Chinook	1			1.10	1.03	CB	CG
10/15/2007	Reach 1A	Chinook	1			0.90	1.26	RB	CB
10/15/2007	Reach 1A	Chinook	1			1.40	1.43	RB	CB
10/15/2007	Reach 1A	Chinook	1			2.15	3.16	CB	CG
10/2/2006	Reach 2	Chinook	1			0.95	0.58	RB	CB
10/2/2006	Reach 2	Chinook	1			2.20	1.26	CB	CG
10/2/2006	Reach 2	Chinook	1			1.60	1.67	CG	CB
10/2/2006	Reach 2	Chinook	1			1.45	1.97	FG	RB
10/2/2006	Reach 2	Chinook	1			1.65	1.46	CG	CB
10/2/2006	Reach 2	Chinook	1			1.85	1.97	RB	CB
10/2/2006	Reach 2	Chinook	1			0.90	1.52	CB	CG
10/2/2006	Reach 2	Chinook	1			2.10	1.54	RB	CB
10/2/2006	Reach 2	Chinook	1			2.45	1.80	RB	CB
10/2/2006	Reach 2	Chinook	1			2.45	1.39	CG	CB
10/2/2006	Reach 2	Chinook	1			1.50	2.52	CG	CB
10/2/2006	Reach 2	Chinook	1			1.70	1.93	CB	CG
10/2/2006	Reach 2	Chinook	1			2.50	0.61	RB	CB

Sultan River HSC Curve Observation Data: Spawning Observations

Date	Reach	Species	# of Obs.	Redd Width (ft)	Redd Length (ft)	Water Depth (ft)	Mean Column Velocity (ft/s)	Dom Sub.	Subdom. Sub.
10/2/2006	Reach 2	Chinook	1			1.90	1.40	CB	RB
10/2/2006	Reach 2	Chinook	1			2.00	0.98	RB	CB
10/10/2006	Reach 2	Chinook	1			3.60	0.76	CB	CG
10/10/2006	Reach 2	Chinook	1			3.40	0.86	CG	FG
10/10/2006	Reach 2	Chinook	1			1.90	1.30	FG	CG
10/10/2006	Reach 2	Chinook	1			1.25	1.73	RB	CB
10/10/2006	Reach 2	Chinook	1			1.80	2.15	CB	RB
10/10/2006	Reach 2	Chinook	1			3.40	1.36	CG	RB
10/10/2006	Reach 2	Chinook	1			1.70	3.19	RB	CB
10/10/2006	Reach 2	Chinook	1			1.70	3.19	RB	CB
10/10/2006	Reach 2	Chinook	1			1.70	3.19	RB	CB
10/10/2006	Reach 2	Chinook	1			1.90	1.95	CB	CG
10/10/2006	Reach 2	Chinook	1			2.10	1.95	CG	CB
10/10/2006	Reach 2	Chinook	1			2.00	2.64	CG	CB
10/10/2006	Reach 2	Chinook	1			2.45	1.78	CB	CG
10/10/2006	Reach 2	Chinook	1			3.50	1.52	CG	CB
10/10/2006	Reach 2	Chinook	1			2.30	2.28	CB	RB
9/24/2007	Reach 2	Chinook	1			1.95	5.09	CG	RB
9/24/2007	Reach 2	Chinook	1			2.80	2.52	FG	CG
9/24/2007	Reach 2	Chinook	1			1.90	1.90	RB	FG
9/24/2007	Reach 2	Chinook	1			1.90	1.90	RB	FG
9/24/2007	Reach 2	Chinook	1			1.45	1.45	RB	FG

Sultan River HSC Curve Observation Data: Spawning Observations

Date	Reach	Species	# of Obs.	Redd Width (ft)	Redd Length (ft)	Water Depth (ft)	Mean Column Velocity (ft/s)	Dom Sub.	Subdom. Sub.
9/24/2007	Reach 2	Chinook	1			1.75	1.75	CG	RB
9/24/2007	Reach 2	Chinook	1			0.95	0.95	FG	CG
9/24/2007	Reach 2	Chinook	1			0.70	0.70	FG	CG
9/24/2007	Reach 2	Chinook	1			2.10	2.30	CG	FG
9/24/2007	Reach 2	Chinook	1			2.10	1.36	CG	FG
9/24/2007	Reach 2	Chinook	1			2.10	1.71	CG	CB
9/24/2007	Reach 2	Chinook	1			2.30	0.96	CB	CG
9/24/2007	Reach 2	Chinook	1			1.20	1.15	CG	CB
9/24/2007	Reach 2	Chinook	1			2.10	1.72	RB	CB
9/24/2007	Reach 2	Chinook	1			1.45	2.93	RB	CB
9/24/2007	Reach 2	Chinook	1			1.75	2.61	RB	CB
9/24/2007	Reach 2	Chinook	1			2.30	1.40	RB	CB
9/24/2007	Reach 2	Chinook	1			2.90	1.58	RB	CB
9/24/2007	Reach 2	Chinook	1			1.90	1.32	RB	CB
9/24/2007	Reach 2	Chinook	1			2.10	0.96	CB	CG
9/24/2007	Reach 2	Chinook	1			1.35	1.37	CG	CB
10/12/2007	Reach 2	Chinook	1			1.15	1.27	CG	FG
10/12/2007	Reach 2	Chinook	1			2.00	2.27	CB	CG
10/12/2007	Reach 2	Chinook	1			2.05	2.79	CB	RB
10/12/2007	Reach 2	Chinook	1			0.95	3.32	CB	CG
10/12/2007	Reach 2	Chinook	1			1.00	0.67	RB	FG
10/12/2007	Reach 2	Chinook	1			0.70	0.91	CG	CB

Sultan River HSC Curve Observation Data: Spawning Observations

Date	Reach	Species	# of Obs.	Redd Width (ft)	Redd Length (ft)	Water Depth (ft)	Mean Column Velocity (ft/s)	Dom Sub.	Subdom. Sub.
10/12/2007	Reach 2	Chinook	1			1.00	1.55	CG	CB
10/12/2007	Reach 2	Chinook	1			2.00	1.93	CG	CB
10/12/2007	Reach 2	Chinook	1			2.40	1.73	CG	CB
10/12/2007	Reach 2	Chinook	1			1.95	2.31	CG	CB
10/12/2007	Reach 2	Chinook	1			1.25	2.36	CB	CG
10/12/2007	Reach 2	Chinook	1			2.00	2.38	CB	CG
10/12/2007	Reach 2	Chinook	1			0.90	2.21	CG	FG
10/12/2007	Reach 2	Chinook	1			2.45	1.80	CB	CG
10/12/2007	Reach 2	Chinook	1			1.75	1.62	CB	CG
10/12/2007	Reach 2	Chinook	1			1.35	2.40	RB	CB
10/12/2007	Reach 2	Chinook	1			1.65	2.25	RB	CB
10/12/2007	Reach 2	Chinook	1			1.70	2.54	RB	CB
10/12/2007	Reach 2	Chinook	1			1.45	2.50	RB	CB
10/12/2007	Reach 2	Chinook	1			2.10	2.03	RB	CB
10/12/2007	Reach 2	Chinook	1			1.10	1.09	RB	CB
10/12/2007	Reach 2	Chinook	1			1.40	1.12	CB	FG
10/12/2007	Reach 2	Chinook	1			1.75	2.77	RB	CB
10/12/2007	Reach 2	Chinook	1			1.60	1.80	RB	CB
10/12/2007	Reach 2	Chinook	1			1.40	3.35	RB	CB
10/12/2007	Reach 2	Chinook	1			1.75	2.31	RB	CB
10/12/2007	Reach 2	Chinook	1			1.30	1.52	RB	CB
10/12/2007	Reach 2	Chinook	1			0.70	3.27	RB	CB

Sultan River HSC Curve Observation Data: Spawning Observations

Date	Reach	Species	# of Obs.	Redd Width (ft)	Redd Length (ft)	Water Depth (ft)	Mean Column Velocity (ft/s)	Dom Sub.	Subdom. Sub.
10/12/2007	Reach 2	Chinook	1			0.85	2.63	RB	CB
10/12/2007	Reach 2	Chinook	1			2.60	1.13	CG	CB
10/12/2007	Reach 2	Chinook	1			2.60	1.33	CG	CB

Sultan River HSC Curve Observation Data: Juvenile Observations

Date	Reach	# of Obs.	Species	Fish Length (mm)	Water Depth (ft)	Mean Column Velocity (ft/s)	Fish Position (ft)	Nose Velocity (ft/s)	Dom Sub.	Subdom. Sub.	% Dom	Cover
7/27/2007	Reach 1A	1	Chinook	70	1.9	0.06	0.6-1.1	same	SC	LG	80	veg/undercut bank/ roots
8/8/2007	Reach 1A	1	Chinook	70	1.4	0.12	0.4	same	LC	SC	60	overhanging veg/swd
7/27/2007	Reach 1A	1	Coho	70	1.70	0.02	0.1	0.02	B	LC	60	wood
7/27/2007	Reach 1A	1	Coho	70	0.75	0.24	0.3	same	SC	LG	60	veg
7/27/2007	Reach 1A	1	Coho	70	0.90	0.30	0.2	0.26	SC	LG	60	veg
7/27/2007	Reach 1A	1	Coho	70	1.25	0.02	0.6	same	LG	LC	60	veg
7/27/2007	Reach 1A	1	Coho	75	0.80	0.02	0.2	0.02	LG	SLT	80	undercut bank
7/27/2007	Reach 1A	1	Coho	70	1.45	0.08	0.3	0.02	LC	SND	60	veg/wood
7/27/2007	Reach 1A	4	Coho	65-85	1.3	0.63	0.3-0.4	same	LC	LG	60	roots/undercut bank
7/27/2007	Reach 1A	6	Coho	70-90	1.25	0.19	0.25	0.18	LG	LC	60	wood
7/27/2007	Reach 1A	10	Coho	60-80	0.60	0.83	0.1-0.15	0.36	SC	LC	70	
7/27/2007	Reach 1A	10	Coho	60-80	0.60	0.12	0.1-0.15	0.06	SC	LC	70	
7/27/2007	Reach 1A	10	Coho	65-85	1.7	0.02	0.6-0.8	0.02	SC	LG	60	roots/undercut bank
7/27/2007	Reach 1A	10	Coho	65-85	1.9	0.02	0.6-1.0	0.02	SC	LG	60	
7/27/2007	Reach 1A	12	Coho	65-80	1.55	0.07	0.6-1.1	0.02	SC	LG	80	veg/undercut bank/ roots
7/27/2007	Reach 1A	12	Coho	65-80	1.1	0.09	0.3	same	SC	LG	80	veg/undercut bank/ roots
7/27/2007	Reach 1A	20	Coho	65-100	1.8	0.10	0.8	same	SC	LG	80	veg/undercut bank/ roots
7/27/2007	Reach 1A	20	Coho	65-100	2.2	0.02	0.6-1.1	0.02	SC	LG	80	veg/undercut bank/ roots
7/27/2007	Reach 1A	20	Coho	65-100	1.9	0.06	0.6-1.1	same	SC	LG	80	veg/undercut bank/ roots
7/27/2007	Reach 1A	20	Coho	65-85	1.95	0.20	0.5-1.0	same	LC	LG	60	veg/wood/roots
7/27/2007	Reach 1A	20	Coho	65-85	1.5	0.06	0.4-0.8	same	LC	LG	60	veg
8/8/2007	Reach 1A	1	Coho	70	0.55	0.26	0.15	same	SC	SG	60	bank

