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ECOLOGY

Open File Technical Report

East Fork Lewis River Fish Habitat Analysis Using the Instream Flow Incremental Methodology and Toe-Width Method for WRIA 27

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East Fork Lewis River Fish Habitat Analysis Using the Instream Flow Incremental Methodology and Toe-Width Method for WRIA 27

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SUMMARY

The Washington State Department of Ecology (Ecology) conducted an instream flow study on the East Fork Lewis River using the Instream Flow Incremental Methodology (IFIM). In addition, we collected Toe-Width information on 13 streams in WRIA 27. These studies provide information about the relationship between streamflows and fish habitat which can be used in developing minimum instream flow requirements for fish in the East Fork Lewis River and the 13 chosen streams in WRIA 27. For the IFIM study on the E.F. Lewis River one site, composed of eight transects, was chosen. The site was located at approximate River Mile 10.8 at Daybreak County Park. Streamflow measurements and substrate information were recorded at high, medium and low flows. This information was entered into the IFG4 hydraulic model to simulate the distribution of water depths and velocities with respect to substrate and cover under a variety of flows. Using the HABTAT model, the simulated information was then used to generate an index of change in available habitat relative to changes in flow; this index is referred to as "weighted usable area" (WUA).

Determination of a minimum instream flows for WRIA 27 will require setting priorities for river reaches, fish species and lifestages. Different fish species and lifestages exist simultaneously in the river and each has a different flow requirement. There is no single flow that will simultaneously provide optimum habitat for all fish species and lifestages.

In addition, minimum instream flows must include flows necessary for incubation of fish eggs, smolt out-migration, fish passage to spawning grounds, and prevention of stranding fry and juveniles. Other variables to be considered include water temperature, water quality, and sediment load. These variables were not addressed in this study.

No instream flow recommendations were made in this report. Those recommendations would be the next step after this study. Instream flow determinations would require an evaluation of the environmental variables listed above combined with the long-range fishery management objectives of the state and federal natural resource agencies and affected Tribes. Some results of the IFIM study are portrayed in the table below:

Flow and Habitat Relationships for the East Fork Lewis River

Species	Instream Flow Which Provides Maximum Spawning Habitat	Instream Flow Which Provides Maximum Juvenile Habitat
Chinook	500 cfs	240 cfs
Steelhead	460 cfs	420 cfs
Coho	320 cfs	N/A

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Introduction

The Washington State Department of Ecology (Ecology) is mandated by the 1971 Water Resources Act (Chapter 90.54 RCW) to maintain instream flows necessary to provide for preservation of wildlife, fish, scenic, aesthetic and other environmental values. As part of Ecology's commitment to the Lower Columbia Steelhead Conservation Initiative to provide more protection for salmonids after the listing of steelhead as a threatened species in the lower Columbia River in March 1998, Ecology agreed to conduct instream flow studies to provide information for determining instream flows. To determine appropriate minimum instream flows for fish habitat, one tool Ecology often uses is the Instream Flow Incremental Methodology (IFIM) to generate some of the necessary information. Another tool is the Toe-Width Method to generate streamflows needed by fish. The minimum flows determined by Ecology cannot take away any existing water rights and serve to protect existing water right users by restricting new upstream diversions if the river is already experiencing low flows. This information may be used by Ecology to determine the impact of future water appropriations on fish habitat or to condition new water rights to protect instream flows for fish habitat.

Study participants included staff from Ecology and Washington State Department of Fish and Wildlife (WDFW).

Project Background: Location and Description

The East Fork of the Lewis River is located in southwestern Washington in Clark and Skamania counties. It is the largest tributary of the Lewis River with a drainage basin area of 217 sq. miles. The river runs about 43 miles from its source to its convergence at approximately river mile 3.5 of the mainstem Lewis River. The eastern portion of the river drainage basin lies in the forested foothills of the Cascade Mountains within Gifford Pinchot National Forest. Major tributaries within the eastern portion of the East Fork of the basin include Rock and Yacolt creeks. The western portion of the drainage is comprised of rural residential and agricultural areas. Major tributaries in the western portion of the East Fork Lewis River drainage basin are Mason Creek, Jenny Creek, Breeze, and McCormick Creeks. Elevations in the basin range from 4,400 feet in the eastern portion to approximately 200 to 250 feet on the western plains (Pacific Groundwater Group, 1996).

The climate within the East Fork Lewis basin consists of warm dry summers and cool wet winters. The mean annual temperatures in the region are approximately 52 degrees (F). Average annual precipitation in the basin varies from about 45 inches in the west to 110 inches in eastern higher elevations (Pacific Groundwater Group, 1996). Private timber companies own and manage approximately 56 percent of the East Fork Lewis watershed, the Washington Department of Natural Resources manages 21 percent, and the Forest Service 23 percent (WDFW, 1998).

The quality of fish habitat in the East Fork Lewis River is largely a function of forest practices in the upper reaches of the watershed. Exposing large quantities of soil through the logging process (e.g. tractor skidding) and deficient road building results in ditch erosion and cut bank failures. The consequences of these activities include changes in water quality and quantity, changes in streamflow extremes, increases in sedimentation and destabilization of the streambed. Habitat in the lower reaches are impacted by farming and livestock grazing of riparian vegetation along with non-point source pollution from agricultural land uses and increased urban development. Contamination by septic systems, fertilizers, herbicides and pesticides are all areas of concern as is excessive water withdrawal (WDFW, 1998).

The daily exceedence flows for the East Fork Lewis River are portrayed in Figure 1. This graph is based upon daily averages from a 1929-93 period of record obtained from the USGS gage near Heisson at river mile 20.2 (1.5 miles northeast of Heisson). The exceedence graph is useful in assessing variances in streamflows at certain times of the year rather than relying on a single number such as mean monthly flow. The exceedence graph shows the range of flows one might expect on a given day or during a particular time period.

When a single number is used to describe the flow in a stream, such as average monthly flow, it gives a very distorted idea of the normal flow in the stream. A range, such as the 10% to 90% flow exceedence values, best describes streamflow. This flow range describes the flow one would expect to see 80% of the time in the stream. The 10% exceedence value can be viewed as the quantity of flow in the stream on a specific day that reaches that flow level or higher one out of every 10 years. The 50% exceedence flow value is the median flow: over all the years of record, half of the time on that day the flow was higher and half of the time the flow was lower. The 90% exceedence level means the flow is that level or higher in 9 out of 10 years on that day.

The 10% exceedence flow level is not an unusual flow in the stream. Streamflow in a certain year in not at the 10%, 50%, or 90% level on a consistent basis. Rather, flow normally jumps back and forth on a daily or weekly basis from the 10% to 90% exceedence level and sometimes from the 5% to 95% exceedence levels. Usually the reason for this flow behavior is either it's raining and streamflows are very high, or it has stopped raining for a week and streamflows are now very low.

Hydrographs for Speelyai Creek, Cedar Creek, and Canyon Creek in WRIA 27 for which USGS data was available are in Appendix A. All hydrographs do not include water diverted for irrigation or other purposes and used consumptively. This diverted water would need to be added to the hydrographs to determine the natural flow in the stream. Additional spot measurements of flow taken by Ecology are in Table 3.

Water Quality Standards

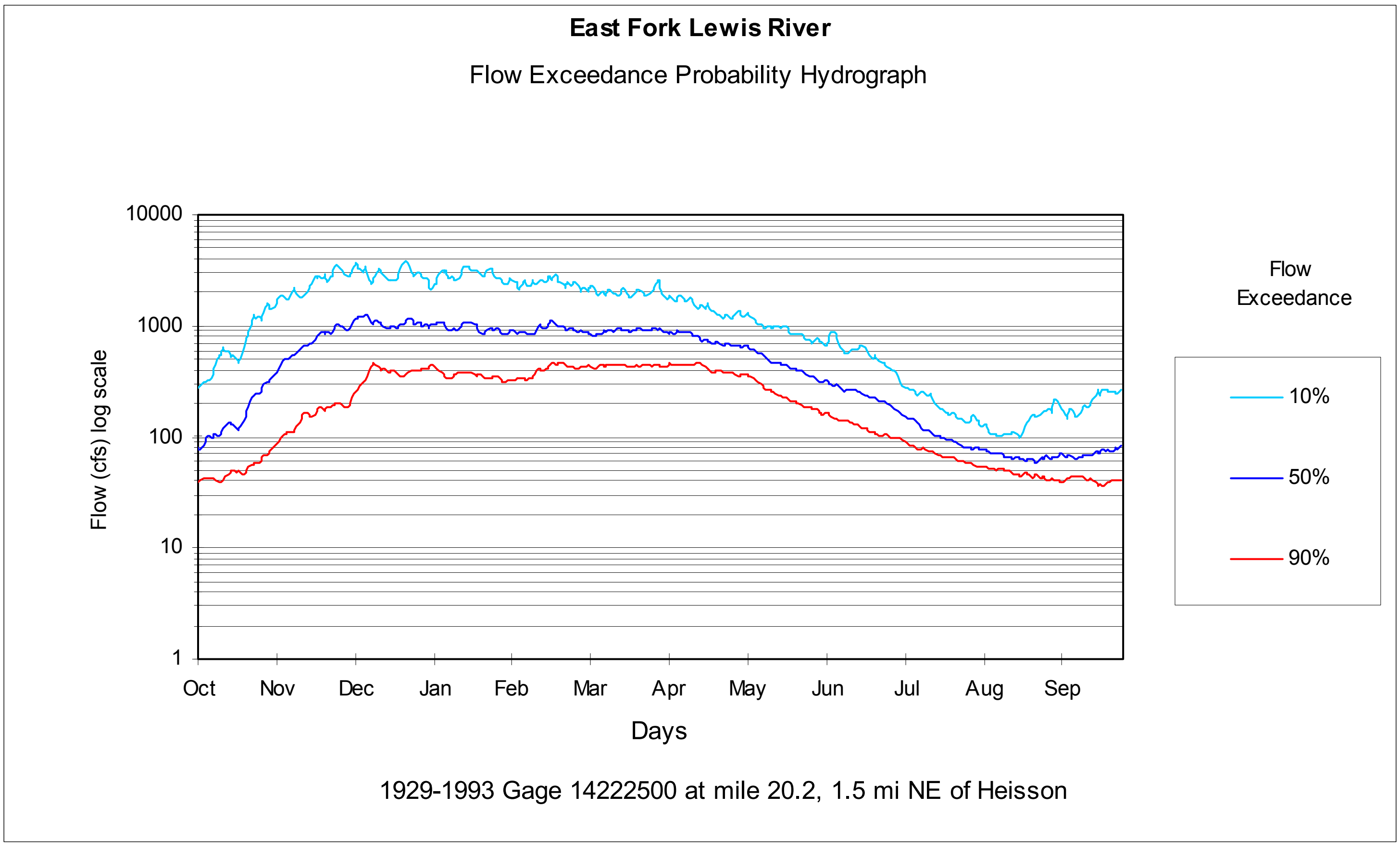
Monitoring of water quality on the East Fork Lewis River has indicated excursions (a situation where water quality conditions do not meet state water quality standards) for temperature, pH and fecal coliform. Monitoring of the river has been conducted by Ecology since 1977 at ambient monitoring station 27D090 located at River Mile 10.2. This station is approximately three miles northwest of Battleground and 0.6 miles upstream of Daybreak Park where the IFIM study was conducted. Because of these excursions, the East Fork Lewis River is listed on Ecology's 303(d) list of water bodies that fail to meet state water quality standards (Ecology, 1996).

Fish Use and Status

The Lewis River basin is in the area for three different fish species listed as threatened under the Endangered Species Act: steelhead were listed in March, 1998 for the Lower Columbia River ESU; chinook salmon were listed in March, 1999 for the Lower Columbia River ESU; and chum salmon were listed in March, 1999 for the Columbia River ESU. Maps of these ESU areas are in Appendix B.

As part of the 1992 Salmon and Steelhead Stock Inventory (SASSI), the Washington State Department of Fish and Wildlife identified winter steelhead and coho stocks as being "depressed" (WDFW, 1993). The rating

Figure 1. East Fork Lewis River Hydrograph.



"depressed" means a stock of fish whose production is below expected levels based on available habitat and natural variations in survival rates, but above the level where permanent damage to the stock is likely.

Chinook

Fall chinook salmon in the East Fork Lewis River spawn primarily in a 4.2 mile stretch from Lewisville Park downstream to Daybreak Park. There are two spawning segments in this stock. An early segment spawns in October and is believed to be similar to lower Columbia River hatchery stocks. A later segment spawns from November through January and is more similar to Lewis River Stocks. According to SASSI this stock is healthy although escapements since 1989 have been below average. Few if any spring chinook return to the East Fork Lewis River (WDF, 1993).

Steelhead

Summer steelhead in the East Fork Lewis River generally run from May through November and spawn from early March to early June. While information concerning spawning areas on the East Fork Lewis is scarce it is interesting to note that approximately 12 percent of spawning occurs in the headwaters and upper tributaries above Sunset Falls. Hatchery summer as well as winter steelhead has been planted since 1964. Due to a lack of survey information the status of the summer stock according to the SASSI report is unknown although available data suggests the stock is depressed. The escapement goal for summer steelhead in the East Fork is 512 (Governors Joint Natural Resources Cabinet, 1998).

Winter steelhead stock run timing is usually December through April with spawning occurring from March to early June. Winter steelhead stock status is listed as depressed in SASSI. The spawning escapement goal of 204 wild winter steelhead was not met in five of the seven years from 1986 through 1992. Escapements during this period ranged from 72 to 282 (WDFW, 1993). Some of the factors affecting steelhead production in the East Fork Lewis River include urbanization of the watershed, reduction of riparian vegetation, gravel mining in the lower reaches and other non-point pollution sources. Harvest and hatchery management issues are also believed to contribute to the generally depressed wild steelhead populations (WDFW, 1998).

Coho

Wild coho salmon may comprise only 5 to 10 percent of the total Lewis River basin produced coho stock. These natural stocks have been declining since the middle of this century due to habitat degradation from agriculture, logging, urbanization and high exploitation in the fisheries. Before the decline of the wild stocks in the East Fork Lewis River, coho migration was effectively blocked at Lucia Falls (RM 21.3) although under certain flow conditions they may have passed as far as Moulton Falls (RM 24.6) (WDFW, 1998). Coho usually begin running in the East Fork Lewis in late September through October with spawning occurring from October through early November. Coho return as two-year-old jacks and three-year-old adults. SASSI lists the stock status of coho in the East Fork Lewis as depressed (WDFW, 1993)

Study Methods

Instream Flow Incremental Methodology (IFIM)

IFIM was selected as the best available method for predicting how the quantity of available fish habitat changes in response to incremental changes in streamflow. The U.S. Fish and Wildlife Service in the late 1970s (Bovee, 1982) developed this methodology. The IFIM involves putting site-specific streamflow and habitat data into a group of models collectively called PHABSIM (physical habitat simulation). The most common model is

IFG4, which uses multiple transects to predict depths and velocities in a river over a range of flows. IFG4 creates a cell for each measured point along the transect or cross-section. Each cell has an average water depth and water velocity associated with a type of substrate or cover for a particular flow. The cell's area is measured in square feet. Fish habitat is defined in the computer model by the variables of velocity, depth, substrate, and/or cover. These are important habitat variables that can be measured, quantified, and predicted.

The IFIM is used nationwide and is accepted by most resource managers as the best available tool for determining the relationship between flows and fish habitat. However, the methodology only uses four variables in hydraulic simulation. At certain flows, such as extreme low flows, other variables such as fish passage, food supply (aquatic insects), competition between fish species, and predators (birds, larger fish, etc.) may be of overriding importance. In addition to the PHABSIM models, IFIM may include reviewing water quality, sediment, channel stability, temperature, hydrology, and other variables that affect fish production. These additional variables are not analyzed in this report.

After the IFG4 model is calibrated and run, its output is entered into another model (HABTAT) with data describing fish habitat preferences in terms of depth, velocity, substrate, and cover. These preferences vary according to fish species and life-stage (adult spawning and juvenile rearing).

The output of the HABTAT model is an index of fish habitat known as Weighted Useable Area (WUA). The preference factor for each variable at a cell is multiplied by the other variables to arrive at a composite, weighted preference factor for that cell. For example: a velocity preference of 1.0 multiplied by a depth preference of 0.9, then multiplied by a substrate preference of 0.8 equals a composite factor of 0.72 for that cell. This composite-preference factor is multiplied by the number of square feet of area in that cell.

A summation of all the transect cells' areas results in the total number of square feet of preferred habitat available at a specified flow. This quantity is normalized to 1,000 feet of stream or river. The final model result is a listing of fish habitat values (WUA) in units of square feet per 1,000 feet of stream. The WUA values are listed with their corresponding flows (given in cubic feet per second).

Study Site and Transect Selection

A preliminary study site was selected for the IFIM study by reviewing topographic maps. Actual site selection was done during field visits. Eight transects were chosen around RM 10.9 (see Figure 2) to represent the lower river. These transect sites are shown in the table below.

East Fork Lewis River Transects

Transect #	Location
1	River Mile 10.8
2	194 feet upstream of Transect 1
3	477 feet upstream of Transect 2
4	300 feet upstream of Transect 3
5	166 feet upstream of Transect 4
6	165 feet upstream of Transect 5
7	213 feet upstream of Transect 6
8	113 feet upstream of Transect 7

Field Procedures

IFIM measurements were taken in May (high flow), July (medium flow) and September (low flow) of 1998. We measured flows on the East Fork Lewis at 282, 97, and 34 cfs respectively

A temporary gage at each site was used to verify that streamflow at each transect remained steady during measurement. Transects were marked using survey hubs and flagging. Water velocity was measured using standard USGS methods with a calibrated Swoffer velocity meter mounted on a top-set wading rod.

Water surface elevations and stream-bank profiles were surveyed with a survey level and stadia rod. These points were referenced to an arbitrary, fixed benchmark. Substrate composition and cover were assessed by visually estimating the percent of the two main particle size classes and type of cover according to a scale recommended by the Washington Departments of Fisheries and Wildlife. This scale is included as Appendix F.

Hydraulic Model

Calibration Philosophy

Calibration of the hydraulic model involved checking the velocities and depths predicted by the model against velocities and depths measured in the field. This included examining indicators of the model's accuracy such as mean error and Velocity Adjustment Factor (VAF). The calibration philosophy was to change data or to manipulate data using a computer calibration option only when doing so would improve the model's ability to extrapolate without reducing the accuracy of predicted depths and velocities at the measured calibration flows.

Calibration of the IFG4 model was done cell by cell for each transect to decide whether the predicted cell velocities adequately represented measured velocities. Generally, if the predicted cell velocity at the calibration flow was within 0.2 feet per second (fps) of the measured cell velocity, the predicted velocity was considered adequate. Any change to a calibration velocity was limited to a change of 0.2 fps. The 0.2-fps change limit was thought to be reasonable considering the normal range of velocity measurement error. All cell velocities were reviewed at the highest and lowest extrapolated flows to ensure that extreme cell velocities were not predicted.

Indicators of Model Accuracy

Two indicators of the IFG4 model's accuracy in predicting depths and velocities are the mean error and the Velocity Adjustment Factor (VAF). See Appendix D for mean errors and VAFS for each transect at each site.

The mean error is the ratio of the calculated flow (from depths and velocities at the measured flows) to the predicted flow (from depth and velocity regressions). As a rule of thumb, the mean error for the calculated discharge should be less than 10 percent.

The Velocity Adjustment Factor (VAF) for a three-flow IFG4 hydraulic model indicates whether the flow predicted from the velocity/discharge regressions matches the flow predicted from the stage/discharge regressions. The velocities predicted from the velocity/discharge regressions for a transect are all multiplied by the same VAF to achieve the flow predicted from the stage/discharge regression. Calculating and comparing the flows predicted from two different regressions gives an indication as to whether or not some of the model's assumptions are being met.

A range in the VAF value of 0.9 to 1.1 is considered good, 0.85 to 0.9 and 1.1 to 1.15 fair, 0.8 to 0.85 and 1.15 to 1.20 marginal, and less than 0.8 and more than 1.2 poor (Milhous, 1984). The standard extrapolation range is 0.4 times the low calibration flow and 2.5 times the high calibration flow. The extrapolation range of the model is usually limited when two or more transects have VAFs which fall below 0.8 or above 1.2.

Options in IFG4 Model

Several options are available in the IFG4 hydraulic model (Milhous, 1989). Ecology's standard method is to set all the options to zero except for option 8 which is set at 2, and option 13 to 1 to get a summary of the velocity adjustment factors. The standard options were used for the models in this study.

Site Specific Calibration

A three-flow IFG4 model with eight transects was run for the E.F. Lewis River site. The IFG4 input file, a summary of the calibration details, data changes, and the velocity adjustment factors are included as Appendix D. The velocity adjustment factors range from 0.80 to 1.10 allowing an extrapolation range from 14 to 705 cfs.

Transect Weighting

The table below lists the percent weighting each transect received relative to the whole site. Transect weighting is determined one of two ways: either the model automatically determines weighting for each transect by using the distance between the transects or transect weight is set to predetermined levels by specifying distances between transects and upstream weighting (referred to as composite weighting). Composite weighting is done when the transects are located far apart and the distances between the transects would create incorrect weighing, or the investigator wants to increase the weight of a particular type of fish habitat for that site. Transect weighting for the E.F. Lewis River site was done using the distances between transects.

Transect Weighting for the E.F. Lewis River Site

Transect #	1	2	3	4	5	6	7	8
Percent of Total Site	5.96	20.61	23.86	14.30	10.17	11.61	10.01	3.47

Agency Approval of the Hydraulic Model

Brad Caldwell of the Department of Ecology and Hal Beecher of the Department of Fish and Wildlife met December 3, 1998 and after reviewing the calibration details decided the hydraulic models were adequate for the extrapolation range listed above.

Habitat Use Model (HABTAT)

Options Used in HABTAT

The HABTAT program combines the depths and velocities predicted from the IFG4 hydraulic model with the depths, velocities, cover, and substrate preferences from the habitat-use curves. The HABTAT program calculates WUA for each flow modeled. The IOC options used in HABTAT were IOC 00000 00101 00000 000.

Habitat Preference Curves

Fish preference curves for the E.F. Lewis River were agreed to by Brad Caldwell for the Department of Ecology and by Hal Beecher for the Department of Fish and Wildlife at a December 3, 1998 meeting. Existing agency preference curves were used for chinook, coho, and steelhead. These preference curves are listed in Appendix E. The substrate and cover code is listed in Appendix F.

Observations on use by juvenile salmonids of water depth, velocity, substrate, and cover were gathered by Department of Fish and Wildlife biologist Hal Beecher. These observations are in Appendix C.

Results and Discussion

The results are the fish habitat versus flow curves in Figure 3. Figure 4 shows how the wetted area changes with flow. The total area number can be divided by 1,000 to calculate the average wetted width for any flow from 14 to 705 cfs. Table 1 shows what percent of optimum habitat is available for each species at a given flow.

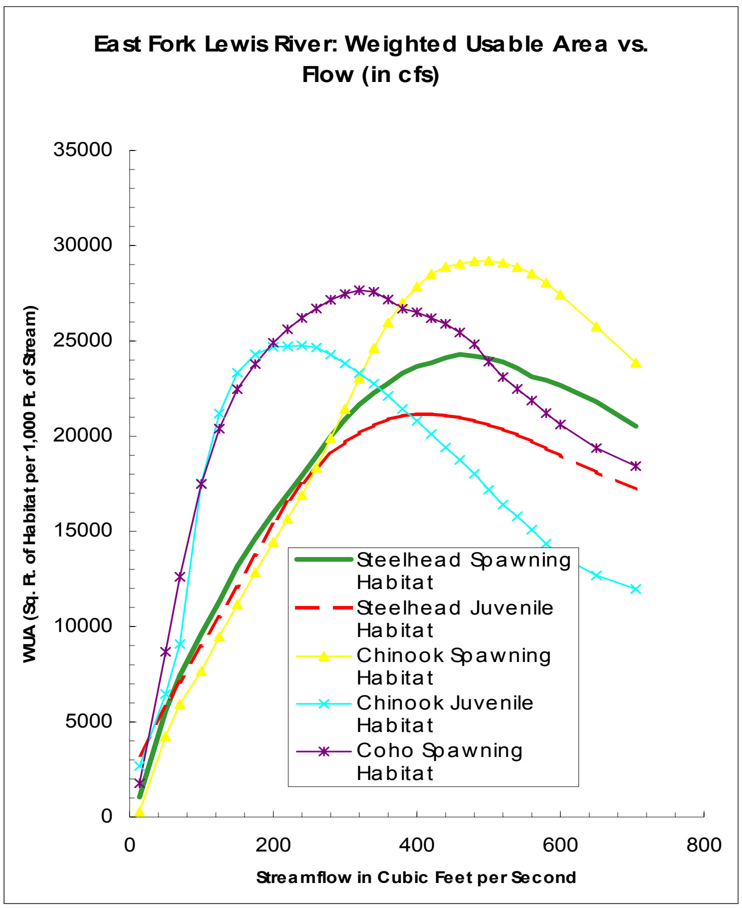
These results can be interpreted by biologists to determine a minimum flow regime to protect and preserve instream flow for fish under Washington State law.

Toe-Width Method

The Toe-Width Method was developed by the Department of Fisheries (WDF), the Department of Game (WDG), and the U.S. Geological Service (USGS) in the 1970s at the request of the state legislature in response to the need to determine minimum instream flows for fish. After the legislature passed the Minimum Water Flows and Levels law in 1969 and the Water Resources Act of 1971, USGS collected water depths and velocities along transects over known spawning areas. WDF and WDG provided the criteria for salmon and steelhead spawning and rearing and the locations of the known spawning areas. After 9 years of data collection, USGS had measured 28 streams and rivers in eastern and western Washington. They had 84 study reaches with each reach consisting of 4 transects. They measured each transect at 8 to 10 different flows. USGS used the data from the 336 transects to calculate spawning and rearing flows for salmon and steelhead. Criteria for the needed spawning and rearing depths and velocities for each fish species and lifestage were used to calculate the

Figure 3. WUA vs Flow for East fork Lewis River.