Sultan River HSC Curve Observation Data: Juvenile Observations

Date	Reach	# of Obs.	Species	Fish Length (mm)	Water Depth (ft)	Mean Column Velocity (ft/s)	Fish Position (ft)	Nose Velocity (ft/s)	Dom Sub.	Subdom. Sub.	% Dom	Cover
8/8/2007	Reach 1A	1	Coho	70	0.55	0.38	0.2	same	LG	MG	60	bank
8/8/2007	Reach 1A	1	Coho	100	1.35	0.40	0.3	0.64	LG	SC	60	roots
8/8/2007	Reach 1A	1	Coho	65	2.1	0.25	0.5	same	SC	LC	60	lwd
8/8/2007	Reach 1A	1	Coho	65	2.8	0.48	1.9	same	SC	LC	60	lwd
8/8/2007	Reach 1A	1	Coho	65	2.6	0.51	0.4	same	SC	LC	60	lwd
8/8/2007	Reach 1A	1	Coho	70	2.6	0.83	1.8	same	SC	LC	60	lwd
8/8/2007	Reach 1A	1	Coho	65	0.35	0.23	0.2	same	LG	MG	60	overhanging veg/swd
8/8/2007	Reach 1A	1	Coho	70	3	0.47	0.6	0.39	SC	LC	60	lwd
8/8/2007	Reach 1A	1	Coho	70	3	0.43	1.2	0.39	SC	LC	60	lwd
8/8/2007	Reach 1A	1	Coho	75	2.9	0.42	1.3	0.24	SC	LC	60	lwd
8/8/2007	Reach 1A	1	Coho	75	3.3	0.32	2	0.14	B	LC	60	lwd
8/8/2007	Reach 1A	1	Coho	85	2.8	0.84	1.8	0.26	B	LC	60	lwd
8/8/2007	Reach 1A	1	Coho	85	2.8	0.28	1.6	0.03	B	SC	60	lwd
8/8/2007	Reach 1A	1	Coho	80	2.5	1.71	0.5	0.85	SC	LC	60	overhanging veg
8/8/2007	Reach 1A	1	Coho	100	2.4	1.52	0.4	0.46	SC	LC	60	overhanging veg
8/8/2007	Reach 1A	1	Coho	70	1.4	0.58	0.2	0.27	SC	LG	80	lwd
8/8/2007	Reach 1A	1	Coho	75	1.45	0.60	0.2	0.26	SC	LG	80	lwd
8/8/2007	Reach 1A	1	Coho	75	1.1	0.75	0.3	0.72	SC	LC	60	lwd
8/8/2007	Reach 1A	1	Coho	75	1.4	0.08	0.5	same	LC	SC	60	overhanging veg/swd
8/8/2007	Reach 1A	1	Coho	70	1.1	0.39	0.3	same	LC	SC	60	overhanging veg/swd
8/8/2007	Reach 1A	1	Coho	70	1.6	0.30	0.4	same	LC	SC	60	overhanging veg/swd
8/8/2007	Reach 1A	1	Coho	70	0.6	0.05	0.1	same	LC	SC	60	overhanging lwd

Sultan River HSC Curve Observation Data: Juvenile Observations

Date	Reach	# of Obs.	Species	Fish Length (mm)	Water Depth (ft)	Mean Column Velocity (ft/s)	Fish Position (ft)	Nose Velocity (ft/s)	Dom Sub.	Subdom. Sub.	% Dom	Cover
8/8/2007	Reach 1A	1	Coho	70	2	0.05	1.5	same	BR	SC	60	overhanging veg/bank
8/8/2007	Reach 1A	2	Coho	65-80	0.65	0.32	0.2	same	LG	MG	60	swd
8/8/2007	Reach 1A	2	Coho	65-80	1.3	0.66	0.3	0.57	LG	SC	60	roots
8/8/2007	Reach 1A	2	Coho	80	0.8	0.06	0.3	same	LC	SC	70	bank
8/8/2007	Reach 1A	2	Coho	75-85	0.6	0.04	0.1	same	LC	SC	60	overhanging lwd
8/8/2007	Reach 1A	2	Coho	65-85	2.4	0.94	0.8	same	BR	SC	60	overhanging veg
8/8/2007	Reach 1A	3	Coho	65-80	0.7	0.34	0.1	same	LG	MG	60	swd
8/8/2007	Reach 1A	3	Coho	65-80	0.65	0.40	0.2	same	LG	MG	60	swd
8/8/2007	Reach 1A	3	Coho	65-80	0.75	0.23	0.25	same	LG	LC	60	bank
8/8/2007	Reach 1A	3	Coho	65-80	0.45	0.15	0.25	same	LG	SC	60	bank
8/8/2007	Reach 1A	3	Coho	65-80	1.5	0.69	0.2	0.24	SC	LG	80	
8/8/2007	Reach 1A	3	Coho	65-85	2.4	0.82	0.6	0.76	BR	SC	60	
8/8/2007	Reach 1A	3	Coho	65-85	2.1	0.78	0.6	same	BR	SC	60	
8/8/2007	Reach 1A	4	Coho	80-85	3.95	0.28	1.4	same	LC	SC	70	overhanging veg
8/8/2007	Reach 1A	4	Coho	70-80	1	0.17	0.3	same	SC	LC	80	lwd
8/8/2007	Reach 1A	4	Coho	65-85	2.8	0.91	0.8	same	BR	SC	60	overhanging veg
8/8/2007	Reach 1A	4	Coho	65-85	2.9	1.14	1	same	BR	SC	60	overhanging veg
8/8/2007	Reach 1A	5	Coho	65-85	1.7	0.23	0.4	same	SC	LC	60	bank
8/8/2007	Reach 1A	6	Coho	80-85	3.4	0.19	0.8	same	LC	SC	70	overhanging veg
8/8/2007	Reach 1A	6	Coho	65-85	3.2	0.86	1.2	same	BR	SC	60	overhanging veg
8/8/2007	Reach 1A	8	Coho	65-85	1.9	0.14	0.4	same	SC	LC	60	bank
8/8/2007	Reach 1A	8	Coho	65-85	3.1	0.26	1.2	0.15	LC	SC	70	overhanging veg

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Date	Reach	# of Obs.	Species	Fish Length (mm)	Water Depth (ft)	Mean Column Velocity (ft/s)	Fish Position (ft)	Nose Velocity (ft/s)	Dom Sub.	Subdom. Sub.	% Dom	Cover
8/8/2007	Reach 1A	8	Coho	65-85	3.6	0.38	1	0.27	LC	SC	70	overhanging veg
8/8/2007	Reach 1A	8	Coho	65-85	3	0.20	0.8	same	LC	SC	70	overhanging veg
8/8/2007	Reach 1A	8	Coho	70-85	3.6	0.32	1.2	same	LC	SC	70	overhanging veg
8/8/2007	Reach 1A	10	Coho	65-85	1.5	0.02	0.2	same	B	LC	60	lwd
8/8/2007	Reach 1A	10	Coho	65-85	1.7	0.09	0.4	same	B	LC	60	lwd
8/8/2007	Reach 1A	10	Coho	65-100	2.7	0.05	0.6	same	BR	SC	60	undercut bank
8/8/2007	Reach 1A	10	Coho	65-100	3.6	0.40	0.8	0.5	BR	SC	60	undercut bank
8/8/2007	Reach 1A	10	Coho	65-100	3.25	0.21	0.8	0.28	BR	SC	60	undercut bank and lwd
8/8/2007	Reach 1A	10	Coho	65-100	3.6	0.36	1.4	0.52	BR	SC	60	lwd
8/8/2007	Reach 1A	10	Coho	65-100	3.8	0.44	1.8	0.59	BR	SC	60	lwd
8/8/2007	Reach 1A	13	Coho	65-100	0.95	0.02	0.2	same	LC	B	60	overhanging veg
8/8/2007	Reach 1A	13	Coho	65-100	1.15	0.02	0.3	same	LC	B	60	overhanging veg
8/8/2007	Reach 1A	13	Coho	65-100	1.35	0.02	0.4	same	LC	B	60	overhanging veg
7/27/2007	Reach 2	1	Coho	70	1.40	0.22	0.15	0.09	SC	LG	60	
7/27/2007	Reach 2	1	Coho	65	0.65	0.15	0.2	0.11	B	LG	60	
7/27/2007	Reach 2	1	Coho	60	0.60	0.50	0.1	0.39	LG	SC	60	
7/27/2007	Reach 2	1	Coho	65	1.25	0.02	0.2	0.02	B	MG	80	
7/27/2007	Reach 2	2	Coho	60-70	1.95	0.04	0.3	0.03	B	LC	80	boulder
7/27/2007	Reach 2	3	Coho	60-65	0.40	0.49	0.1	same	LC	MG	60	
7/27/2007	Reach 2	3	Coho	60-80	1.05	0.05	0.15	0.14	LC	LG	60	
7/27/2007	Reach 2	3	Coho	60-80	1.10	0.60	0.15	0.43	LG	B	70	
7/27/2007	Reach 2	3	Coho	70	0.80	0.02	0.1	0.02	B	MG	80	