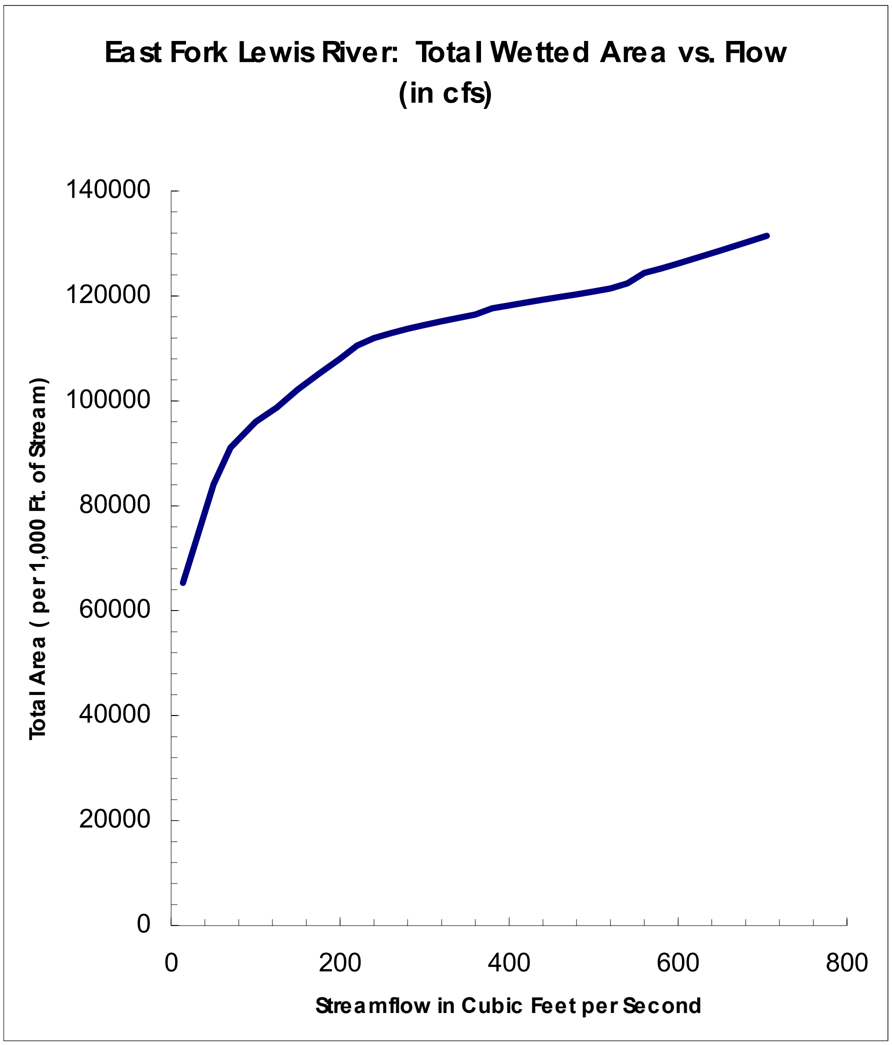
East Fork Lewis River Fish Habitat: Weighted Usable Area vs. Flow (in CFS)



Flow in cfs	Steelhead Spawning Habitat	Steelhead Juvenile Habitat	Chinook Spawning Habitat	Chinook Juvenile Habitat	Coho Spawning Habitat
705	20516	17219	23848	11969	18418
650	21807	18102	25747	12687	19374
600	22665	18976	27412	13708	20607
580	22936	19346	28049	14352	21199
560	23111	19728	28529	15079	21865
540	23564	20075	28870	15783	22468
520	23898	20353	29089	16398	23098
500	24077	20590	29202	17186	23905
480	24196	20804	29178	18017	24816
460	24284	20979	29045	18754	25434
440	24112	21084	28879	19403	25893
420	23837	21157	28507	20105	26195
400	23659	21153	27846	20807	26499
380	23301	21067	27007	21421	26689
360	22767	20886	25962	22115	27167
340	22262	20554	24614	22754	27576
320	21649	20177	23051	23307	27652
300	20871	19677	21418	23815	27453
280	19986	19086	19893	24278	27149
260	18944	18346	18337	24646	26693
240	17913	17494	16898	24763	26204
220	16940	16540	15649	24708	25605
200	15958	15362	14439	24682	24908
175	14629	13757	12836	24286	23779
150	13169	12072	11162	23330	22460
125	11328	10511	9480	21182	20392
100	9625	8984	7663	17514	17482
70	7424	7091	5931	9089	12606
50	5578	5801	4244	6464	8680
14	1054	3192	283	2680	1770

Figure 4. Wetted Area vs Flow.

East Fork Lewis River: Total Wetted Area vs. Flow



Flow in cfs	Total Area
705	131439
650	128640
600	126160
580	125233
560	124352
540	122385
520	121450
500	120846
480	120292
460	119812
440	119298
420	118768
400	118222
380	117656
360	116436
340	115818
320	115168
300	114472
280	113710
260	112894
240	111960
220	110551
200	108047
175	105153
150	102166
125	98742
100	96002
70	91059
50	84042
14	65279

Table 1. Habitat as a percent of optimum.

Flow in cfs	Steelhead Spawning Habitat	Steelhead Juvenile Habitat	Chinook Spawning Habitat	Chinook Juvenile Habitat	Coho Spawning Habitat
705	84%	81%	82%	48%	67%
650	90%	86%	88%	51%	70%
600	93%	90%	94%	55%	75%
580	94%	91%	96%	58%	77%
560	95%	93%	98%	61%	79%
540	97%	95%	99%	64%	81%
520	98%	96%	100%	66%	84%
500	99%	97%	100%	69%	86%
480	100%	98%	100%	73%	90%
460	100%	99%	99%	76%	92%
440	99%	100%	99%	78%	94%
420	98%	100%	98%	81%	95%
400	97%	100%	95%	84%	96%
380	96%	100%	92%	87%	97%
360	94%	99%	89%	89%	98%
340	92%	97%	84%	92%	100%
320	89%	95%	79%	94%	100%
300	86%	93%	73%	96%	99%
280	82%	90%	68%	98%	98%
260	78%	87%	63%	100%	97%
240	74%	83%	58%	100%	95%
220	70%	78%	54%	100%	93%
200	66%	73%	49%	100%	90%
175	60%	65%	44%	98%	86%
150	54%	57%	38%	94%	81%
125	47%	50%	32%	86%	74%
100	40%	42%	26%	71%	63%
70	31%	34%	20%	37%	46%
50	23%	27%	15%	26%	31%
14	4%	15%	1%	11%	6%

square feet of habitat at each measured flow. These points of habitat quantity at different flows were connected to create a fish habitat versus streamflow relationship. Next, these fish habitat relationships were compared to many different variables in the watershed to determine if there were any correlations that could be used to avoid having to do so many flow measurements to calculate a spawning or rearing flow for a certain fish species. The toe-width was the only variable found to have a high correlation. The toe-width is the distance from the toe of one streambank to the toe of the other streambank across the stream channel. This width of the stream is used in a power function equation to derive the flow needed for spawning and rearing salmon and steelhead (Swift, 1976 and 1979).

Field Procedure

Toe-Width measurements were gathered on September 9, 16, 22, and 23 for the 13 streams chosen in WRIA 27. A fiberglass tape was used by Brad Caldwell (Ecology) and Hal Beecher and Cynthia Pratt (WDFW). Usually 4 toe-widths were measured at each site and then averaged.

Jim Shedd (Ecology) gathered additional flow data on the 13 streams by collecting flows measurements in September, October, and November to facilitate synthesizing hydrographs.

Results and Discussion

The toe-width data is summarized in Table 2. The additional spot flow measurements are summarized in Table 3. These results are ready to be interpreted by biologists to determine a minimum flow regime to protect and preserve instream flow for fish under Washington State law.

Factors To Consider When Developing A Minimum Insteam Flow

Determining a minimum instream flow for a river or stream requires more than choosing the peak WUA flow for one lifestage of one species at one reach from the IFIM study. Because multiple lifestages existing simultaneously in a river, no specific flow will provide an optimum flow for all lifestages and species. Setting a minimum instream flow requires ranking the importance of each fish species and lifestage. This ranking requires considering long-range management plans for the fishery resources as determined by the state and federal natural resource agencies and the affected Tribes.

In addition, minimum instream flows must include flows necessary for incubation of fish eggs, smolt out-migration, fish passage to spawning grounds, and prevention of stranding of fry and juveniles. Other variables, which have to be considered, include water temperature, water quality, and sediment load. None of these variables were measured in this IFIM study. Therefore, reaching a conclusion about an appropriate minimum instream flow involves integrating the results of the IFIM study with consideration of these additional variables.

It’s important to know that under a minimum instream flow under Washington State’s laws is not the minimum flow that must be in the stream. No one has to stop using an existing water right to meet the minimum instream flow set by rule. The minimum instream flow only applies to new water rights issued after the date the rule was adopted. The minimum instream flow is the flow at which water is unneeded for the protection and preservation of fish and therefore new water rights can be given to anyone who requests since there is surplus water available.

Setting the minimum instream flow at the monthly mean during the low flow month sounds reasonable, but under State law it means that one-half of the flow during the low flow month is now available for new diversions. This is because the flow in the stream is higher than the mean about 50% of the time.

Table 2. Toe-Width Flows: WRIA 27

Stream Name	Tributary to	Average Toe Width (in feet)	Toe-Width Flow for Fish Spawning and Rearing (in cfs)					
			Chinook Spawning	*Coho Spawning*	*Chum Spawning*	*Steelhead Spawning*	*Steelhead Rearing*	*Salmon Rearing*
Cedar Creek (nr Lewis River Hatchery)	Lewis River	53.3	188.2	100.5	188.2	156.1	46.4	42.6
Gee Creek (@ Ridgefield, HWY 501 croossing)	Lake River to Columbia River	17.3	46.6	23.0	46.6	42.3	9.4	8.4
Canyon Creek (@ NE Healy Rd)	Lewis River	68.3	256.0	139.1	256.0	208.1	66.0	60.9
Speelyai Creek (@ HWY 503)	Merwin Lake to Lewis River	49.7	172.6	91.7	172.6	143.9	42.0	38.5
Cougar Creek (@ HWY 503)	Yale Lake to Lewis River	43.5	146.3	77.1	146.3	123.3	34.8	31.8
Jenny Creek (@ Pacific HWY/Clark Co. Rd)	EF Lewis River	15	39.1	19.1	39.1	35.9	7.7	6.9
McCormick Creek (@ 11th Ave. crossing)	EF Lewis River	12.3	30.6	14.7	30.6	28.5	5.8	5.2
Breeze Creek (@ La Center, Co. Rd 42 crossing)	EF Lewis River	16	42.3	20.8	42.3	38.6	8.4	7.5
Lockwood Creek (@ Co. Rd 42)	EF Lewis River	21.3	60.4	30.2	60.4	53.9	12.6	11.4
Mason Creek (@ J.A. Moore Rd crossing)	EF Lewis River	17.3	46.6	23.0	46.6	42.3	9.4	8.4
Yacolt Creek (@ confluence at Moulton Falls)	EF Lewis River	35.5	113.7	59.0	113.7	97.4	26.1	23.7
Rock Creek (#1) (1/2 mi. south of Dole)	EF Lewis River	42.7	143.0	75.2	143.0	120.7	33.9	31.0
Rock Creek (#2) (@ 319th st. Bridge off HWY 503)	EF Lewis River	17.5	47.3	23.4	47.3	42.9	9.5	8.6

Table 3. Spot Flow Measurements by Ecology.

WRIA 27 Measured Flows (in cfs)			
Date	9/10/98	10/9/98	11/9/98
NF Lewis River Tributaries			
Cedar Creek (nr Lewis River Hatchery)	**11.3**	**74.3**	**94.4**
Canyon Creek (@ NE Healy Rd)	**34.7**	**129.4**	**110.8**
Speelyai Creek (@ HWY 503)	**2.6**	**79.8**	**66.9**
Cougar Creek (@ HWY 503)		**76.7**	**66.8**
EF Lewis River Tributaries			
Jenny Creek (@ Pacific HWY/Clark Co. Rd)	**0.3**	**0.6**	**1.9**
McCormick Creek (@ 11th Ave. crossing)	**0.2**	**0.4**	**2.4**
Breeze Creek (@ La Center, Co. Rd 42 crossing)	**0.7**	**1.0**	**1.9**
Lockwood Creek (@ Co. Rd 42)	**0.7**	**1.4**	**5.9**
Mason Creek (@ J.A. Moore Rd crossing)	**0.3**	**0.6**	**5.1**
Yacolt Creek (@ confluence at Moulton Falls)	**3.9**	**7.4**	**16.0**
Rock Creek (#1) (1/2 mi. south of Dole)	**5.0**	**22.9**	**24.0**
Rock Creek (#2) (@ 319th st. Bridge off HWY 503)	**0.2**	**1.9**	**6.3**
Lake River Tributary			
Gee Creek (@ Ridgefield, HWY 501 croossing)	**0.6**	**1.2**	**2.7**

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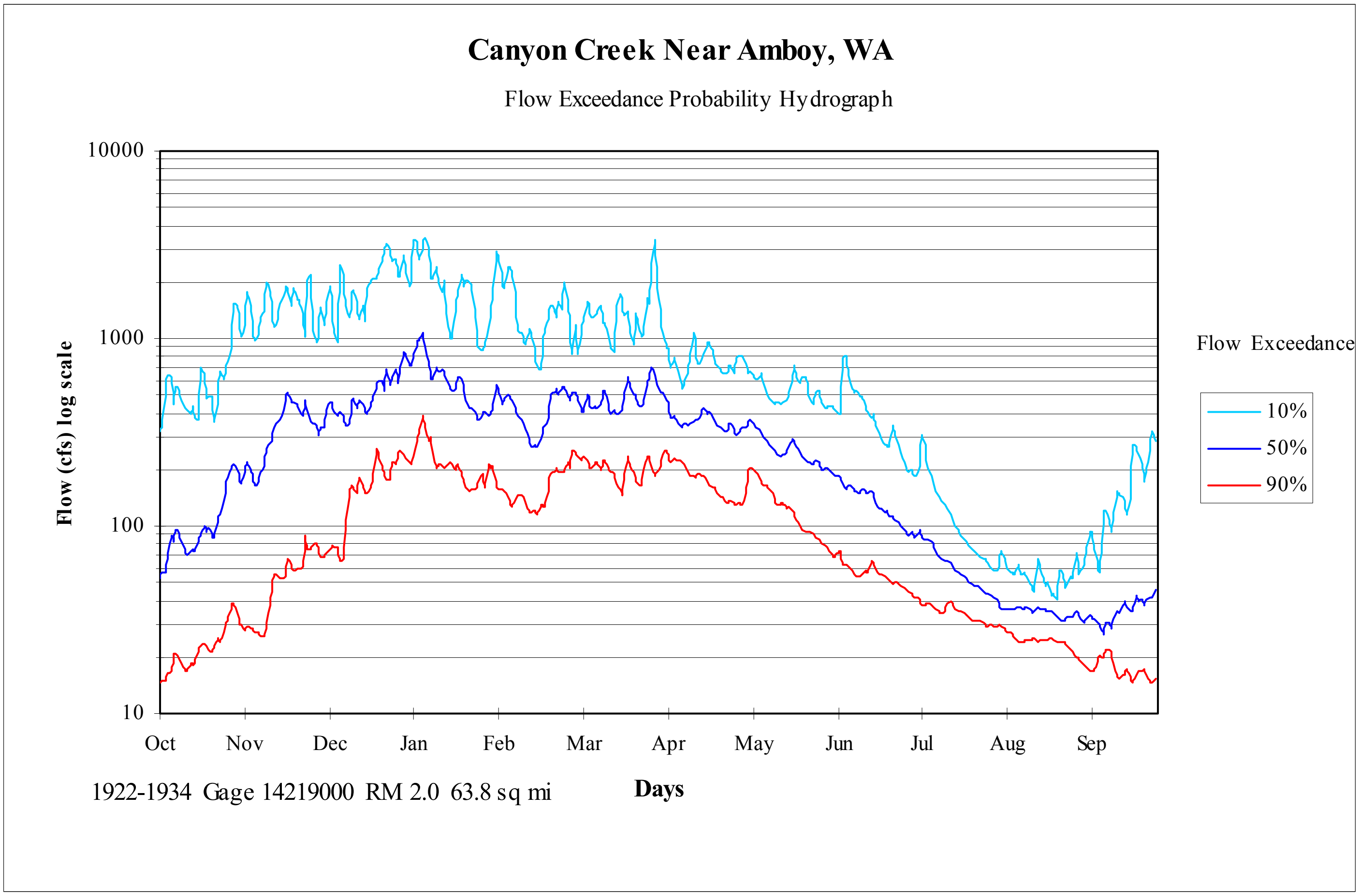
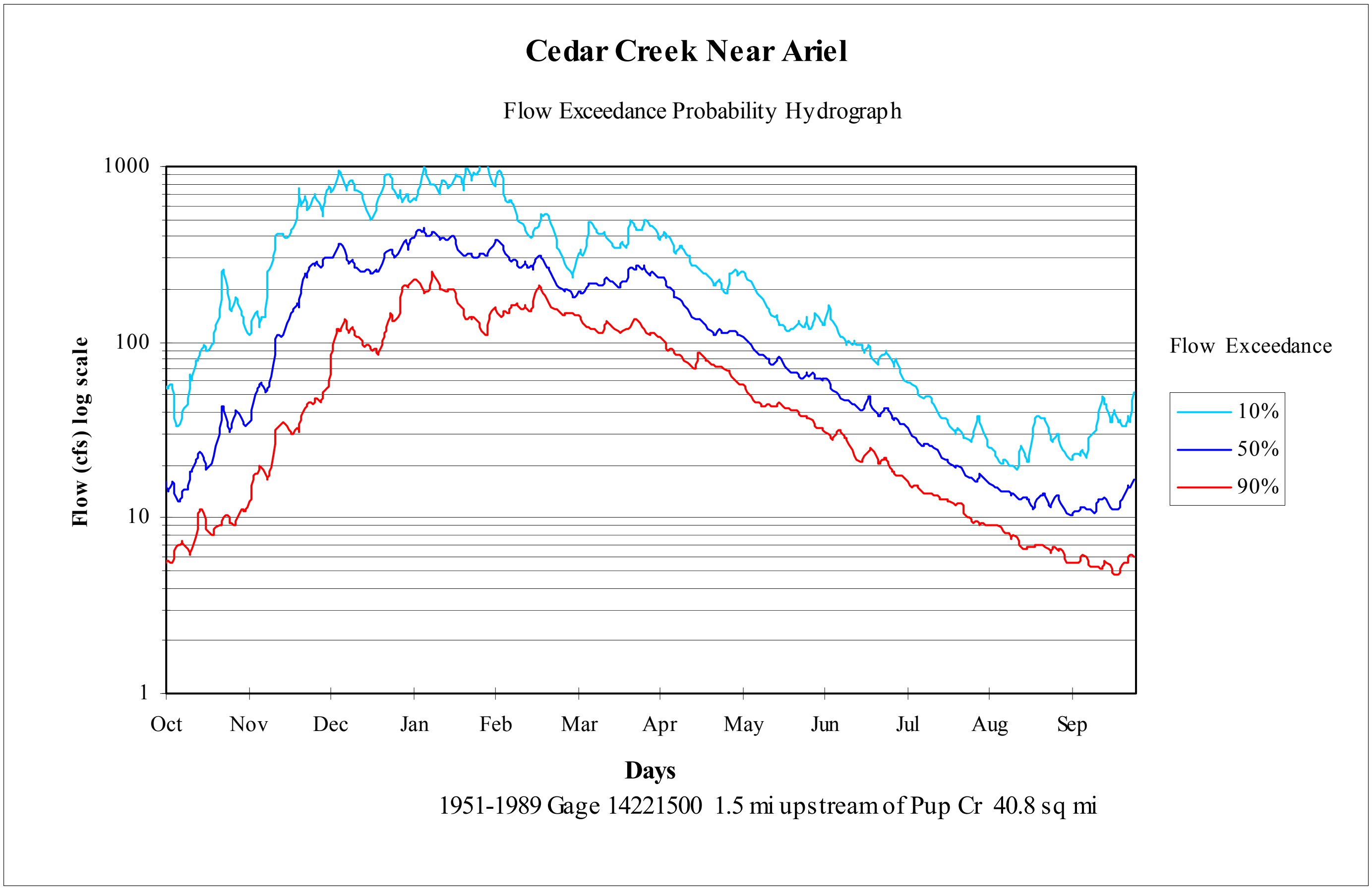
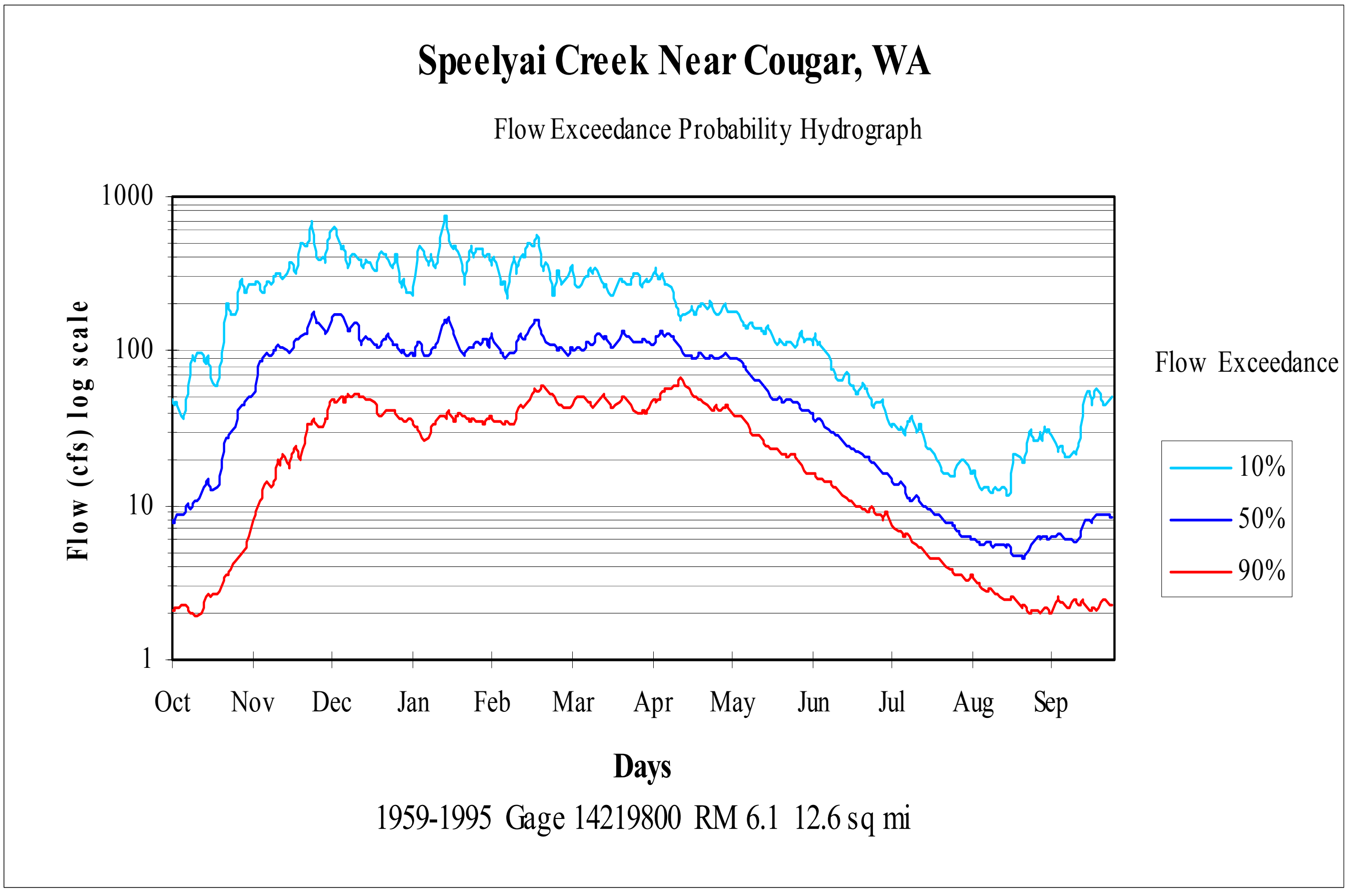
Appendix A. Hydrographs of Canyon, Cedar, and Speelyai Creeks



Canyon Creek Near Amboy, WA
Flow Exceedance Probability Hydrograph
Flow (cfs) log scale
10000
1000
100
10
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Days
1922-1934 Gage 14219000 RM 2.0 63.8 sq mi
Flow Exceedance
10%
50%
90%


Cedar Creek Near Ariel
Flow Exceedance Probability Hydrograph
Flow (cfs) log scale
1000
100
10
1
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Days
Flow Exceedance
10%
50%
90%
1951-1989 Gage 14221500 1.5 mi upstream of Pup Cr 40.8 sq mi



Speelyai Creek Near Cougar, WA
Flow Exceedance Probability Hydrograph
Flow (cfs) log scale
1000
100
10
1
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Days
Flow Exceedance
10%
50%
90%
1959-1995 Gage 14219800 RM 6.1 12.6 sq mi

Appendix B. Maps of Chinook, Steelhead, and Chum ESUs for WRIA 27

(not available in online version)

Appendix C. Snorkeling Observations in the East Fork Lewis River

Snorkel observations EAST FORK LEWIS RIVER Daybreak Park 7/31/98
IFIM study site Hal Beecher

T1	1445 PDT	no fish, some caddis - swift cobble run tailout	side channel through woods seeping only
T2	1515	LB side channel - school of chiselmouth (? possibly squawfish?), ~6 3" juvenile chinook, sculpins, snails in deep water by logjam upstream of T2	
		Swift cobble run - No fish observed crossing T2; caddis	
		Chute above T2 - moderate abundance of juvenile steelhead and whitefish, some longnose dace and sculpins	
T3		lower end of deep pool - juvenile dace along RB, sculpins, other juvenile cyprinid, caddis, snails	
T4	1535	middle of deep pool - snails, caddis, few juvenile dace	

NO CHANGE IN WSEL DURING IFIM CALIBRATION MEASUREMENTS

T5	1545	upper end of deep pool - snails, caddis, juv dace, sucker fry (?), adult suckers
T6	1555	chute (RB) and riffle - no fish in chute, 1 juvenile steelhead in left channel Tail of T6 chute - several juvenile steelhead
T7	1610	pool and underwater entrance to beaver lodge on RB, head of riffle - about 40 juvenile coho near rootwad near RB, school of ~10(+?) juvenile chinook (I) in entrance to beaver lodge, 1 juvenile steelhead near tip of fallen cottonwood in R side of river, many juvenile steelhead on riffle near LB RB pool below T7 - mixed school: coho, steelhead, and chiselmouth or young squawfish, about 6-10 juvenile steelhead out in pool
T8	1620	upper end of RB side channel through woods to T1 not connected to river Tailout of glide - no fish, some caddis & snails

Appendix D. Calibration Information for the IFIM Computer Model.