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Date	Reach	# of Obs.	Species	Fish Length (mm)	Water Depth (ft)	Mean Column Velocity (ft/s)	Fish Position (ft)	Nose Velocity (ft/s)	Dom Sub.	Subdom. Sub.	% Dom	Cover
7/27/2007	Reach 2	8	Coho	60-70	1.35	0.40	0.2	0.3	B	SG	60	
7/27/2007	Reach 2	8	Coho	60-70	1.55	0.41	0.3	0.14	B	SG	60	
7/27/2007	Reach 2	8	Coho	60-70	1.35	0.76	0.4	0.4	B	SG	60	
7/27/2007	Reach 1A	1	Trout	40	1.40	0.10	0.3	0.12	B	LC	60	undercut bank
7/27/2007	Reach 1A	1	Trout	40	0.70	0.83	0.2	same	SC	LC	70	
7/27/2007	Reach 1A	1	Trout	40	0.50	0.10	0.25	same	SC	LC	70	
7/27/2007	Reach 1A	1	Trout	40	0.60	0.50	0.3	same	SC	LC	70	
7/27/2007	Reach 1A	1	Trout	35	0.50	0.35	0.2	same	SC	LG	60	
7/27/2007	Reach 1A	1	Trout	40	1.25	0.02	0.9	0.13	LG	LC	60	veg
7/27/2007	Reach 1A	1	Trout	35	0.95	0.51	0.4	same	SC	LG	70	
7/27/2007	Reach 1A	1	Trout	45	0.55	0.06	0.2	same	SC	LG	70	
7/27/2007	Reach 1A	1	Trout	40	1.8	0.81	0.8	same	SC	LG	70	veg
7/27/2007	Reach 1A	1	Trout	40	1.95	0.02	1.7	0.02	SC	LG	70	veg/wood/roots
7/27/2007	Reach 1A	1	Trout	40	0.8	0.02	0.3	0.02	SC	LG	60	
7/27/2007	Reach 1A	1	Trout	40	1	0.05	0.05	0.02	LC	SC	70	
7/27/2007	Reach 1A	1	Trout	35-40	0.9	0.43	0.4	same	SC	LC	60	veg
7/27/2007	Reach 1A	1	Trout	35-40	0.7	0.21	0.3	same	SC	LC	60	veg
7/27/2007	Reach 1A	2	Trout	35-40	0.45	0.20	0.3	same	SC	LC	70	
7/27/2007	Reach 1A	2	Trout	40	0.55	0.02	0.45	same	SC	SG	60	veg/wood
7/27/2007	Reach 1A	2	Trout	40	1.2	0.02	1	0.02	LC	SC	60	wood
7/27/2007	Reach 1A	2	Trout	40	0.6	0.13	0.3	same	SC	LG	60	
7/27/2007	Reach 1A	2	Trout	35-40	0.25	0.02	0.05	0.02	LC	SC	70	

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Date	Reach	# of Obs.	Species	Fish Length (mm)	Water Depth (ft)	Mean Column Velocity (ft/s)	Fish Position (ft)	Nose Velocity (ft/s)	Dom Sub.	Subdom. Sub.	% Dom	Cover
7/27/2007	Reach 1A	2	Trout	35-40	0.3	0.02	0.05	0.02	LC	SC	70	
7/27/2007	Reach 1A	2	Trout	35-40	0.55	0.13	0.2	same	SC	LC	60	veg
7/27/2007	Reach 1A	2	Trout	35-40	0.5	0.23	0.25	same	SC	LC	60	veg
7/27/2007	Reach 1A	3	Trout	35-45	0.95	0.58	0.5	same	SC	LG	60	veg
7/27/2007	Reach 1A	3	Trout	35-45	0.85	0.42	0.5	same	SC	LG	60	veg
7/27/2007	Reach 1A	3	Trout	35-45	0.7	0.47	0.3	same	SC	LG	70	
7/27/2007	Reach 1A	3	Trout	35-40	0.2	0.02	0.05	0.02	LC	SC	70	
7/27/2007	Reach 1A	3	Trout	35-40	0.3	0.03	0.15	same	SC	LC	60	veg
7/27/2007	Reach 1A	4	Trout	40	0.4	0.24	0.2	same	LG	LC	60	
7/27/2007	Reach 1A	4	Trout	40	0.7	0.02	0.3	0.02	LC	SC	70	
7/27/2007	Reach 1A	5	Trout	35-45	0.80	0.34	0.2	same	SC	LC	70	
7/27/2007	Reach 1A	5	Trout	40	0.6	0.10	0.3	same	SC	LG	60	veg
7/27/2007	Reach 1A	5	Trout	40	0.5	0.27	0.3	same	SC	LG	60	veg
7/27/2007	Reach 1A	6	Trout	35-45	0.65	0.28	0.2	same	SC	LC	60	
7/27/2007	Reach 1A	20	Trout	35-50	0.60	0.83	0.1-0.15	0.36	SC	LC	70	
7/27/2007	Reach 1A	20	Trout	35-50	0.60	0.12	0.1-0.15	0.06	SC	LC	70	
8/8/2007	Reach 1A	1	Trout	45	0.5	0.30	0.4	same	SC	LC	60	grass
8/8/2007	Reach 1A	1	Trout	40	1	0.25	0.3	same	SC	LC	60	
8/8/2007	Reach 1A	1	Trout	45	0.95	0.33	0.2	same	SC	LG	60	
8/8/2007	Reach 1A	1	Trout	45	0.5	0.06	0.4	same	SC	LG	60	
8/8/2007	Reach 1A	1	Trout	50	0.4	0.02	0.2	same	LG	SC	60	swd
8/8/2007	Reach 1A	1	Trout	45	0.55	0.22	0.2	same	LG	SC	60	swd

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8/8/2007	Reach 1A	1	Trout	55	0.4	0.08	0.2	same	LG	SC	60	
8/8/2007	Reach 1A	1	Trout	45	0.75	0.72	0.5	0.82	LG	SND	60	bank
8/8/2007	Reach 1A	1	Trout	55	0.6	0.30	0.2	same	LG	SC	60	
8/8/2007	Reach 1A	1	Trout	45	0.5	0.35	0.2	same	LG	SC	60	
8/8/2007	Reach 1A	1	Trout	50	0.45	0.20	0.2	same	LG	SC	60	
8/8/2007	Reach 1A	1	Trout	40	0.5	0.02	0.2	same	LG	MG	60	
8/8/2007	Reach 1A	1	Trout	45	0.5	0.15	0.2	same	SC	LC	60	
8/8/2007	Reach 1A	1	Trout	50	0.75	0.22	0.2	same	SC	LG	60	
8/8/2007	Reach 1A	1	Trout	45	0.5	0.85	0.2	same	SC	LG	60	
8/8/2007	Reach 1A	1	Trout	45	0.6	0.32	0.2	same	SC	LG	60	
8/8/2007	Reach 1A	1	Trout	45	0.9	0.74	0.2	same	SC	LG	60	
8/8/2007	Reach 1A	1	Trout	45	0.75	0.11	0.3	same	SC	LG	60	overhanging veg
8/8/2007	Reach 1A	1	Trout	50	1.2	0.03	0.2	same	SC	LG	60	
8/8/2007	Reach 1A	1	Trout	45	0.3	0.15	0.2	same	SC	LG	60	
8/8/2007	Reach 1A	1	Trout	50	0.45	0.26	0.25	same	LG	SC	60	overhanging veg
8/8/2007	Reach 1A	1	Trout	45	0.3	0.13	0.15	same	LG	SC	60	overhanging veg
8/8/2007	Reach 1A	1	Trout	50	0.4	0.19	0.15	same	LG	SC	60	bank
8/8/2007	Reach 1A	1	Trout	50	0.5	0.89	0.15	same	LG	LC	60	
8/8/2007	Reach 1A	1	Trout	40	0.35	0.23	0.2	same	LG	MG	60	overhanging veg/swd
8/8/2007	Reach 1A	1	Trout	45	0.5	0.54	0.2	same	LG	MG	60	overhanging veg/swd
8/8/2007	Reach 1A	1	Trout	250	2.5	0.66	0.3	0.08	B	SC	60	lwd
8/8/2007	Reach 1A	1	Trout	50	0.45	0.86	0.2	same	LG	SC	60	

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8/8/2007	Reach 1A	1	Trout	35	0.45	0.17	0.3	same	SC	LG	60	swd
8/8/2007	Reach 1A	1	Trout	120	2.5	0.59	0.3	0.67	SC	LC	60	overhanging veg
8/8/2007	Reach 1A	1	Trout	150	1.5	1.24	0.2	0.82	SC	LG	80	lwd
8/8/2007	Reach 1A	1	Trout	150	1.45	1.49	0.2	0.73	SC	LG	80	lwd
8/8/2007	Reach 1A	1	Trout	135	1.4	1.18	0.3	0.26	SC	LG	80	lwd
8/8/2007	Reach 1A	1	Trout	130	1.1	1.10	0.3	0.6	SC	LC	60	lwd
8/8/2007	Reach 1A	1	Trout	55	1.25	0.08	0.4	same	B	SC	60	
8/8/2007	Reach 1A	1	Trout	55	0.7	0.15	0.3	same	B	SC	60	bank
8/8/2007	Reach 1A	1	Trout	150	1.5	1.96	0.2	0.71	B	LC	60	
8/8/2007	Reach 1A	1	Trout	60	1.75	0.18	0.2	0.02	B	LC	90	bank
8/8/2007	Reach 1A	1	Trout	50	1.4	0.08	0.3	same	LC	SC	60	overhanging veg/swd
8/8/2007	Reach 1A	1	Trout	150	0.8	0.05	0.4	same	LC	SC	60	overhanging veg/swd
8/8/2007	Reach 1A	1	Trout	50	0.5	0.24	0.1	same	LC	SC	60	overhanging lwd
8/8/2007	Reach 1A	1	Trout	55	0.6	0.05	0.1	same	LC	SC	60	overhanging lwd
8/8/2007	Reach 1A	1	Trout	45	0.6	0.06	0.2	same	LC	SC	60	overhanging lwd
8/8/2007	Reach 1A	1	Trout	40	0.6	0.33	0.2	same	LC	SC	60	
8/8/2007	Reach 1A	1	Trout	45	0.5	0.70	0.1	same	LC	SC	60	
8/8/2007	Reach 1A	1	Trout	45	1	0.23	0.4	same	SC	LC	80	
8/8/2007	Reach 1A	1	Trout	50	1.2	0.20	0.5	same	SC	LC	80	
8/8/2007	Reach 1A	1	Trout	45	1	0.27	0.5	same	SC	LC	80	
8/8/2007	Reach 1A	1	Trout	50	1.1	0.48	0.3	same	SC	LC	80	lwd
8/8/2007	Reach 1A	1	Trout	50	1.2	0.59	0.1	0.35	BR	SC	60	