Appendix D1. IFG4 Input File

E.F. Lewis River at Daybreak Park measured 282 cfs on 5-13-98, 97 cfs on 7-31-98, and 34 cfs on 9-16-98.

```
IOC       11000002000010000 10 1
QARD 705.0
QARD 650.0
QARD 600.0
QARD 580.0
QARD 560.0
QARD 540.0
QARD 520.0
QARD 500.0
QARD 480.0
QARD 460.0
QARD 440.0
QARD 420.0
QARD 400.0
QARD 380.0
QARD 360.0
QARD 340.0
QARD 320.0
QARD 300.0
QARD 280.0
QARD 260.0
QARD 240.0
QARD 220.0
QARD 200.0
QARD 175.0
QARD 150.0
QARD 125.0
QARD 100.0
QARD  70.0
QARD  50.0
QARD  14.0
XSEC   1.0       0.0 .50     89.20    .00250
       1.0  5.595.27 10.094.17 15.094.17 20.094.87 21.191.92 24.0 90.5
       1.0 28.089.47 32.089.57 36.0 89.2 40.0 90.0 44.090.22 48.090.32
       1.0 52.090.52 56.0 90.7 60.090.67 64.090.59 68.0 90.7 72.091.07
       1.0 76.091.29 80.091.29 84.091.62 88.091.72 92.091.82 96.091.52
       1.0100.091.72104.091.82108.091.82112.091.82116.091.62120.091.77
       1.0124.091.07128.091.09132.091.62136.391.91138.091.27140.091.47
       1.0150.092.07164.393.17
NS     1.0       .80       .80       .80       .80       .80     76.50
NS     1.0     76.70     76.70     76.60     76.60     76.50     67.70
NS     1.0     67.60     65.90     67.50     75.50     65.70     65.50
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NS     1.0     65.50     65.50     65.50     54.50     54.50     75.50
NS     1.0     76.50     76.50     65.50     67.50     22.90     22.90
NS     1.0     22.90     22.90     76.80     75.80     75.80     75.80
NS     1.0     72.60       .80
CAL1   1.0     91.92    282.00
VEL1   1.0                        2.91 4.36 4.77 4.14 3.47 3.46 2.73
VEL1   1.0 3.02 3.51 2.79 2.55 2.73 2.66 1.73 1.87 1.53  .57  .47 0.00
VEL1   1.0  .29  .07  .97 1.00  .32 0.00 0.00 0.00 0.00
VEL1   1.0
CAL2   1.0     91.46     97.00
VEL2   1.0                         .87 2.48 2.60 2.59 2.48 1.89 1.50
VEL2   1.0 1.49 0.00 1.69 1.05  .67 1.00 0.00 0.00
VEL2   1.0                              .50 0.00
VEL2   1.0
CAL3   1.0     90.73     34.00
VEL3   1.0                         .56 1.56 1.86 1.36 1.36 1.01  .63
VEL3   1.0  .55 0.00  .85  .48  .40
VEL3   1.0
VEL3   1.0
XSEC   2.0     194.0 .50     90.01     .00250
       2.0  2.497.68 12.495.17 22.494.17 23.0 93.0 24.092.36 25.092.16
       2.0 26.092.11 27.092.01 28.092.09 29.091.81 30.091.74 31.091.59
       2.0 32.091.64 33.091.71 34.091.79 35.092.16 36.092.24 37.092.26
       2.0 38.092.69 40.394.07 50.395.07 60.395.67 83.896.17107.395.37
       2.0115.694.37125.692.77128.691.84130.691.35132.690.49134.690.51
       2.0136.690.01138.690.01140.690.04142.690.09144.690.28146.690.23
       2.0148.690.26150.690.38152.690.28154.690.58156.690.48158.690.58
       2.0160.690.81162.690.84164.690.94166.691.09168.691.18170.691.38
       2.0172.691.54174.691.88176.692.03178.692.29180.692.59191.693.77
       2.0195.693.97200.693.97208.694.47228.994.47249.293.87253.492.74
       2.0254.492.74255.492.21256.491.74257.491.65258.491.65259.491.52
       2.0260.491.43261.491.26262.491.25263.491.21264.491.13265.491.18
       2.0266.491.25267.491.15268.4 91.3269.491.35270.491.38271.491.53
       2.0272.491.41274.491.51275.492.14276.492.79278.794.87
NS     2.0       .80     76.80     76.70     76.70     76.70     76.70
NS     2.0     76.70     76.70     76.70     76.70     76.70     76.70
NS     2.0     76.70     76.70     76.70     76.70     76.70     76.70
NS     2.0     76.70     76.70     76.70     76.70     76.70       .80
NS     2.0     57.50     65.70     74.90     76.70     75.80     68.50
NS     2.0     58.60     57.80     57.70     56.60     57.50     57.60
NS     2.0     76.50     76.50     75.60     57.60     57.50     67.70
NS     2.0     57.80     57.80     57.70     56.70     65.70     67.60
NS     2.0     57.50     57.80     61.80     74.70     64.70     56.50
NS     2.0     52.80     57.80     57.80     57.80       .80     45.50
NS     2.0     45.50     45.50     45.50     45.50     45.50     45.50
NS     2.0     57.50     56.50     65.60     65.70     65.80     65.70
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NS     2.0     65.80     65.70     56.50     56.50     57.80     56.50
NS     2.0     52.50     52.50       .80       .80       .80
CAL1   2.0     92.79    282.00
VEL1   2.0               0.00  .12  .27  .41  .43  .44  .52  .49  .51
VEL1   2.0  .32  .45  .24  .38  .24 0.00
VEL1   2.0           1.49 2.25 2.98 2.82 4.41 4.7934.11 4.12 3.55 2.98
VEL1   2.0 3.51 3.01 3.33 2.84 3.02 3.34 3.30 2.72 2.57 2.18 2.25 1.38
VEL1   2.0 1.38 1.27  .99  .55  .01
VEL1   2.0
VEL1   2.0
CAL2   2.0     92.08     97.00
VEL2   2.0
VEL2   2.0
VEL2   2.0                .93 1.30 2.57 1.62 2.50 1.86 2.03 2.04 1.52
VEL2   2.0 2.18 1.93 1.75 1.15 1.21  .95 1.54 1.26 1.27 1.14  .93  .70
VEL2   2.0  .70
VEL2   2.0
VEL2   2.0
CAL3   2.0     91.17     34.00
VEL3   2.0
VEL3   2.0
VEL3   2.0               0.00  .66 1.82 1.43 1.53 1.74 1.69 1.25 1.52
VEL3   2.0 1.25 1.44 1.17 1.12 1.04  .72  .80  .82  .62  .57  .39
VEL3   2.0
VEL3   2.0
VEL3   2.0
XSEC   3.0     477.0 .50     91.72    .00250
       3.0  0.0100.5  2.899.06  6.098.16  9.295.95 12.095.37 15.094.36
       3.0 18.093.99 21.093.34 24.092.91 27.092.69 30.092.22 33.092.14
       3.0 36.091.72 39.092.01 42.091.86 45.091.99 48.092.07 51.091.74
       3.0 54.091.91 57.092.12 60.092.59 63.092.76 66.092.66 69.092.79
       3.0 72.093.19 75.093.19 78.093.34 81.093.62 84.093.66 87.093.72
       3.0 90.093.62 93.094.07 96.094.34 99.094.59102.094.91105.094.96
       3.0108.0 95.3111.095.65114.595.95118.096.56120.096.96130.097.96
       3.0140.098.36150.098.76172.499.16
NS     3.0     74.50     74.50     74.50     64.70     75.80     76.90
NS     3.0     76.30     67.50     76.70     76.50     76.60     76.90
NS     3.0     76.70     78.80     78.80     78.80     78.70     76.50
NS     3.0     76.50     75.50     67.60     75.50     64.80     57.80
NS     3.0     64.80     67.90     64.90     61.90     61.70     61.80
NS     3.0     75.50     57.80     51.80     76.50     65.70     67.50
NS     3.0     57.70     57.50     57.50     75.70     57.70     65.50
NS     3.0     56.50     75.80     15.50
CAL1   3.0     95.95    282.00
VEL1   3.0                    0.00  .27  .50  .59  .94  .78 1.11  .70
VEL1   3.0  .63  .97 1.03  .81 1.08  .96 1.12  .74  .60  .97 1.05  .86
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VEL1   3.0  .88 1.04  .89 1.00  .86  .74  .75  .74  .55  .47  .30  .33
VEL1   3.0  .11
CAL2   3.0     95.40     97.00
VEL2   3.0                   0.00 0.00  .14  .40  .47  .96  .51  .65
VEL2   3.0  .44  .55  .59  .40  .58  .55  .42  .50  .17  .37  .52  .33
VEL2   3.0  .49  .40  .26  .39  .22  .35  .31  .22  .14 0.00 0.00 0.00
VEL2   3.0 0.00
CAL3   3.0     94.62     34.00
VEL3   3.0                        .01  .02 0.00  .21  .23  .14  .10
VEL3   3.0  .13  .20  .23  .20  .08  .13  .22  .09  .02  .09 0.00  .04
VEL3   3.0 0.00  .21  .21  .21  .21 0.00 0.00 0.00 0.00 0.00
VEL3   3.0
XSEC   4.0     300.0 .50     91.72     .00250
     4.0 -2.0103.4  0.098.46  2.595.96  5.094.73  7.593.85 10.0 93.1
     4.0 12.592.77 15.092.27 17.5 91.8 20.091.25 22.5 91.2 25.090.67
     4.0 27.590.57 30.0 90.6 32.5 90.7 35.091.07 37.5 91.3 40.091.62
     4.0 42.591.75 45.092.13 47.592.15 50.092.13 52.592.57 55.092.88
     4.0 57.5 93.0 60.093.15 62.593.37 65.093.63 67.593.92 70.0 94.1
     4.0 72.594.43 75.0 94.6 77.594.78 80.094.88 82.595.15 85.095.35
     4.0 87.595.66 90.095.76 95.596.16105.597.16115.598.06125.598.46
     4.0130.598.76140.599.96
NS     4.0     56.50     56.50     56.50     67.60     76.50     76.50
NS     4.0     87.50     87.50     87.70     68.60     68.60     68.60
NS     4.0     86.50     86.50     76.50     82.50     76.50     76.50
NS     4.0     81.70     71.70     87.50     87.50     81.60     76.50
NS     4.0     76.50     76.50     76.50     72.50     72.50     72.50
NS     4.0     76.50     76.50     62.50     76.50     62.50     76.50
NS     4.0     76.50     76.50     86.50     56.50     56.50     56.50
NS     4.0     75.70     76.50
CAL1   4.0     95.96    282.00
VEL1   4.0               .47  .92 1.27 1.29 1.19 1.40 1.24 1.41 1.80
VEL1   4.0 1.32 1.29 1.28 1.12  .99 1.13 1.19 1.08 1.18  .97  .97  .94
VEL1   4.0  .93  .92  .96  .85  .73  .66  .68  .58  .43  .43  .39  .29
VEL1   4.0  .08 0.00
CAL2   4.0     95.40     97.00
VEL2   4.0              0.00  .28  .35  .42  .46  .38  .43  .43  .43
VEL2   4.0  .35  .39  .50  .42  .26  .39  .43  .32  .44  .43  .38  .25
VEL2   4.0  .34  .22  .24  .16  .15  .14 0.00 0.00 0.00 0.00 0.00 0.00
VEL2   4.0
CAL3   4.0     95.14     34.00
VEL3   4.0              0.00 0.00 0.00 0.00  .07  .10  .13  .16  .16
VEL3   4.0  .23  .22  .13  .13  .17  .18  .14  .09  .11  .08  .08  .11
VEL3   4.0  .08  .11  .05 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
VEL3   4.0
XSEC   5.0     166.0 .50     91.72     .00250
     5.0 -2.5 99.2  3.5 98.0  4.595.98  5.095.93  7.594.94 10.094.51
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      5.0 15.093.21 20.092.55 25.092.08 30.0 91.6 35.091.83 40.091.83
      5.0 45.0 92.4 50.092.71 55.092.98 60.093.28 65.093.38 70.093.58
      5.0 75.093.48 77.593.53 80.093.68 82.593.75 85.093.96 87.594.01
      5.0 90.094.31 92.594.38 95.094.56 97.594.88100.094.78102.594.85
      5.0105.095.04107.595.68109.095.98112.0 96.8114.0 97.2118.8 98.4
      5.0129.0 99.5
NS     5.0     .80    75.60    75.60    75.60    76.50    87.50
NS     5.0   82.70    82.50    82.50    82.50    82.50    82.50
NS     5.0   82.50    72.50    72.50    72.50    76.60    76.60
NS     5.0   76.60    76.50    62.70    26.50    27.50    28.60
NS     5.0   82.50    27.50    27.50    26.50    26.50    26.50
NS     5.0   26.90    22.90      .80      .80      .80      .80
NS     5.0     .80
CAL1   5.0    95.98    282.00
VEL1   5.0             0.00  .34  .43  .41  .92 1.28 1.65 1.28 1.09
VEL1   5.0 1.23 1.02  .74  .52  .74  .96 1.26 1.26 1.16 1.23 1.27 1.34
VEL1   5.0 1.15  .99  .80  .73  .59  .21 0.00 0.00
VEL1   5.0
CAL2   5.0    95.41     97.00
VEL2   5.0                  0.00 0.00  .38  .50  .59  .49  .37  .32
VEL2   5.0  .34  .43  .39  .24  .33  .44  .47  .51  .57  .68  .55  .30
VEL2   5.0  .34  .53  .33  .22 0.00 0.00 0.00
VEL2   5.0
CAL3   5.0    95.15     34.00
VEL3   5.0                       0.00  .09  .17  .11  .17  .16  .17
VEL3   5.0  .15 0.00  .05  .15  .10  .17  .18  .18  .18  .11  .19 0.00
VEL3   5.0  .14  .04  .03 0.00 0.00 0.00
VEL3   5.0
XSEC   6.0     165.0 .50     94.67    .00250
      6.0 -3.0 99.1  2.9 97.1  4.096.55  7.0 95.7 10.095.62 13.0 95.4
      6.0 16.095.22 19.095.12 22.095.32 25.095.32 28.095.34 31.095.19
      6.0 34.095.34 37.0 95.7 40.095.62 43.095.72 46.095.82 49.095.74
      6.0 52.095.79 56.095.92 59.095.97 62.095.74 65.095.79 68.095.82
      6.0 71.095.77 74.095.54 77.0 95.6 80.095.75 83.095.42 86.095.84
      6.0 89.095.35 92.095.27 95.094.99 98.094.92101.094.67104.0 94.7
      6.0107.0 94.9110.095.54114.0 97.7115.0 97.8116.0 98.0121.6 98.4
NS     6.0     .80      .50      .30      .30    85.70    87.50
NS     6.0   75.70    57.60    78.80    68.70    68.70    68.70
NS     6.0   68.70    68.70    68.70    68.70    68.70    67.50
NS     6.0   67.50    67.50    67.50    67.50    67.50    67.50
NS     6.0   68.80    67.50    67.50    68.60    67.70    68.70
NS     6.0   76.70    78.80    87.50    68.50    76.50    67.50
NS     6.0   76.50    68.80    71.80    71.80    75.50    86.50
CAL1   6.0    96.50    282.00
VEL1   6.0             1.07  .83 0.00 2.21 2.38 1.68 2.33 3.53 1.80
VEL1   6.0 2.90 2.20 1.62 2.08 1.54  .94 1.71 2.27  .60 1.55  .42 2.06
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VEL1   6.0 1.43 1.93 1.33 2.15 1.97 4.22 4.30 3.74 5.17 6.07 4.67 4.58
VEL1   6.0 4.49  .90
CAL2   6.0     96.00     97.00
VEL2   6.0                .17  .63  .44 1.56 1.03 1.34  .56 2.82  .41
VEL2   6.0  .16  .61 0.00 0.00  .42  .97  .37 0.00  .18 1.10  .56 1.46
VEL2   6.0 1.23  .37  .75 1.15 1.31 1.69 1.93 2.00 4.08 4.39 4.59 3.17
VEL2   6.0 2.86  .95
CAL3   6.0     95.72     34.00
VEL3   6.0                     0.00       .86  .54       .37 2.25 0.00
VEL3   6.0  .52      0.00           0.00 0.00            .37 0.00  .84
VEL3   6.0  .10 0.00 0.00       .52 2.12 1.59 1.39 2.80 2.76 2.51 2.26
VEL3   6.0 2.33  .97
XSEC   7.0     213.0 .50     96.90    .00250
     7.0 10.0102.7 20.0100.3 28.0 99.1 34.3 99.1 40.3 98.6 52.398.64
     7.0 58.398.93 64.398.93 70.398.83 76.398.83 82.398.93 88.398.53
     7.0 94.3 98.5100.398.58106.3 98.5112.398.32118.397.97124.398.14
     7.0130.398.15136.397.87142.397.94148.398.09154.397.94160.397.95
     7.0166.397.97172.398.09178.3 98.2184.397.95190.397.99196.397.69
     7.0202.397.25208.3 96.9214.397.24220.199.03224.0100.4228.0102.7
NS     7.0       .80       .80     81.90     57.70     68.60     76.60
NS     7.0     76.80     76.80     76.70     86.50     78.50     78.80
NS     7.0     76.70     78.80     78.50     76.70     68.50     78.80
NS     7.0     76.50     76.50     67.60     75.70     75.50     67.50
NS     7.0     76.50     67.70     57.70     75.50     67.70     75.50
NS     7.0     64.80     16.50       .40       .40       .40       .80
CAL1   7.0     99.03    282.00
VEL1   7.0                    .36  .01 0.00 0.00  .41  .95 0.00  .33
VEL1   7.0  .40  .73 1.56 1.70 3.34 2.55 3.79 1.71 2.04 2.23 2.51 2.31
VEL1   7.0 2.90 1.17 2.08 1.75 1.78 1.56 1.58 1.43 1.79
CAL2   7.0     98.72     97.00
VEL2   7.0
VEL2   7.0               0.00 2.28 2.86 2.13 1.70 1.60  .97 1.65 1.54
VEL2   7.0 1.79  .64  .85  .72  .78  .70  .78  .66  .42
CAL3   7.0     98.47     34.00
VEL3   7.0
VEL3   7.0                .34 1.66 2.53 2.18  .52  .71 1.39 1.63  .67
VEL3   7.0 1.53  .08 0.00  .44  .52  .52  .58  .66  .45
XSEC   8.0     113.0 .50     97.57    .00250
     8.0  1.0103.8  3.5102.8 10.0100.3 30.0 99.9 34.099.67 36.099.59
     8.0 40.099.29 45.099.01 50.099.09 55.098.89 60.099.14 65.098.89
     8.0 70.099.09 75.099.19 80.098.69 85.098.74 90.0 98.3 95.098.39
     8.0100.097.99105.098.15110.097.89115.097.57120.097.75125.097.89
     8.0130.097.64135.098.07140.097.97145.098.22150.098.09155.098.09
     8.0160.098.24165.0 98.5170.098.67175.0 98.7180.098.65185.098.85
     8.0190.098.99195.099.39200.099.49205.099.49208.099.59223.0100.9
     8.0224.5100.7233.0102.6
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NS     8.0       .80       .80    61.50    76.50    75.50    64.60
NS     8.0    57.70    57.80    67.50    76.60    76.50    76.70
NS     8.0    76.70    75.80    76.70    75.80    78.80    78.80
NS     8.0    78.80    68.50    68.60    76.60    78.60    67.50
NS     8.0    67.80    67.70    68.60    67.60    57.50    57.50
NS     8.0    67.80    67.80    57.70    75.60    57.70    75.60
NS     8.0    57.70    67.80    56.50    67.80    67.80    67.50
NS     8.0    67.50    67.50
CAL1   8.0    99.59   282.00
VEL1   8.0                           .09  .30  .18  .35  .01  .11
VEL1   8.0  .32  .28  .82  .88 1.36 1.38 1.68 2.17 2.00 2.10 2.34 2.39
VEL1   8.0 2.11 2.23 1.63 2.95 2.24 2.05 2.02 1.13 1.83 1.57  .97  .89
VEL1   8.0  .90  .88  .30 0.00
CAL2   8.0    99.18    97.00
VEL2   8.0                                0.00 0.00 0.00 0.00 0.00
VEL2   8.0 0.00 0.00  .08  .53  .45  .20  .79  .73 1.08 1.50 1.49 1.74
VEL2   8.0 1.01 1.41  .72 1.32 1.18  .94  .78  .60 0.00  .38  .48  .17
VEL2   8.0  .22
CAL3   8.0    98.94    34.00
VEL3   8.0
VEL3   8.0            .18  .11  .25  .09  .36  .49  .81  .41  .71  .56
VEL3   8.0  .59  .59 1.05  .94  .79  .65 0.00  .16 0.00 0.00 0.00 0.00
VEL3   8.0
ENDJ
```