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8/8/2007	Reach 1A	1	Trout	45-50	1.3	0.12	0.4	same	LC	SC	60	
8/8/2007	Reach 1A	1	Trout	45	1	0.14	0.6	same	SC	LG	70	
8/8/2007	Reach 1A	2	Trout	45-50	0.3	0.27	0.2	same	LG	SND	60	bank
8/8/2007	Reach 1A	2	Trout	45	0.45	0.27	0.2	same	LG	SC	60	overhanging branch
8/8/2007	Reach 1A	2	Trout	45	1.3	0.36	0.15	same	SC	MG	60	
8/8/2007	Reach 1A	2	Trout	40	0.5	0.29	0.1	same	LC	SC	60	
8/8/2007	Reach 1A	2	Trout	40-50	0.6	0.40	0.1	same	SC	LG	60	bank
8/8/2007	Reach 1A	2	Trout	35-40	1.2	0.42	0.3	same	LC	LG	70	
8/8/2007	Reach 1A	2	Trout	45-50	1.2	0.02	0.4	same	LC	SC	60	
8/8/2007	Reach 1A	2	Trout	40-45	0.8	0.38	0.2	same	LC	SC	80	
8/8/2007	Reach 1A	2	Trout	40-45	0.6	0.14	0.3	same	LC	SC	60	
8/8/2007	Reach 1A	3	Trout	40-55	0.7	0.19	0.3	same	SC	LC	60	
8/8/2007	Reach 1A	3	Trout	45-50	0.3	0.08	0.2	same	SC	LG	60	swd
8/8/2007	Reach 1A	3	Trout	40-50	0.5	0.03	0.2	same	SC	LG	60	swd
8/8/2007	Reach 1A	3	Trout	45-55	0.5	0.25	0.2	same	SC	LG	60	
8/8/2007	Reach 1A	3	Trout	45-55	0.5	0.30	0.2	same	SC	LG	60	
8/8/2007	Reach 1A	3	Trout	40-45	0.5	0.07	0.2	same	LG	SC	60	overhanging branch
8/8/2007	Reach 1A	3	Trout	40-50	0.85	0.28	0.3	same	LC	SC	60	
8/8/2007	Reach 1A	3	Trout	40-45	0.5	0.13	0.2	same	LC	SC	80	
8/8/2007	Reach 1A	4	Trout	40	0.5	0.40	0.2	same	LG	MG	60	bank
8/8/2007	Reach 1A	4	Trout	40-45	0.7	0.04	0.4	same	SC	LG	70	
8/8/2007	Reach 1A	5	Trout	35-45	0.7	0.02	0.2	same	SC	LC	60	

Sultan River HSC Curve Observation Data: Juvenile Observations

Date	Reach	# of Obs.	Species	Fish Length (mm)	Water Depth (ft)	Mean Column Velocity (ft/s)	Fish Position (ft)	Nose Velocity (ft/s)	Dom Sub.	Subdom. Sub.	% Dom	Cover
8/8/2007	Reach 1A	5	Trout	40-45	0.4	0.11	0.2	same	SC	B	60	
8/8/2007	Reach 1A	6	Trout	35-45	0.4	0.02	0.2	same	SC	LG	60	overhanging veg
8/8/2007	Reach 1A	12	Trout	40-45	0.6	0.50	0.2	same	SC	B	60	
7/27/2007	Reach 2	1	Trout	50	2.15	0.00	0.05	0	B	LC	80	boulder
7/27/2007	Reach 2	1	Trout	40	0.40	0.52	0.1	same	LG	B	90	
7/27/2007	Reach 2	1	Trout	40	0.55	0.23	0.2	0.21	LG	LC	70	
7/27/2007	Reach 2	1	Trout	50	1.60	0.27	0.2	0.49	B	SG	70	
7/27/2007	Reach 2	1	Trout	45	0.70	0.45	0.2	0.17	B	MG	80	boulder
7/27/2007	Reach 2	1	Trout	45	1.25	0.12	0.1	0.01	B	MG	80	
7/27/2007	Reach 2	1	Trout	50	1.05	1.09	0.1	0.61	LG	LC	60	
7/27/2007	Reach 2	1	Trout	50	1.15	1.72	0.15	1.18	LC	LG	60	
7/27/2007	Reach 2	1	Trout	50	1.50	2.03	0.15	0.8	LG	LC	60	
7/27/2007	Reach 2	1	Trout	45	0.75	0.20	0.2	0.39	B	MG	70	
7/27/2007	Reach 2	1	Trout	40	0.45	0.01	0.1	same	LC	LG	60	
7/27/2007	Reach 2	1	Trout	35	0.35	0.08	0.05	same	LC	LG	60	
7/27/2007	Reach 2	1	Trout	45	1.45	2.01	0.1	0.15	MG	LG	60	
7/27/2007	Reach 2	1	Trout	40	1.30	0.41	0.2	0.27	SND	SG	70	
7/27/2007	Reach 2	1	Trout	40	0.95	0.11	0.5	same	SND	SG	70	
7/27/2007	Reach 2	1	Trout	45	1.40	0.02	0.5	0.02	B	LC	70	
7/27/2007	Reach 2	1	Trout	35	0.70	0.02	0.2	0.02	B	LC	70	
7/27/2007	Reach 2	1	Trout	40	1.50	0.21	0.15	0.03	LC	B	60	
7/27/2007	Reach 2	2	Trout	45	0.80	0.02	0.2	0.02	LC	LG	70	

Sultan River HSC Curve Observation Data: Juvenile Observations

Date	Reach	# of Obs.	Species	Fish Length (mm)	Water Depth (ft)	Mean Column Velocity (ft/s)	Fish Position (ft)	Nose Velocity (ft/s)	Dom Sub.	Subdom. Sub.	% Dom	Cover
7/27/2007	Reach 2	2	Trout	45	0.85	0.23	0.2	0.19	LC	LG	70	
7/27/2007	Reach 2	2	Trout	50	1.40	0.19	0.2	0.12	SC	LG	60	
7/27/2007	Reach 2	2	Trout	40	0.85	0.69	0.1	0.41	LG	B	70	
7/27/2007	Reach 2	2	Trout	35-45	0.55	0.75	0.2	0.54	SC	LC	70	
7/27/2007	Reach 2	2	Trout	45-50	2.30	0.11	0.3	0.02	B	LC	70	
7/27/2007	Reach 2	2	Trout	40	1.10	0.60	0.15	0.43	LG	B	70	
7/27/2007	Reach 2	3	Trout	40	0.60	0.03	0.1	0.02	B	LG	70	
7/27/2007	Reach 2	3	Trout	35-45	0.40	0.40	0.1	same	LC	LG	60	
7/27/2007	Reach 2	3	Trout	35-45	0.55	0.58	0.1	0.4	SG	LG	60	
7/27/2007	Reach 2	3	Trout	35-45	0.45	0.12	0.1	same	LC	LG	60	
7/27/2007	Reach 2	3	Trout	50	0.95	0.29	0.15	0.08	LG	SC	60	
7/27/2007	Reach 2	4	Trout	40	0.70	0.21	0.05-0.1	0.08	SC	LG	60	sparse small wood
7/27/2007	Reach 2	4	Trout	40-50	0.40	0.14	0.15	same	LC	MG	70	
7/27/2007	Reach 2	4	Trout	35-40	0.25	0.12	0.05	same	MG	LG	70	
7/27/2007	Reach 2	5	Trout	30-40	1.30	0.06	0.2	0.06	B	SC	60	
7/27/2007	Reach 2	5	Trout	35-45	1.00	0.49	0.1-0.2	0.23	LC	SG	60	
7/27/2007	Reach 2	6	Trout	45	0.65	0.50	0.15	0.4	LC	LG	80	
7/27/2007	Reach 2	6	Trout	45	0.55	0.06	0.15	0.09	LC	LG	80	
7/27/2007	Reach 2	6	Trout	40-45	0.65	0.11	0.1	0.12	SC	MG	60	
7/27/2007	Reach 2	6	Trout	45	1.05	0.05	0.15	0.14	LC	LG	60	
7/27/2007	Reach 2	10	Trout	35-45	0.45	0.05	0.15	same	SC	LC	70	
7/27/2007	Reach 2	15	Trout	40	0.65	0.15	0.2	0.11	B	LG	60	

Sultan River HSC Curve Observation Data: Juvenile Observations

Date	Reach	# of Obs.	Species	Fish Length (mm)	Water Depth (ft)	Mean Column Velocity (ft/s)	Fish Position (ft)	Nose Velocity (ft/s)	Dom Sub.	Subdom. Sub.	% Dom	Cover
7/27/2007	Reach 2	15	Trout	35-45	0.50	0.58	0.15	same	SC	LC	70	
7/27/2007	Reach 2	30	Trout	35-45	0.55	0.30	0.1	same	LG	B	80	
7/27/2007	Reach 2	30	Trout	35-45	0.75	0.03	0.1	0.03	LG	B	80	

ATTACHMENT 3

HSC Field Notes

1628.05.1004

Sno Pud

Sultan River

"Rite in the Rain"®
ALL-WEATHER
LEVEL
No. 311

HSI Curve Data

Book 1

1628.05

1628.05

June 7, 2007

Sutton R. Spawner Survey

Crew: M. Wagner
T. Sullivan

Weather: overcast w/ light rain

water visib.lty: good - R2
mod. - poor R1A

Equipment: Swoffer # 3602
prop. 5A
cal: 0175

	In	Out
Time:	8:35	3:30

Flow: Reach 2 - 180 cfs
Reach 1A - 900 cfs

Reach 2 Lower 06/07/07

Spawner Survey

Redd #	width(ft)	Length	Depth	Vel.	Substr.
R2L #1	3.7	8.5	0.88	1.46	mg/LG/70
#2	3.0	6.0	1.19	1.44	"
#3	3.5	~~6.5~~ 7.0	1.~~7~~0	1.64	"
#4	2.5	5.5	0.95	0.78	"/60
#5	3.0	6.5	1.70	3.22/2.93	mg/LG/70
#6	3.0	7.5	1.40	2.69	"/60
#7	3.5	7.0	1.68	2.59	"

T2L6

Length - top of redd to bottom of spawn

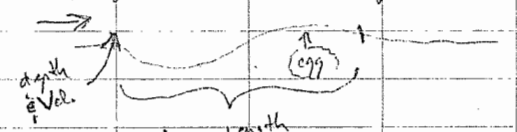


photo #1 placard
#2 marker by redds looking u/s
#3 " looking rt/Lt
#4 looking at d/s most redd
#5, 6 gravel comp.