Appendix D2. Summary of Calibration Details

East Fork Lewis River

Calibration Information for Calculated Discharges

Transect Number	1	2	3	4	5	6	7	8
Discharge	306.62 111.96 32.06	481.99 105.50 34.33	224.03 94.10 18.28	293.19 76.41 22.62	273.59 85.10 23.17	289.26 103.24 41.88	262.73 101.68 51.44	287.64 99.57 40.23
Stage	91.92 91.46 90.73	92.79 92.08 91.17	95.95 95.40 94.62	95.96 95.40 95.14	95.98 95.41 95.15	96.50 96.00 95.72	99.03 98.72 98.47	99.59 99.18 98.94
Plotting Stage	2.72 2.26 1.53	2.78 2.07 1.16	4.23 3.68 2.90	4.24 3.68 3.42	4.26 3.69 3.43	1.83 1.33 1.05	2.13 1.82 1.57	2.02 1.61 1.37
Ratio of Measured vs. Predicted Discharge								
	1.13 0.84 1.06	1.31 0.67 1.15	0.98 1.04 0.99	0.93 1.25 0.86	0.90 1.35 0.82	0.98 1.05 0.97	1.04 0.93 1.04	0.98 1.06 0.97
Mean Error of Stage/Discharge Relationship for Calculated Q								
	12.24	28.69	2.47	14.49	19.63	3.51	4.87	3.87
Mean Error of Stage/Discharge Relationship for Given Q								
	17.02	15.65	12.77	13.80	14.11	6.46	1.05	7.34
Stage/Discharge Relationship (S vs. Q) S=A*QB+SZF**								
A=	0.6257	0.3552	1.8712	2.5804	2.5268	0.3542	0.7572	0.6539
B=	0.2622	0.3482	0.1501	0.0863	0.09141	0.2886	0.1868	0.1984
SZF=	89.20	90.02	91.72	91.72	91.72	94.67	96.90	97.57
Beta Coefficient Log/Log Discharge/Stage Relationship								
	3.52	2.34	5.48	9.53	9.44	3.78	6.93	5.40

Appendix D3. Summary of Data Changes

Data changes for calibration, East Fork Lewis River at Daybreak Park

Transect	Vertical	Vel	Change
1	16	1	2.75 to 2.55
1	18	1	2.86 to 2.66
1	14	2	0.16 to 0.00
1	16	2	0.85 to 1.05
1	18	2	0.80 to 1.00
1	19	2	0.25 to 0.00
1	14	3	0.06 to 0.00
1	16	3	0.28 to 0.48
2	46	1	2.38 to 2.18
2	47	1	2.45 to 2.25
2	48	1	1.58 to 1.38
2	48	2	0.50 to 0.70
2	50	2	0.09 to 0.00
2	28	3	0.12 to 0.00
2	46	3	0.37 to 0.57
2	47	3	0.29 to 0.39
3	8	3	0.02 to 0.00
3	9	3	0.01 to 0.21
3	11	3	0.34 to 0.14
3	12	3	0.30 to 0.10
3	19	3	0.02 to 0.22
3	23	3	0.04 to 0.00
3	25	3	0.03 to 0.00
3	26	3	0.01 to 0.21
3	27	3	0.01 to 0.21
3	28	3	0.01 to 0.21
3	29	3	0.01 to 0.21
4	31	2	0.01 to 0.00
4	6	3	0.04 to 0.00
4	7	3	0.04 to 0.00
4	11	3	0.26 to 0.16
4	12	3	0.26 to 0.16
4	15	3	0.23 to 0.13
4	16	3	0.23 to 0.13
5	9	3	0.21 to 0.11
5	19	3	0.28 to 0.18
5	20	3	0.28 to 0.18
5	21	3	0.28 to 0.18
6	6	1	0.05 to 0.00
6	14	1	2.40 to 2.20

6	14	2	0.41 to 0.61
6	15	2	0.16 to 0.00
6	11	3	2.45 to 2.25
6	12	3	0.03 to 0.00
6	18	3	0.01 to 0.00
6	26	3	0.01 to 0.00
6	27	3	0.03 to 0.00
6	34	3	2.96 to 2.76
6	35	3	2.71 to 2.51
7	32	2	0.46 to 0.66
7	27	3	0.06 to 0.00
7	31	3	0.38 to 0.58
7	32	3	0.46 to 0.66
8	17	2	0.25 to 0.45
8	33	2	0.20 to 0.00
8	34	2	0.18 to 0.38
8	17	3	0.05 to 0.25
8	31	3	0.18 to 0.00

Appendix D4. Velocity Adjustment Factors

E.F. Lewis River at Daybreak Park measured 282 cfs on 5-13-98, 97 cfs on 7-31-98, and 34 cfs on 9-16-98.