Lower (206) 7, 8, 9 — next 4 redds

most N 47° 54. 278
ds W 121° 48.504

Reach 2 Lower Conti 06,07,07

Redd #	width	length	Depth	Vel	Sub.
# 8/TR-3	3.0	6.5	1.32	1.90	mG SG/LG/80
# 9	3.0	~~X~~6.0	2.~~40~~	1.70	"
# 10 not flagged	3.0	6.0	1.80	2.19	"
# 11 "	3.0	6.5	1.14	2.49	mG SG/LG/90
12	2.75	5.5	2.00	1.55	mG SG/LG/60
13	2.5	3.5	2.40	1.52	mG SG/LG/80
Top of island 14	3.0	3.0	2.21	1.54	"
15	2.5	3.0	2.10	1.49	"

yellow capped survey markers at top of island (n=2)

* Reach 2 upper *

# 16	2.75	6.5	0.95	0.79	SG/LG 90

Photo Log

#	Description
TR-3 # 10	– Looking across at R2 lower
# 11	– " d/s mRG w/ clip board
# 12	– " Lt/Rt mRG on TR-3
# 13	– looking across at redds 12, 13, 14
# 14	– " d/s at new jam u/s side of angle bar
# 15	– " u/s from new jam
* 16	– Look across at Redd TR-6 R2 upper
17	– " u/s from just below Div. Dam

June 7, 05

Reach 1A Spawner Survey

Redd #	width	length	Depth	vel	substr.
#1	2.5	7.0	1.80	2.76	mg/Lg 60
#2	2.5	6.0	1.85	2.78	Lg/mg 60
#3	2.6	6.0	1.70	2.66	mg/Lg 70
#4	2.4	6.5	1.45	1.97/2.95	" 60
#5	2.6	6.5	1.40	3.13	" 60
#6	2.5	5.5	1.75	3.30/3.57	"
#7			1.35		

* flow at time of survey was ~ 900 cfs, flow at time of redd construction was ~ 450-600 cfs

* Data will not be used as part of HSI curve development/validation.

Photo Log

#18 looking u/s from bottom, first Redds in R1A

#19 " across MR6 w/ stick & clipboard

unable to find flagged rock measurement made ~ 8' u/s #2

#20 " across @ #4 ± 5

#21 " d/s @ "

#22 " u/s / down @ #5

not flagged likely spot / ~ 10' rt of #4

June 13, 2007

Sultan R. Spawner Survey

Reach 1A ~~DS to US~~

Crew: A. Weybright
T. Sullivan

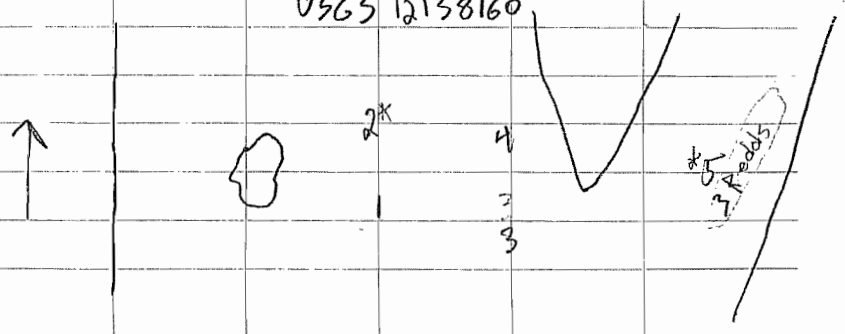
Weather: Overcast
lt. breeze
lt. rain

Water visibility: good - better than on June 7th by ~1 foot or more

Equipment: Swoffer # 3602
prop 5A
Cal 0175

Lv R2 : 7:30
Time in: 8:30
Time out: 11:45
Arr. R2 : 12:45

Flow: 561 cfs @ 10:00 per USGS 12138160



NEAR TR-2

Redd #	width	length	Depth	Vel	Substr
1	5'	10'	1.4	2.84	54.6
				2.61	
2*	6'	8'	1.5	2.71	54.6
				2.82	
Adjacent (D/S) redd #1 on left bank looking downstream - * unmarked by KB					
3	10'	14'	1.1	2.33	54.6
				2.34	
US of #4					
4	8'	12'	1.1	1.99	54.6
				1.90	
5*	6'	8'	1.5	~~3.38~~	56.7
				3.79	
3 redds → look relatively old only measured one					

06/15/07

Photo log: Redds 1-5

1 - looking across from left bank
2 - "
3 - "
4 - looking downstream
5 - looking upstream

P3154 - P3158

Redds 6-7

7 - looking across from left bank
8 - " close up? to redd 6
9 - looking US
10 - looking DS

P3159 - P3162

NEAR TR-6

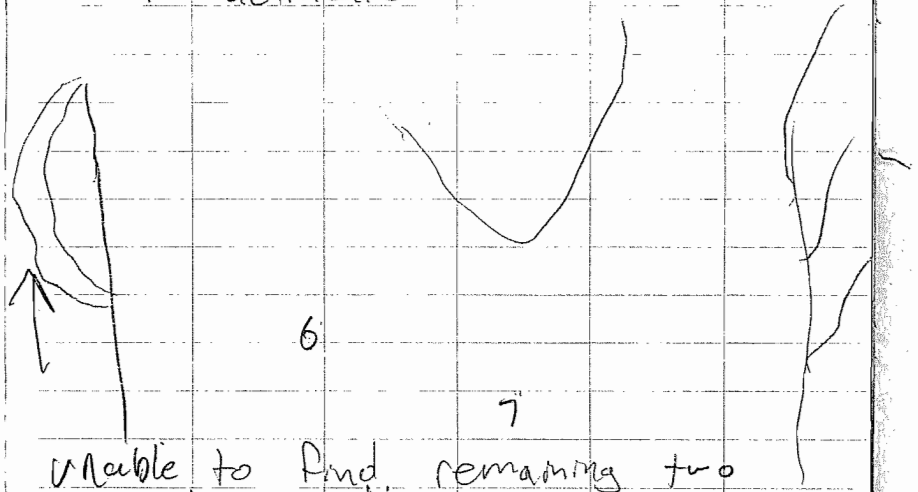
Redd #	width	length	Depth	Vel	Subst
6	3'	6'	1.6	1.53	56.5
				1.54	

"unconventional" redd site

Substrate looks big - cobble, gravel, boulder

7*	3'	6'	2.0	1.36	56.5
				1.38	

unmarked and old redd - difficult to delineate



unable to find remaining two marked redds.

US of oval track ~ TR-12

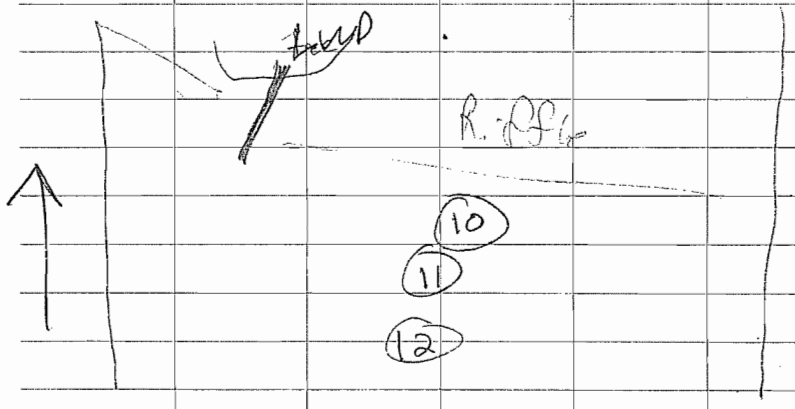
Redd #	width	length	depth	velocity	Substr.
8*	3'	8'	1.5	1.63 1.59	65.5
Unmarked Redd, relatively old but could have been one marked					
9*	4'	10'	1.0	1.19 1.21	56.5
unmarked Redd, relatively old but could have been one marked					

Unable to find marked redds

Photos: looking across towards
11 LB with Aw (Ag) Redd
12 looking US of Redd
13 looking DS of Redd
P3163 - P3165
~~DS of 2 Oval tracks~~

DS of oval track ~ TR-9

Redd #	width	length	Depth	Velocity	Substr.
10*	8'	12'	1.7	2.41 2.38	56.6
unmarked but immediately (5') downstream of redd #11 - looks same age - assumed to be other redd.					
11	6'	8'	1.6	2.16 2.08	56.6
difficult to delineate, ~~somewhat~~					
12	4'	7'	1.5	2.17 2.11	64.5



Photos - 14 looking across at #10*
- 15 looking ds at #11

P3166 - P3167

07/27/07 Sultan River HSI Development Snorkel Surveys

Crew: AWeybright (snorkel)
TSullivan (notes + snorkel)

Temp. 13°C
Visibility 9' (from Secchi reading)

Equipment: Swoffer # 4099
Prop 4B (3')
Cal. bration 125
Flow @ USGS Gage: 500 cfs @ 7:30 AM
Steady for previous few days
weather: mostly sunny

Start. U/s Powerhouse @ new SnoPUD gage/transducer site
Work u/s (Reach 2) Approx 100' d/s TR4

#	Species	Length	Position (from Sub)	Depth/ Vel.	Depth/ Mean V	Dom Subs	Sub Dom Subs.	% Dom	Cover	Notes
2	Trout	45 mm	0.2	0.10.02	0.80/0.02	lg cobble	lg Gravel	70	—	Feeding/Holding
2	"	"	"	0.19	0.85/0.23	"	"	"	—	"
TR4 2	Coho	60-70	0.3	0.03	1.95/0.04	Boulder	lg cobble	80	Boulder	15' DS of TR6
1	Trout	50...	0.05	0.00	2.15/0.00	Boulder	lg Cobble	80	Boulder	holding/15' vs TR6
—	Pool Tail out									
1	Coho	70	0.15	0.09	1.40/0.22	Sm Cobble	lg Gravel	60	-	holding/eddy@Pool head
2	Trout	50	0.2	0.12	1.40/0.19	"	"	"	—	holding/eddy@Pool head
—	Head of pool									
4	trout	40	0.05-0.1	0.08	0.7/0.21	Sm Cobble	lg gravel	60	sparse Sm wood	holding
3	trout	40	0.1	0.02	0.6/0.03	boulder	lg gravel	70	-	holding
1	coho	65	0.2	0.11	0.65/0.15	boulder	lg gravel	60	—	holding/feeding
15	trout	40	0.2	"	"	"	"		-	"
6	trout	45	0.15	0.40	0.65/0.50	lg Cobble	lg gravel	80	—	holding/feeding
6	trout	"	0.15	0.09	0.55/0.06	"	"	"	-	"

7/27	Reach 2 (cont'd)				Depth /	Dom	Sub Dom	%	cover	Notes	
#	Species	length	Position	Nose V	mean V	Substr	Substr	Dom			
~~30~~ 60	Trout	35-45	0.1	same →	0.55/0.30	lg Gravel	Boulder	80	-	h/f	
~~30~~	"	"	"	0.03	0.75/0.03	"	"	"		"	Riffle
1	trout	40	0.1	same →	0.40/0.52	lg gravel	Boulder	90	—	"	margin
1	trout	40	0.2	0.21	0.55/0.23	lg gravel	lg cobble	70	—	"	
1	trout	50	0.2	0.49	1.60/0.27	Boulder	sm gravel	70	—	"	
4	trout	40-45	0.15	same →	0.40/0.14	lg cobble	M. gravel	70	—	holding	ds of lg-boulder
end	~~in~~	Riffle ~250' us of TR1									

Start ~50' ds of TR2 in Boulder Riffle											
2	trout	40	0.1	0.41	085/0.69	lg gravel	boulder	70	—	hold.	50' DS TR2
1	trout	45	0.2	0.17	0.70/0.45	boulder	m gravel	80	Boulder	hold	25' DS TR2
1	trout	45	0.1	0.01	1.25/0.12	boulder	M. grav.	80	-	"	"
	Photo #1										
20-25	Coho	60-70	0.2	0.30	1.35/0.40	Boulder	sm grav.	60	—	h/f	25' DS TR2
	"	"	0.3	0.14	1.55/0.41	"	"	"	"	"	"
	"	"	0.4	0.40	1.35/0.76	"	"	"	"	"	"
5	trout	30-40	0.2	0.06	1.30/0.06	boulder	sm. Cob.	60	—	hold	"
10	trout	35-45	0.15	same →	0.45/0.05	sm Cobble	lg Cob	70	—	h	ON TR2
15	trout	35-45	0.15	same →	0.50/0.58	sm cobble	lg Cob	70	-	h	"
2	trout	35-45	0.2	0.54	0.55/0.75	sm Cob	lg Cob	70	—	h	"
3	trout	35-45	0.1	same →	0.4/0.40	lg Cob	lg grav	60		h/f	15' US TR2
3	Coho	60-65	0.1	same →	0.4/0.49	lg Cob	M grav.	60		h/f	"

#	Species	length	Position	Nose V	Depth / mean V
3	trout	35-45	0.1	0.40	0.55/0.58
1	coho	60	0.1	0.39	0.60/0.50
1	trout	50	0.1	0.61	1.05/1.09
1	trout	50	0.15	1.18	1.15/1.72
1	trout	50	0.15	0.80	1.50/2.03
5	trout	35-45	0.1-0.2	0.23	1.00/0.49
1	trout	45	0.2	0.39	0.75/0.20
1	trout	40	0.1	same→	0.45/0.01
1	trout	35	0.05	same→	0.35/0.08
3	trout	35-45	0.1	same→	0.45/0.12
4	trout	35-40	0.05	same→	0.25/0.12
~~1~~	~~trout~~	45	~~0.1~~		
1	trout	45	0.1	0.15	1.45/2.01
2	trout	45-50	0.3	0.02	2.30/0.11
1	trout	40	0.2	0.27	1.30/0.41
1	trout	40	0.5	same→	0.95/0.11
6	trout	40-45	0.1	0.12	0.65/0.11
	← Photo # 3				
3	Coho	60-80	0.15	0.14	1.05/0.05
6	trout	45			
3	Coho	60-80	0.15	0.43	1.10/0.60
2	trout	40			
3	trout	50	0.15	0.08	0.95/0.29
	Photo	# 4			

Dom Substr	Sub Dom Substr	% Dom	~~Cover~~ Cover	~~Notes~~ Notes	R.Riffle ↓
Sm. Gr.	Lg. Gr.	60	–	h/f	25' US TR2
lg Gr	Sm. Cob.	60	–	h/f	"
lg Gr	lg Cob	60	–	"	"
lg cob	lg grav	60	–	"	"
lg grav	lg Cob	60	–	"	"
lg. Cob	Sm gr	60	–	"	25' DS TR3
boulder	Md gr	70	–	"	"
lg coble	lg gr	60	–	holding	10' DS TR3
lg Cobble	lg gr	60	–	holding	"
"	"	"	–	feeding	"
M grav	lg grav	70	–	~~f~~ h	10' US TR3
← Photo #2			POOL TAILOUT		
M grav.	lg grav	60	–	~~h/f~~ h	DS LWD TR3
Boulder	lg cobble	70	–	h	TR3
Sand	Sm Grav	70	–	h	10' US TR3
"	"	~~70~~ "	–	h	"
Sm Cob	M grav	60	–	h	25' DS TR3
lg Cob	lg grav	60	–	h	TR 5
lg grav	boulder	70	–	h	"
lg grav	Sm cobl	60	–	h	"

#	Species	length	Position	Nose v	Depth/ Mean v	Dom Substr	Sub Dom Substr	% Dom	~~Cover~~ Cover	Notes	
3	coho	70	0.1	0.02est.	0.8/0.02est.	Boulder	M Grav	80	-	h	60' DS TR 6
1	coho	65	0.2	0.02est	1.25/0.02est.	Boulder	M. Grav	80	-	h	20' DS TR 6
	↑ Photo #5										
1	trout	45	0.5	0.02est	1.40/0.02est	Boulder	lg Cob	70	-	h	"
1	trout	35	0.2	0.02est	0.7/0.02est	Boulder	lg Cob	70	-	h	"
1	trout	40	0.15	0.03	1.5/0.21	lg Cobble	Boulder	60	-	h	"

Reach 1A Start at Kiene's ~~Extend~~ Boulder/cobble Riffle looking US

		Started working upstream			Directly across from SC2 outlet on R Bank						
20	coho	60-80	0.1-0.15	0.36	0.6/0.83	Sm Cobble	lg Cob	70	-	h	R bank R. Riffle
40	trout	35-50	"	0.06	0.6/0.12	"	"	"			
	both species distributed over 2 locations above										
2	trout	35-40	0.3	Same →	0.45/0.20	"	"	"	-	h	
1	coho	70	0.1	0.02 est	1.7/0.02est	Boulder	lg Cobb	60	LWD	h	
1	trout	40	0.3	0.12	1.4/0.10	Boulder	lg cob	60	Bank (undercut)	h	
	Photo #6										
6	trout	35-45	0.2	Same →	0.65/028	Sm Cob	Lg Cob	60	-	h	
1	trout	~~35~~ 40	0.2	Same →	0.7/0.83	"	"	70	-	h	
5	trout	35-45	0.2	Same →	0.8/0.34	"	"	"	-	h	
1	trout	40	0.25	Same →	0.5/0.10	"	"	"	-	h	
1	trout	40	0.3	Sam →	0.6/0.50	"	"	"	-	h	
6	trout	35-45	0.5	Same	0.95/0.58	Sm cob	L G	60	Veg	h	
2	trout	"	"	Same	0.85/0.42	"	"	"	"	h	
1	coho	70	0.3	Same	0.75/0.24	"	"	"	"	h	
1	coho	70	0.2	0.26	0.90/0.30	"	"	"	"	h	

4/27/07 HSI Snorkel

#	Sp.	Length	Position	Nose	Depth / Mean	Dom subst	Subdom subst	% Dom	Cover	Notes
1	trout	35	0.2	same	0.5/0.35	Sm Cob	LG	60	—	—
1	coho	70	0.6	same	1.25/0.02	LG	LC	60	Veg (overhang)	h
6	coho	70-90	0.25	0.18	1.25/0.19	"	"	"	wood	h
1	trout	40	0.9	0.13	1.25/0.02	"	"	"	Veg (overhang)	h
1	coho	75	0.2	0.02 est	0.8/0.02 est	LG	S.lt	80	cut bank	h
→ Head of Riffle ~ 50'						DS of	SC-1	inlet		
60	coho	65-100	0.8	same	1.8/0.1	Sm Cob	LG	80	overhang	h
	coho	"	0.8-1.1	0.02 est	2.2/0.02 est	"	"	"	Veg w/ roots	h
	coho	"	0.6-1.1	same	1.9/.906	"	"	"	cut bank	h
1	CHN	70								
25	Coho	65-80	0.6-1.1	0.02 est	1.55/0.07	"	"	"		h
	Coho	"	0.3	same	1.1/0.09	"	"	"	"	h
	Photo #7 (previous 6 lines)									
~ 10' US of SC-1 inlet										
1	trout	35	0.4	same	0.95/0.51	Sm Cob	lg Gr	70	—	
3	trout	35-45	~~0.3~~ 0.3	same	0.7/0.47	"	"	"	—	
1	trout	45	~~0.2~~ 0.2	same	0.55/.06	"	"	"	—	
1	trout	40	0.8	same	1.8/0.81	"	"	"	Veg	
1	trout	40	1.7	0.02 est	1.95/0.02 est	"	"	"	Veg + wood	
40	Coho	65-85	0.5-1	same	1.95/0.20	lg Cob	lg Gr	60	Veg + wood + roots	h
	Coho	"	0.4-0.8	same	1.5/0.06	"	"	60	Veg + wood	h
4	Coho	65-85	0.3-0.4	same	1.3/0.63	"	"	"	Veg overhang	h
20	coho	65-85	0.6-0.8	0.02 est	1.7/0.02 est	Sm Cob	lg Gr	60	roots + cut bank	
	coho	"	0.6-1.0	0.02 est	1.9/0.02 est	"	"	"	"	
Above 101			10-100' US of SC-1 inlet - Photo #8 - from Rope Swing							

#	Sp	length	Position	Nose V	Depth/ mean V	Dom Sub	Sub Dom	% Dom	Cover	Notes
1	coho	70	0.3	0.02est	1.45/0.08	lg Cob	Sand	60	veg + wood	h
2	trout	40	0.45	same	0.55/0.02est	sm Cob	sm gr	60	veg + wood	
2	trout	40	1.00	0.02est	1.20/0.02est	lg. Cob	sm Cob	60	wood	~every 30' btw transect TR-2 + TR-3
4	trout	40	0.2	same	0.4/0.24	lg. grav	lg Cob	60	—	
	Photo # 9									
10	trout	40	0.3	same	0.6/0.10	sm cob	lg grav	60	veg	
	trout	40	0.3	same	0.5/0.27	sm cob	lg grav	60	veg	
2	trout	40	0.3	same	0.6/0.13	"	"	"	—	
1	trout	40	0.3	0.02est	0.8/0.02est	"	"	"	—	
4	Trout	40	0.3	0.02est	0.7/0.02est	lg cob	sm cob	70	—	@ TR 3
2	trout	35-40	0.05	0.02est	0.25/0.02est	~~lg cob~~	"	"	—	
2	trout	35-40	0.05	0.02est	0.30/0.02est	"	"	"	—	
1	trout	40	0.05	0.02est	1.0/0.05	"	"	"	—	5' US TR3
3	trout	35-40	0.05	0.02est	0.2/0.02est	"	"	"	—	10' US TR3
1	trout	35-40	0.4	same	0.9/0.43	sm cob	lg Cob	60	veg	
1	trout	35-40	0.3	same	0.7/0.21	"	"	"	veg	
2	trout	35-40	0.2	same	0.55/0.13	"	"	"	veg	
2	trout	35-40	0.25	same	0.5/0.23					
3	trout	35-40	0.15	same	0.3/0.03					