1.00	705.0	0.862
1.00	650.0	0.864
1.00	600.0	0.865
1.00	580.0	0.866
1.00	560.0	0.867
1.00	540.0	0.869
1.00	520.0	0.870
1.00	500.0	0.872
1.00	480.0	0.874
1.00	460.0	0.876
1.00	440.0	0.879
1.00	420.0	0.882
1.00	400.0	0.885
1.00	380.0	0.889
1.00	360.0	0.894
1.00	340.0	0.899
1.00	320.0	0.905
1.00	300.0	0.912
1.00	280.0	0.920
1.00	260.0	0.928
1.00	240.0	0.937
1.00	220.0	0.946
1.00	200.0	0.954
1.00	175.0	0.961
1.00	150.0	0.967
1.00	125.0	0.971
1.00	100.0	0.975
1.00	70.0	0.975
1.00	50.0	0.979
1.00	14.0	0.953
2.00	705.0	0.873
2.00	650.0	0.889
2.00	600.0	0.904
2.00	580.0	0.910
2.00	560.0	0.916
2.00	540.0	0.922
2.00	520.0	0.929
2.00	500.0	0.935
2.00	480.0	0.942
2.00	460.0	0.948
2.00	440.0	0.955
2.00	420.0	0.962

2.00	400.0	0.969
2.00	380.0	0.976
2.00	360.0	0.984
2.00	340.0	0.991
2.00	320.0	0.999
2.00	300.0	1.006
2.00	280.0	1.014
2.00	260.0	1.022
2.00	240.0	1.030
2.00	220.0	1.037
2.00	200.0	1.045
2.00	175.0	1.053
2.00	150.0	1.060
2.00	125.0	1.064
2.00	100.0	1.063
2.00	70.0	1.050
2.00	50.0	1.029
2.00	14.0	0.927
3.00	705.0	0.966
3.00	650.0	0.974
3.00	600.0	0.981
3.00	580.0	0.984
3.00	560.0	0.987
3.00	540.0	0.990
3.00	520.0	0.992
3.00	500.0	0.995
3.00	480.0	0.998
3.00	460.0	1.000
3.00	440.0	1.002
3.00	420.0	1.004
3.00	400.0	1.007
3.00	380.0	1.008
3.00	360.0	1.010
3.00	340.0	1.011
3.00	320.0	1.013
3.00	300.0	1.013
3.00	280.0	1.014
3.00	260.0	1.014
3.00	240.0	1.013
3.00	220.0	1.012
3.00	200.0	1.010
3.00	175.0	1.006
3.00	150.0	1.001
3.00	125.0	0.992
3.00	100.0	0.979
3.00	70.0	0.955

3.00	50.0	0.927
3.00	14.0	0.802
4.00	705.0	1.013
4.00	650.0	1.013
4.00	600.0	1.012
4.00	580.0	1.012
4.00	560.0	1.012
4.00	540.0	1.012
4.00	520.0	1.012
4.00	500.0	1.011
4.00	480.0	1.011
4.00	460.0	1.010
4.00	440.0	1.010
4.00	420.0	1.009
4.00	400.0	1.008
4.00	380.0	1.007
4.00	360.0	1.006
4.00	340.0	1.004
4.00	320.0	1.003
4.00	300.0	1.001
4.00	280.0	0.999
4.00	260.0	0.997
4.00	240.0	0.994
4.00	220.0	0.991
4.00	200.0	0.987
4.00	175.0	0.981
4.00	150.0	0.973
4.00	125.0	0.964
4.00	100.0	0.951
4.00	70.0	0.930
4.00	50.0	0.908
4.00	14.0	0.832
5.00	705.0	0.998
5.00	650.0	1.000
5.00	600.0	1.001
5.00	580.0	1.001
5.00	560.0	1.002
5.00	540.0	1.002
5.00	520.0	1.002
5.00	500.0	1.003
5.00	480.0	1.003
5.00	460.0	1.003
5.00	440.0	1.003
5.00	420.0	1.003
5.00	400.0	1.003
5.00	380.0	1.002

5.00	360.0	1.002
5.00	340.0	1.001
5.00	320.0	1.001
5.00	300.0	1.000
5.00	280.0	0.999
5.00	260.0	0.997
5.00	240.0	0.995
5.00	220.0	0.993
5.00	200.0	0.990
5.00	175.0	0.986
5.00	150.0	0.980
5.00	125.0	0.972
5.00	100.0	0.962
5.00	70.0	0.943
5.00	50.0	0.925
5.00	14.0	0.857
6.00	705.0	0.967
6.00	650.0	0.975
6.00	600.0	0.982
6.00	580.0	0.985
6.00	560.0	0.988
6.00	540.0	0.991
6.00	520.0	0.993
6.00	500.0	0.996
6.00	480.0	0.998
6.00	460.0	1.000
6.00	440.0	1.002
6.00	420.0	1.004
6.00	400.0	1.006
6.00	380.0	1.007
6.00	360.0	1.009
6.00	340.0	1.010
6.00	320.0	1.011
6.00	300.0	1.011
6.00	280.0	1.011
6.00	260.0	1.010
6.00	240.0	1.009
6.00	220.0	1.008
6.00	200.0	1.006
6.00	175.0	1.002
6.00	150.0	0.997
6.00	125.0	0.990
6.00	100.0	0.981
6.00	70.0	0.967
6.00	50.0	0.974
6.00	14.0	0.856

7.00	705.0	0.990
7.00	650.0	0.991
7.00	600.0	0.991
7.00	580.0	0.991
7.00	560.0	0.991
7.00	540.0	0.991
7.00	520.0	0.992
7.00	500.0	0.992
7.00	480.0	0.992
7.00	460.0	0.992
7.00	440.0	0.992
7.00	420.0	0.992
7.00	400.0	0.992
7.00	380.0	0.992
7.00	360.0	0.992
7.00	340.0	0.992
7.00	320.0	0.992
7.00	300.0	0.992
7.00	280.0	0.992
7.00	260.0	0.992
7.00	240.0	0.992
7.00	220.0	0.992
7.00	200.0	0.991
7.00	175.0	0.990
7.00	150.0	0.988
7.00	125.0	0.986
7.00	100.0	0.984
7.00	70.0	0.985
7.00	50.0	0.989
7.00	14.0	1.103
8.00	705.0	0.969
8.00	650.0	0.973
8.00	600.0	0.977
8.00	580.0	0.979
8.00	560.0	0.980
8.00	540.0	0.982
8.00	520.0	0.984
8.00	500.0	0.985
8.00	480.0	0.987
8.00	460.0	0.988
8.00	440.0	0.990
8.00	420.0	0.991
8.00	400.0	0.993
8.00	380.0	0.994
8.00	360.0	0.995
8.00	340.0	0.997

8.00	320.0	0.998
8.00	300.0	0.999
8.00	280.0	1.000
8.00	260.0	1.001
8.00	240.0	1.001
8.00	220.0	1.001
8.00	200.0	1.001
8.00	175.0	1.000
8.00	150.0	0.998
8.00	125.0	0.994
8.00	100.0	0.988
8.00	70.0	0.976
8.00	50.0	0.963
8.00	14.0	0.908