End ~~at~~ at downstream end of Roses Island ~ 100' US of TR3

Temp: 14°C

Visibility: 11'

"Veg" indicates overhanging Riparian Veg

Velocity estimated @ 0.02 fps when too slow to move prop

"h" - indicates fish observed holding

- Assume "h" unless otherwise noted

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CONTENTS

PAGE	REFERENCE	DATE

8/8/07
Weather: light Rain ~60° @ 6:30am
crew: A. weybright - snorkel
T. Sullivan - Notes/Velocity

In: 8:00
out: 18:30

water Temp: 12°C
Secchi 9'

Started on secondary Channel @ Rose I.
working upstream

Swoffer: 4099
Prop = .48
Cal = .125

② Obs#	#fish	Species	Position/Depth/ Nose V	Mean V	Length	Dom/Sub	%	Dist. Cov/ type	Map Section	Notes ③
1	1	TRT	.4/same	0.5/.3	45	SC/LC	60	0/Grass	A	Margin (R)
2	1	TRT	.3/same	1.0/.25	40	"	"	-	A	"
3	3	TRT	.3/same	0.7/.19	40-55	"	"	-	A	"
4	1	TRT	.2/same	0.95/.33	45	SC/LG	60	-	A	
5	1	TRT	.4/same	0.5/.06	45	SC/LG	60	-	A	"
6	3	TRT	.2/same	0.3/.08	45-50	SC/LG	60	0/SWD	A	"
7	3	TRT	.2/S	0.5/.03	40-50	SC/LG	60	0/SWD	A	"
8	1	TRT	.2/S	0.4/~0 2	50	LG/SC	60	3/SWD	A	"
9	1	TRT	.2/S	0.55/.22	45	"	"	2/SWD	A	"
10	1	TRT	.2/S	0.4/.08	55	"	"	-	A	
11	3	TRT	.2/S	0.5/.25	45-55	SC/LG	60	-	A	"
12	3	TRT	.2/S	0.5/.30	45-55	"	"	-	A	"
13	1	TRT	.5/.82	0.75/.72	45	LG/SND	60	3/Bank	A	"
14	2	TRT	.2/S	0.3/.27	45-50	LG/SND	60	1/Bank	A	"
15	1	TRT	.2/S	0.6/.30	55	LG/SC	60	-	B	Margin (R) - on TR4
16	1	TRT	.2/S	0.5/.35	45	"	60	-	B	
17	1	TRT	.2/S	0.45/.20	50	"	"	-	B	
18	1	CHO	.15/S	0.55/.26	70	SC/SG	60	2/Bank	B	"
19	1	CHO	.2/S	0.55/.38	70	LG/MG	60	2/Bank	B	"
20	4	TRT	.2/S	0.5/.40	40	"	"	3/Bank	B	"
21	1	TRT	.2/S	0.5/~.02	40	"	"	-	B	"
22	3	TRT	.2/S	0.5/.07	40-45	LG/SC	60	2/OH Branch	B	"
23	2	TRT	.2/S	0.45/.27	45	"	"	"	B	"

Photos:

1 - Section A looking US
2 - Section B looking US
3 - Section C looking US
4 - Section D looking US
5 - Section E looking US
6 - Section F looking US
7 - " G "
8 - Obs # 88-90
9 - Section H looking US
10 - Section I looking US
11 - Section J looking US
12 - Obs # 101-104

Map Sections

A - Secondary channel on R side of Rose's Island - RUN
Depth: 1.1 } Upper Thalweg
Mean V: 2.55 }

Depth: 1.1 } Lower Thalweg
Mean V: 1.93 }
No fish on L bank or Middle

B - Secondary channel - Rose's Island
starts @ end of Riffle and includes TR4.
Directly US of Section A
Habitat: Riffle/Run

C - Secondary channel - Rose's Island
Starts just US of overhanging Cedar (R bank) - Directly US of Section B. Starts ~ halfway between TR4 + TR5
Habitat: Pool/Glide
Ends at base of Riffle below TR5
Thalweg @ Mid Reach
Depth: 2.4
Mean V: 1.38
Lower thalweg { Depth: 1.1
meanV: 0.79

Obs #	#fish	Species	Position/ Nose V	D/ Mean V	Length	Dom/ Sub	%	Dist./ Cov. Type	Map Section	Notes
24	1	TRT	.2/S	0.5/.15	45	SC/LC	60	-	B	Mid - on TR4
25	3	TRT	.3/S	0.85/.28	40-50	LC/SC	60	-	B	"
26	3	CHO	.1/S	0.7/.34	65-80	LG/MG	60	0/sm D	B	Margin(L) - on TR4
27	3	CHO	.2/S	0.65/.40	"	"	60	1/sm D	B	"
28	2	CHO	.2/S	0.65/.32	"	"	60	1/sm D	B	"
29	1	TRT	.2/S	.75/.22	50	SC/LG	60	-	B	Mid ~ 60' US TR4
30	2	CHO	.3/.57	1.3/.66	65-80	LG/SC	60	0/Roots	C	Margin(R) ~200' DS TR5
31	1	CHO	.3/.64	1.35/.40	100	"	"	0/Roots	C	"
32	6	TRT	.2/S	.4/~.02	35-45	SC/LG	60	1/OH veg	C	Margin(L) ~150' DS TR5
33	3	CHO	.25/S	.75/.23	65-80	LG/LC	60	3/Bank	C	"
34	3	CHO	.25/S	.45/.15	65-80	LG/SC	60	2/Bank	C	"
35	1	TRT	.2/S	.5/.85	45	SC/LG	60	-	D	Mid on TR5
36	1	TRT	.2/S	.6/.32	45	SC/LG	60	-	D	"
37	1	TRT	.2/S	.9/.74	45	SC/LG	60	-	D	In 3° channel
38	1	TRT	.3/S	.75/.11	45	SC/LG	"	0/OH veg	D	on TR5 -
39	1	TRT	.2/S	1.2/.03	50	"	"	-	D	middle of 3°
40	1	TRT	.2/S	.3/.15	45	"	"	-	D	channel
41	1	TRT	.25/S	.45/.26	50	LG/SC	"	0/OH veg	E	Margin(L) ~ 25'
42	1	TRT	.15/S	.3/.13	45	"	"	0/OH veg	E	US of Confl area
43	1	TRT	.15/S	.4/.19	50	"	"	2/Bank	E	
44	1	TRT	.15/S	.5/.89	50	LG/LC	60	-	E	Mid in L channel
45	1	CHO	.5/S	2.1/0.25	65	SC/LC	"	1"/LWD		pool of L split
46	1	CHO	1.9/S	2.8/0.48	65	SC/LC	"	2"/LWD		" " TR
47	1	CHO	.4/S	2.6/0.51	65	"	"	2"/LWD		" "
48	1	CHO	1.8/S	2.6/0.83	70	"	"	3"/LWD		" "

(8)

obs #	# fish	species	Position / Nose V	Depth / Mean V	length	Dom/Sub	%	Dist/ cover Type	Map section	Notes
49	1	CHO	.2/S	0.35/0.23	65	LG/MG	60	O/OHveg SWD	E	RB of L split
50	1	TRT	.2/S	0.35/0.23	40	"	"	"	"	" " "
51	1	TRT	.2/S	0.5/0.54	45	"	"	"	"	" "
52	1	CHO	.6/.39	3.0/.47	70	SC/LC	60	2/LWD	E	pool of L split
53	1	CHO	1.2/.39	3.0/.47/.39	70	"	"	"	"	" "
54	1	CHO	1.3/.24	2.9/.60/.24	75 ~~70~~	"	"	2/LWD	E	" "
55	1	CHO	2.0/.14	3.3/.50/.14	75	B/LC	"	O/LWD	E	" "
56	1	CHO	1.8/.26	2.8/1.41/.26	85	B/LC	"	1/LWD	E	" "
57	1	Trout	0.3/0.08	2.5/0.66	350	B/SC	"	0.5/LWD	E	" "
58	1	coho	1.6/..03	2.8/0.53/0.03	85	B/SC	"	1/LWD	E	" "
59	2	trout	0.15/—	1.3/0.36	45	SC/MLG	60	—	E	RB of L split
60	1	TRT	0.2/S	.45/.86	50	LG/SC.	60	—	E	Riffle in R split
61	1	TRT	0.3/S	.45/.17	35	SC/LG	160	O/SWD	E	Run in R split
62	1	Trout	0.3/0.67	2.5/0.59	120	SC/LC	60	O/h veg	E	Run in split TRT
63	1	coho	0.5/0.85	2.5/1.71	80	" / "	"	"	E	" " d/s TRT
64	1	Coho	0.4/0.46	2.4/1.52	100	" / "	"	"	E	" " d/s TRT
65	5	Coho	0.4/—	1.7/0.23	65-85	" / "	"	Bank	"	" " d/s TRT
66	8	coho	0.4/—	1.9/0.14	65-85	" / "	"	O/ bank	E	" " d/s TRT
67	10	CHO	0.2/S	1.5/~.02	65-85	B/LC	"	O/LWD	E	" "
68	10	CHO	0.4/S	1.7/.09	65-85	"		O/LWD	E	" "
69	1	trout	0.2/0.82	1.5/1.24	150	SC/LG	80	O/SWD	E	Head of L split
70	1	trout	0.2/0.73	1.45/1.49	150	SC/LG	80	" / "	E	Head of L split
71	1	trout	0.3/.26	1.4/1.18	135	SC/LG	60	2/LWD	E	" "
72	3	Coho	0.2/0.24	1.5/0.69	~~70~~ 65-80	" / "	"	—	E	" "
73	1	Coho	0.2/0.27	1.4/0.58	70	" / "	"	2/LWD	E	" "
74	1	Coho	0.2/0.26	1.45/0.60	75	" / "	"	2/LWD	E	" "

(9)

Map sections (cont'd)

D - secondary channel on R side of Roses Island - ends at TR5
Hab: Riffle/cascade

E - SC 3 starts at confluence w/ mainstem
Habitat: Riffle w/ sm Pool
Follows L channel + R channel
~~ENDS~~ Above Island - Riffle w/ Runs
Ends ~60' US of TR1

F - Glide transitions into lg Pool
Starts ~60' US of TR1
Ends below Riffle DS of TR2
Pool > 10' with minimal velocity

G - Begins at Riffle at head of Section F
Transitions to Run @ TR2
Ends ~50 ft US of TR3
@ head of Riffle
No Fish Observed

H - Begins @ Glide ~50' US TR3
Ends @ Head of glide ~ 300' DS of TR6
Section comprised of 1 habitat unit (Glide)

I - Riffle/Run sequence

J - Riffle sequence in side channel (R) up to split from confluence w/ mainstem
Lower Thalweg (R Channel Spl.t)
Depth: 0.6
Vel: 1.47

K - Lower Thalweg US of split near DS end of SC
Depth: 1.0
Vel: .66

Mid Thalweg (middle of Pool
Depth: 3.7
Vel: 0.61 (bottom)
0.79 (Top)

(12)

Obs #	# Fish	Species	Position N/S	Depth Max	Length	Dom/Sub	%	Dist/Cov. type	Map section	Notes
75	1	Coho	[illegible]	[illegible]	75	SC/LC	60	1/LWD	E	Head of Split
76	1	trout	0.3/0.[illegible]	1.1/1.1	130	" / "	"	2/LWD	E	Thalweg D/S: 1.1/4.5
77	1	TRT	.4/S	1.25/.08	55	B/SC	60	—	E	on TR1
78	1	TRT	.3/S	.7/.15	55	B/SC	60	2/Bank	E	on TR1
79	1	TRT	.2/.7	1.5/1.96	150	B/LC	60	-	E	~60' US TR1
80	2	CHO	.3/S	0.8/.06	80	LC/SC	70	3/Bank	F	Margin (L) - Glide
81	1	TRT	.2/~.02	1.75/.18	60	B/LC	90	2/Bank	F	Margin (L) - Glide
82	~~8~~	coho	1.2/0.15	3.1 0.37/0.15	55-65	LC/SC	70	0/ OH veg		LB / thalweg - Glide
83	~~8~~	coho	1.0/0.27	3.6 0.49/0.27	65-85	" / "	"	0/ OH veg		LB/thalweg - Glide
84	~~8~~	Coho	0.8/~~0.[illegible]~~	3.0 0.7/0.20	65-85	" / "	"	0 / "		" "
85	~~8~~ 8	coho	1.2/~~[illegible]~~	3.6 0.42/.21	70-85	" / "	"	0/ "		" "
86	6	coho	0.8/-	3.4 0.33/0.05 ~~80-85~~	80-85	"/"	"	0/ "		" "
87	4	coho	1.4/-	3.95 0.58/0.17 ~~80-85~~		" / "	"	0/ "	F	" "
88	13	CHO	.2/S	.95/~.02	65-100	LC/B	60	0/OH veg	H	Margin (R) ~ 10' DS TR4
89	13	CHO	.3/S	1.15/~.02	"	"	"	"	"	" ↕ glide
90	13	CHO	.4/S	1.35/~.02	"	"	"	"	"	" ↙
91	2	TRT	.1/S	0.5/.29	40	LC/SC	60	—	I	Margin (R) Run
92	2	TRT	.1/S	.6/.40	40-50	SC/LG	60	3/Bank	I	Margin (L) Riffle
93	1	TRT	.3/S	1.4/.08	50	LC/SC	60	0/OH veg SWD	I	"
94	1	COHO	.5/S	"	75	"	"	[illegible] "	I	"
95	1	TRT	.4/S	0.8/.05	150	"	"	"	I	"
96	1	CHN	.4/S	1.4/.12	70	"	"	"	I	"
97	1	CHO	.3/-	1.1/0.39	70	"	"	"	I	"
98	1	CHO	.4/-	1.6/0.30	70	"	"	"	I	"
99	2	TRT	.3/S	1.2/.42	35-40	LC/LG	70	—	I	Mid ~ 20' DS TR6
100	5	TRT	.2/S	0.7/.02	35-45	SC/LC	60	—		L Margin H of SC

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(14)

Obs #	# Fish	Species	Position/ Nose v	Depth/ Mean v	Length	Dom/ Sub	%	Dist/ Cov. type	Map section	Notes (15)
101	1	TRT	.1/S	.5/.24	50	LC/SC	60	0/OH LWD	J	R. Riffle near DSend
102	1	CHO	.1/S	.6/.05	70	"	"	0/OH "	J	"
103	1	TRT	.1/S	.6/.05	55	"	"	"	J	"
104	2	CHO	.1/S	.6/.04	75-85	"	"	"	J	"
105	1	TRT	.2/S	.6/.06	45	"	"	"	J	"
106	1	TRT	.2/S	.6/.33	40	LC/SC	60	—	J	R Channel @ split
107	1	TRT	.1/S	.5/.70	45	LC/SC	60	—	J	"
108	1	Trt	0.4/-	1.0/0.23	45	SC/LC	80	-	~~J~~K	d/s end of pool
109	1	trt	0.5/-	1.2/0.20	50	"/"	80	-	~~J~~K	" "
110	1	Trt	0.5/-	1.0/0.27	45	"/"	80	-	~~J~~K	" "
111	1	Trt	0.5/-	1.1/0.41	50	"/"	80	2/LWD	K	" "
112	4	Coho	0.3/-	1.0/0.17	70-80	"/"	80	0/LWD	K	" "
113	10	CHO	0.6/S	2.7/0.05	65-100	BR/SC	60	0.5/undercut bank	K	M. d/s of Pool us of split
114	10	CHO	0.8/.5	3.6/.3/.5	"	"	60	3/bank UC	K	"
115	10	CHO	0.8/.28	3.25/.14/.28	"	"	60	1/undercut bank + LWD	K	"
116	10	CHO	1.4/.52	3.6/.2/.52	"	"	60	2/LWD	K	"
117	10	CHO	1.8/.59	3.8/.28/.59	"	"	60	1/LWD	K	"
118	3	CHO	.6/.76	2.4/.82	65-85	"		-		
119	3	CHO	.6/-	2.1/.78	"	"		-		
120	6	Coho	1.2/-	3.2 0.91/0.81	"	"		2/OH veg		
121	4	Coho	0.8/-	2.8/0.41	"	"		4/OH veg		
122	4	Coho	1.0/-	2.9/1.14	"	"		0/OH veg		
123	~~3~~ 2	Coho	0.8/-	2.4/0.94	"	"		0/OH veg		
124	1	TRT	.1/.35	1.2/0.59	50	"	LO	—	K	Mid pool Thalweg next D/S = 2to1 pool

(16)

Obs #	# Fish	Species	Position/ Nose ✓	Depth/ Mean ✓	Length
125	2	TRT	.4/S	1.2/~.02	45-50
126	1	TRT	.4/S	1.3/.12	45-50
127	1	CHO	1.5/S	2.0/.05	70
128	3	TRT	.2/S	0.5/.13	40-45
129	2	TRT	.2/S	0.8/.38	40-45
130	1 DS	TRT	.6/S	1.0/.14	45
131	4 US	TRT	.4/S	0.7/.04	40-50
132	5	TRT	.2/S	0.4/.11	40-50
133	12	TRT	.2/S	0.6/.50	40-50
134	2	TRT	.3/S	0.6 .14	40-45

(17)

Dom/Sub	%	Dist/ Cover type	Map Section	Notes
LC/SC	60	—	L	Margin (L) in Run
"	"	—	L	"
BR/SC	60	PH Veg/ Bank	L	Margin (R) in Run
LC/SC	80	—	L	Head of R. ffle →
LC/SC	80	—	L	Near Head of SC
SC/LG	70	—	L	"
SC/LG	70	—	L	"
SC/B	60	—	L	L margin near
"	"	—	L	Head of island
LC/SC	60	—	L	Run

Map Sections cont'd

L - begins at u/s end of Pool and ends at top of Side Channel

Notes: Distance to cover in ft.
Estimated Fish Location Number
Depth in feet
Velocity in ft/sec
OH indicates overhead cover

APPENDIX C3

HSC Curves Used in Habitat-flow Modeling

From: Presler, Dawn [mailto:DJPresler@SNOPUD.com]
Sent: Friday, August 08, 2008 4:14 PM
To: Binkley, Keith; dreiser@r2usa.com; Keith Binkley
Subject: FW: Jackson Project (FERC No. 2157) - HSC Curves Memo forreview and comment

Here is an email from WDFW re: HSC proposal.

Dawn Presler
Relicensing Information Coordinator
Snohomish County PUD
425-783-1709 (phone)
425-267-6369 (fax)

-----Original Message-----
From: Rich Johnson [mailto:JOHNSRJ@DFW.WA.GOV]
Sent: Thursday, August 07, 2008 9:19 AM
To: Hal Beecher; Presler, Dawn; Binkley, Keith
Subject: Re: Jackson Project (FERC No. 2157) - HSC Curves Memo forreview and comment

Hi Dawn,
The Washington Department of Fish and Wildlife does have some concerns about how the HSCs have been calculated, but we have concluded that any re-calculated changes would be small. Therefore, we accept the proposed HSCs, except with the following request: for steelhead spawning depth, dropping to 0.2 at 3.4 feet and then continuing out.
Rich Johnson / Habitat Biologist
WDFW
>>> "Presler, Dawn" <DJPresler@SNOPUD.com> 08/04/2008 10:26 AM >>>
Dear ARWG Members:

The attached technical memorandum presents details of the analysis surrounding the development of site specific Habitat Suitability Curves and provides additional information to support the proposed application of revised curves for steelhead trout and Chinook salmon in the Sultan River. Please review. If you choose to comment, please do so **by Monday August 11**. This will provide us with sufficient time to complete the modeling and prepare the technical report in advance of our September 19 ARWG meeting. Comments, if any, can be emailed to me at DJPresler@snopud.com. If you have any further questions on the study, please contact Keith Binkley at KMBinkley@snopud.com . Thank you.
Sincerely,

Dawn Presler
Relicensing Specialist
Jackson Hydroelectric Project (P-2157)
Snohomish County PUD
Phone: 425-783-1709
Fax: 425-267-6369