Appendix E. Fish Habitat Preference Curves

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Fishcrv for E.F. Lewis approved by Hal Beecher 12-3-98
H    101  9  7 75  0 Chinook                              Spawning
V    101  0.00  0.00  0.50  0.00  1.00  0.10  1.30  0.70  1.75  1.00  3.00  1.00
V    101  3.50  0.70  4.00  0.00 99.90  0.00
D    101  0.00  0.00  0.50  0.00  1.00  0.75  1.20  1.00  3.40  1.00  5.00  0.00
D    101 99.90  0.00
S   101  0.10  0.00 12.50  0.00 14.80  0.20 15.50  0.50 15.80  0.20 16.50  0.50
S   101 17.50  0.15 17.90  0.03 18.50  0.00 22.90  0.00 23.50  0.15 23.90  0.03
S   101 24.50  0.50 24.80  0.20 25.50  0.50 25.60  0.40 26.50  0.50 26.90  0.10
S   101 27.50  0.15 27.80  0.06 28.60  0.00 29.50  0.00 31.70  0.21 34.80  0.44
S   101 42.50  0.50 42.80  0.80 43.50  0.65 45.50  1.00 46.80  1.00 48.50  0.50
S   101 51.50  0.50 51.80  0.80 52.50  0.50 52.80  0.80 54.50  1.00 56.80  1.00
S   101 57.50  0.65 57.80  0.86 58.50  0.50 58.60  0.60 61.50  0.50 61.90  0.90
S   101 62.50  0.50 62.90  0.90 64.60  1.00 65.90  1.00 67.50  0.65 67.90  0.93
S   101 68.50  0.50 68.80  0.80 71.50  0.15 71.80  0.24 72.50  0.15 72.90  0.27
S   101 74.50  0.65 74.90  0.37 75.50  0.65 75.90  0.37 76.50  0.65 76.90  0.37
S   101 78.50  0.15 78.80  0.24 81.50  0.00 82.70  0.00 83.80  0.06 84.80  0.20
S   101 84.90  0.10 85.50  0.50 85.90  0.10 86.50  0.50 86.90  0.10 87.50  0.15
S   101 87.90  0.03 88.50  0.00 99.90  0.00
H    102 12  8 87  0 Chinook                              Juvenile
V    102  0.00  0.09  0.20  0.20  0.30  0.26  0.40  0.93  0.60  1.00  1.10  0.90
V    102  1.30  0.75  2.00  0.50  2.20  0.08  2.70  0.03  3.60  0.00 99.00  0.00
D    102  0.00  0.00  0.40  0.00  0.50  0.05  1.00  0.33  1.20  0.50  1.50  0.80
D    102  2.20  1.00 99.00  1.00
S   102  0.10  1.00  0.40  1.00  0.50  0.80  0.80  0.10 12.50  0.10 14.80  0.14
S   102 15.50  0.20 15.80  0.14 16.50  0.30 17.50  0.40 17.90  0.16 18.50  0.55
S   102 18.70  0.37 22.50  0.10 23.90  0.10 24.50  0.20 24.80  0.14 25.50  0.20
S   102 25.60  0.18 26.50  0.30 26.90  0.14 27.50  0.40 27.80  0.22 28.60  0.46
S   102 29.50  0.20 31.70  0.10 34.80  0.14 42.50  0.20 42.80  0.26 43.50  0.20
S   102 45.50  0.30 45.90  0.30 46.60  0.38 46.80  0.34 48.50  0.65 51.50  0.20
S   102 51.80  0.26 52.50  0.20 52.80  0.26 54.50  0.30 54.80  0.30 56.50  0.40
S   102 56.80  0.34 57.50  0.50 57.80  0.38 58.50  0.65 58.60  0.58 61.50  0.30
S   102 61.90  0.46 62.50  0.30 62.90  0.46 64.60  0.42 64.90  0.48 65.50  0.40
S   102 65.90  0.48 67.50  0.60 67.90  0.52 68.50  0.75 68.80  0.60 71.50  0.40
S   102 71.80  0.58 72.50  0.40 72.90  0.64 74.50  0.50 74.90  0.66 75.50  0.50
S   102 75.90  0.66 76.50  0.60 76.90  0.68 78.50  0.85 78.80  0.76 81.50  0.55
S   102 81.90  0.91 82.50  0.55 82.70  0.73 83.80  0.82 84.80  0.86 84.90  0.93
S   102 85.50  0.65 85.90  0.93 86.50  0.75 86.90  0.95 87.50  0.85 87.90  0.97
S   102 88.50  1.00 88.90  1.00 99.90  0.30
H    201 11  9 75  0 Steelhead                            Spawning
V    201  0.00  0.00  1.10  0.45  2.10  0.97  2.90  1.00  3.20  1.00  3.30  0.62
V    201  3.60  0.40  4.00  0.20  4.50  0.10  5.00  0.00 99.00  0.00
D    201  0.00  0.00  0.60  0.00  0.70  0.50  1.00  1.00  1.50  1.00  1.60  0.75
D    201  2.20  0.60  2.40  0.50 99.00  0.50
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S    201  0.10  0.00 12.50  0.00 14.80  0.20 15.50  0.50 15.80  0.80 16.50  0.50
S    201 17.50  0.15 17.90  0.03 18.50  0.00 22.90  0.00 23.50  0.25 23.90  0.05
S    201 24.50  0.50 24.80  0.20 25.50  0.50 25.60  0.40 26.50  0.50 26.90  0.10
S    201 27.50  0.15 27.80  0.06 28.60  0.00 29.50  0.00 31.70  0.35 34.80  0.60
S    201 42.50  0.50 42.80  0.80 43.50  0.75 45.50  1.00 46.80  1.00 48.50  0.50
S    201 51.50  0.50 51.80  0.80 52.50  0.50 52.80  0.80 54.50  1.00 56.80  1.00
S    201 57.50  0.65 57.80  0.86 58.50  0.50 58.60  0.60 61.50  0.50 61.90  0.90
S    201 62.50  0.50 62.90  0.90 64.60  1.00 65.90  1.00 67.50  0.65 67.90  0.93
S    201 68.50  0.50 68.80  0.80 71.50  0.15 71.80  0.24 72.50  0.15 72.90  0.27
S    201 74.50  0.65 74.90  0.37 75.50  0.65 75.90  0.37 76.50  0.65 76.90  0.37
S    201 78.50  0.15 78.80  0.24 81.50  0.00 82.70  0.00 83.80  0.10 84.80  0.20
S    201 84.90  0.10 85.50  0.50 85.90  0.10 86.50  0.50 86.90  0.10 87.50  0.15
S    201 87.90  0.03 88.50  0.00 99.90  0.00
H     202 13 14 87  0 Steelhead                          Juvenile
V     202  0.00  0.23  0.20  0.30  0.50  0.50  0.90  0.80  1.30  1.00  1.50  0.97
V     202  2.40  0.80  3.00  0.35  3.60  0.22  3.70  0.19  5.00  0.16  6.00  0.00
V     202 99.00  0.00
D     202  0.00  0.00  0.50  0.03  0.70  0.07  0.90  0.11  1.10  0.25  1.60  0.35
D     202  1.90  0.40  2.10  0.65  2.20  0.85  2.50  0.90  2.60  1.00  3.40  0.86
D     202  4.50  0.64 99.00  0.64
S    202  0.10  1.00  0.40  1.00  0.50  0.80  0.80  0.10 12.50  0.10 14.80  0.14
S    202 15.50  0.20 15.80  0.14 16.50  0.30 17.50  0.40 17.90  0.16 18.50  0.55
S    202 18.70  0.37 22.50  0.10 23.90  0.10 24.50  0.20 24.80  0.14 25.50  0.20
S    202 25.60  0.18 26.50  0.30 26.90  0.14 27.50  0.40 27.80  0.22 28.60  0.46
S    202 29.50  0.20 31.70  0.10 34.80  0.14 42.50  0.20 42.80  0.26 43.50  0.20
S    202 45.50  0.30 45.90  0.30 46.60  0.38 46.80  0.34 48.50  0.65 51.50  0.20
S    202 51.80  0.26 52.50  0.20 52.80  0.26 54.50  0.30 54.80  0.30 56.50  0.40
S    202 56.80  0.34 57.50  0.50 57.80  0.38 58.50  0.65 58.60  0.58 61.50  0.30
S    202 61.90  0.46 62.50  0.30 62.90  0.46 64.60  0.42 64.90  0.48 65.50  0.40
S    202 65.90  0.48 67.50  0.60 67.90  0.52 68.50  0.75 68.80  0.60 71.50  0.40
S    202 71.80  0.58 72.50  0.40 72.90  0.64 74.50  0.50 74.90  0.66 75.50  0.50
S    202 75.90  0.66 76.50  0.60 76.90  0.68 78.50  0.85 78.80  0.76 81.50  0.55
S    202 81.90  0.91 82.50  0.55 82.70  0.73 83.80  0.82 84.80  0.86 84.90  0.93
S    202 85.50  0.65 85.90  0.93 86.50  0.75 86.90  0.95 87.50  0.85 87.90  0.97
S    202 88.50  1.00 88.90  1.00 99.90  0.30
H     301 13 11 75  0 Coho                              Spawning
V     301  0.00  0.00  0.20  0.00  0.25  0.40  0.40  0.59  0.75  0.80  1.00  0.92
V     301  1.10  0.98  1.20  1.00  2.00  1.00  2.25  0.42  3.40  0.16  4.20  0.00
V     301 99.00  0.00
D     301  0.00  0.00  0.20  0.00  0.40  0.04  0.55  0.08  0.65  0.16  0.75  0.40
D     301  0.95  0.80  1.00  1.00  3.40  1.00  4.00  0.10 99.00  0.00
S    301  0.10  0.00 12.50  0.00 14.80  0.20 15.50  0.50 15.80  0.20 16.50  0.50
S    301 17.50  0.15 17.90  0.03 18.50  0.00 22.90  0.00 23.50  0.15 23.90  0.03
S    301 24.50  0.50 24.80  0.20 25.50  0.50 25.60  0.40 26.50  0.50 26.90  0.10
S    301 27.50  0.15 27.80  0.06 28.60  0.00 29.50  0.00 31.70  0.21 34.80  0.44
S    301 42.50  0.50 42.80  0.80 43.50  0.65 45.50  1.00 46.80  1.00 48.50  0.50
```

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S    301 51.50  0.50 51.80  0.80 52.50  0.50 52.80  0.80 54.50  1.00 56.80  1.00
S    301 57.50  0.65 57.80  0.86 58.50  0.50 58.60  0.60 61.50  0.50 61.90  0.90
S    301 62.50  0.50 62.90  0.90 64.60  1.00 65.90  1.00 67.50  0.65 67.90  0.93
S    301 68.50  0.50 68.80  0.80 71.50  0.15 71.80  0.24 72.50  0.15 72.90  0.27
S    301 74.50  0.65 74.90  0.37 75.50  0.65 75.90  0.37 76.50  0.65 76.90  0.37
S    301 78.50  0.15 78.80  0.24 81.50  0.00 82.70  0.00 83.80  0.06 84.80  0.20
S    301 84.90  0.10 85.50  0.50 85.90  0.10 86.50  0.50 86.90  0.10 87.50  0.15
S    301 87.90  0.03 88.50  0.00 99.90  0.00
H    401 12  8 75  0 Chum                          Spawning
V    401  0.00  0.09  0.20  0.10  0.40  0.20  0.80  0.40  1.90  1.00  2.20  1.00
V    401  2.70  0.80  3.20  0.70  3.50  0.35  3.70  0.10  5.00  0.00 99.00  0.00
D    401  0.00  0.00  0.40  0.17  0.70  1.00  1.50  1.00  1.80  0.44  2.50  0.23
D    401  5.00  0.00 99.00  0.00
S    401  0.10  0.00 12.50  0.00 14.80  0.20 15.50  0.50 15.80  0.20 16.50  0.50
S    401 17.50  0.15 17.90  0.03 18.50  0.00 22.90  0.00 23.50  0.15 23.90  0.03
S    401 24.50  0.50 24.80  0.20 25.50  0.50 25.60  0.40 26.50  0.50 26.90  0.10
S    401 27.50  0.15 27.80  0.06 28.60  0.00 29.50  0.00 31.70  0.21 34.80  0.44
S    401 42.50  0.50 42.80  0.80 43.50  0.65 45.50  1.00 46.80  1.00 48.50  0.50
S    401 51.50  0.50 51.80  0.80 52.50  0.50 52.80  0.80 54.50  1.00 56.80  1.00
S    401 57.50  0.65 57.80  0.86 58.50  0.50 58.60  0.60 61.50  0.50 61.90  0.90
S    401 62.50  0.50 62.90  0.90 64.60  1.00 65.90  1.00 67.50  0.65 67.90  0.93
S    401 68.50  0.50 68.80  0.80 71.50  0.15 71.80  0.24 72.50  0.15 72.90  0.27
S    401 74.50  0.65 74.90  0.37 75.50  0.65 75.90  0.37 76.50  0.65 76.90  0.37
S    401 78.50  0.15 78.80  0.24 81.50  0.00 82.70  0.00 83.80  0.06 84.80  0.20
S    401 84.90  0.10 85.50  0.50 85.90  0.10 86.50  0.50 86.90  0.10 87.50  0.15
S    401 87.90  0.03 88.50  0.00 99.90  0.00
H    501 10 12 75  0 Pink                          Spawning
V    501  0.00  0.30  0.39  0.60  0.40  0.70  0.79  0.90  0.80  1.00  0.99  1.00
V    501  1.00  0.90  1.80  0.80  5.00  0.00 99.00  0.00
D    501  0.00  0.00  0.49  0.80  0.50  1.00  0.69  1.00  0.70  1.00  0.99  0.80
D    501  1.00  0.79  1.20  0.60  1.30  0.30  2.10  0.05  5.00  0.01 99.00  0.00
S    501  0.10  0.00 12.50  0.00 14.80  0.20 15.50  0.50 15.80  0.20 16.50  0.50
S    501 17.50  0.15 17.90  0.03 18.50  0.00 22.90  0.00 23.50  0.15 23.90  0.03
S    501 24.50  0.50 24.80  0.20 25.50  0.50 25.60  0.40 26.50  0.50 26.90  0.10
S    501 27.50  0.15 27.80  0.06 28.60  0.00 29.50  0.00 31.70  0.21 34.80  0.44
S    501 42.50  0.50 42.80  0.80 43.50  0.65 45.50  1.00 46.80  1.00 48.50  0.50
S    501 51.50  0.50 51.80  0.80 52.50  0.50 52.80  0.80 54.50  1.00 56.80  1.00
S    501 57.50  0.65 57.80  0.86 58.50  0.50 58.60  0.60 61.50  0.50 61.90  0.90
S    501 62.50  0.50 62.90  0.90 64.60  1.00 65.90  1.00 67.50  0.65 67.90  0.93
S    501 68.50  0.50 68.80  0.80 71.50  0.15 71.80  0.24 72.50  0.15 72.90  0.27
S    501 74.50  0.65 74.90  0.37 75.50  0.65 75.90  0.37 76.50  0.65 76.90  0.37
S    501 78.50  0.15 78.80  0.24 81.50  0.00 82.70  0.00 83.80  0.06 84.80  0.20
S    501 84.90  0.10 85.50  0.50 85.90  0.10 86.50  0.50 86.90  0.10 87.50  0.15
S    501 87.90  0.03 88.50  0.00 99.90  0.00
```

Appendix F. Substrate and Cover Codes

Instream Flow Studies Substrate and Cover Code Application
November 23, 1987

The three-digit code used describes the dominant substrate (the first number, the subdominant substrate (the second number), and the percent of only the dominant substrate (the third number). The percent of the sulxiominant substrate can be determined by subtraction. Dominant substrate is determined by the largest quantity of a certain substrate not the size of the substrate. The sum of the percent dominant and the percent sulxiominant will total 100 percent. The coding will not allow the dominant percent to be less than 50 percent, or greater than 90 percent. All other preference values are determined by using weighted averages. The value of the dominant substrate is multiplied by the percent of the dominant substrate, and the product is added to the product of the subdominant substrate times the percent of subdominant substrate. The sum of all the codes observed times their preference value will be a value between 0.0 and 1.0. The coding should also give a preference value of zero for the entire substrate observation when the code is class zero, one, or two, and is 50 percent or more of the observation. Where there is a situation where addition of two values could equal more than 1.0, the value will default to 1.0. Overhanging vegetation should be counted as cover if it is within 3 to 4 feet of the water surface. Cover values should be incorporated with the substrate values for both salmon and steelhead juvenile life stages and for Chinook and steelhead adult holding.

Life Stage and Value of Substrate

		Salmon			Steelhead and Trout			
					Spawning		Rearing/Holding	
Code	**Substrate Size In Inches**	**Juvenile Rearing**	**Spawning**	**Adult Holding**	**Steelhead**	**Trout**	**Juvenile & Adult**	**Steelh Adult**
0	**Detritus**	**.1**	**0**	**.1**	**0**	**0**	**.1**	**.1**
1	**Silt, Clay**	**.1**	**0**	**.1**	**0**	**0**	**.1**	**.1**
2	**Sand**	**.1**	**0**	**.1**	**0**	**0**	**.1**	**.1**
3	**Small Gravel .1-0.5**	**.1**	**.3**	**.1**	**.5**	**1**	**.1**	**.1**
4	**Medium Gravel .5-1.5**	**.3**	**1**	**.3**	**1.0**	**1**	**.3**	**.3**
5	**Large Gravel. 1.5-3.0**	**.3**	**1**	**.3**	**1.0**	**1**	**.3**	**.3**
6	**Small Cobble 3.0-6.0**	**.5**	**1**	**.3**	**1.0**	**.5**	**.5**	**.3**
7	**Large Cobble 6.0-12.0**	**.7**	**.3***	**.3**	**.3**	**.0**	**.7**	**.3**
8	**Boulder**	**1.0**	**0**	**1.0**	**0**	**0**	**1.0**	**1.0**
9	**Bedrock**	**.3**	**0**	**.3**	**0**	**0**	**.3**	**.3**
0.1	**Undercut Bank**	**1.0**	**0**	**1.0**	**0**	**0**	**1.0**	**1.0**
0.2	**Overhanging Vegetation**	**1.0**	**0**	**1.0**	**0**	**0**	**1.0**	**1.0**
0.3	**Root Wad**	**1.0**	**0**	**1.0**	**0**	**0**	**1.0**	**1.0**
0.4	**Log Jam**	**1.0**	**0**	**1.0**	**0**	**0**	**1.0**	**1.0**
0.5	**Log Instream**	**.8**	**0**	**.8**	**0**	**0**	**.8**	**.3**
0.6	**Submerged Vegetation**	**1.0**	**0**	**.8**	**0**	**0**	**1.0**	**.8**
0.8	**Grass/Bushes Up on Bank**	**.1**	**0**	**.1**	**0**	**0**	**.1**	**.1**
0.9	**Fine Organic Substrate**	**.1**	**0**	**.1**	**0**	**0**	**.1**	**.1**

(*0.6 for chinook spawning can be used, depending on river size)