FINAL

PRELIMINARY SAWMILL CREEK INSTREAM FLOW REPORT
Blue Lake Hydroelectric Project (FERC No. 2230)

Prepared for:

City and Borough of Sitka Electric Department

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INTRODUCTION

This report documents progress on the application of the Physical Habitat Simulation (PHABSIM) component of the Instream Flow Incremental Methodology (IFIM) on Sawmill Creek near Sitka, Alaska. This study is being completed as part of the relicensing for the Blue Lake hydroelectric Project (Project), Federal Energy Regulatory Commission (FERC) No. 2230, operated by the City and Borough of Sitka Electric Department (City). The Project's FERC license (held by the City and Borough of Sitka) expires in March, 2008, and application material for a new license requires study of Project effects on various resources, including Sawmill Creek fisheries. This report, documenting initial IFIM field work and data processing, is the first in a series of reports documenting effects of altered streamflow on Sawmill Creek fisheries.

INSTREAM FLOW STUDY PLANNING BACKGROUND

Initial study planning for the instream flow component of the relicensing has proceeded since December, 2001, with preparation and revision of a number of study plans as described in the following section. Study planning specifically for the Sawmill Creek instream flow work dates to October 22, 2003 and an interagency meeting in Sitka to discuss instream flow methods (see Blue Lake Project website). Minutes of that meeting were distributed by the City on November 25, 2003.

An additional instream flow meeting was held in Juneau, Alaska on December 8, 2003 with minutes distributed on December 12, 2003. A Draft Instream Flow Study Plan, distributed on February 26, 2004, proposed two methods, one based on hydraulic habitat measurement and the other based on the U.S. Forest Service (USFS) Expert Habitat Mapping (EHM) technique. Later study planning focused primarily on hydraulic habitat measurements and application of PHABSIM field measurement and computer analysis techniques.

To familiarize participants with Sawmill Creek aquatic habitats, the City conducted a site visit on March 4, 2004. Participants visited all Sawmill Creek designated stream reaches and were shown major habitat and structural features as well as areas of primary fish utilization.

Further agency consultation resulted in issuance of a Supplement to Instream Flow Study Plan on April 9, 2004. This document responded to questions and comments received from agencies during the previous months and presented details of the hydraulic measurement-based methodology adopted during the previous months' consultation.

During the following weeks, the City contracted with Miller Ecological Consultants (MEC) of Ft. Collins, Colorado, to conduct the hydraulic measurements described in the April 9 supplement.

On April 20, 2004, agency, City and MEC representatives conducted the site selection for hydraulic measurement cross sections in all applicable Sawmill Creek reaches. Hydraulic measurements, conducted by the City and MEC representatives, as described below, were conducted from April 20-22, 2004.

REPORT OBJECTIVES AND ORGANIZATION

This report provides a brief synopsis on instream flow study planning, Sawmill Creek study reaches, cross section selection, field measurement techniques, data reduction, and initial data processing (model calibration).

The report presents descriptions and results of the April 20-22, 2004, Sawmill Creek field measurements. Only the data entry and computer runs necessary to calibrate the PHABSIM hydraulic model(s) have been performed. No habitat calculations or analyses were performed prior to distribution of this report.

SAWMILL CREEK STREAM REACHES

To better understand references to various stream reaches and features, this section provides a description and map of the six reaches into which fisheries and wildlife researchers have divided Sawmill Creek. These reaches were designated based on similar habitat features (Table 1).

Table 1. Sawmill Creek reach numbering from lower Powerhouse Bridge upstream to base of Blue Lake Project Dam.

Stream Reach and Location (Name)	Identifying Aquatic Habitats and Stream Characteristics
Reach 1	From inlet at SM 0.36 upstream to top of Index Area. (SM 0.43)
Reach 2	Inlet of Index Pool (SM 0.43) to the Pulp Mill Feeder Pool (SM 0.55) (Includes Concrete Area)
Reach 3	Pulp Mill Feeder Outflow pool to the base of the Falls (SM 0.73)
Reach 4	From the top of the Falls to the Slot outflow (SM .75)
Reach 5	From Slot outflow to Fish Valve Unit (SM 1.43)
Reach 6	From the Fish Valve Unit to the base of the Project dam (SM 1.83)

Certain specific names were applied over the course of studies to describe areas or features in which fish were routinely observed, or which offered unique habitats (Table 2). Not all of these features are referenced in this report. They are presented to provide continuity with past fisheries and wildlife reports which have referenced the features.

Table 2. Specific Sawmill Creek sampling features or areas (Reach or sampling area in parentheses, acronyms in bold).

Name of Observation/Sampling Area	Description
Bridge Hold (Reach 1)	A small hold located under and directly below the bridge at SM 0.38
Index Pool (Index Area)	Pool located upstream of bridge at SM 0.38.
Concrete Area **(CA)** (Reach 2)	A long run, pool, and tail out from SM 0.46 to SM 0.49
Pulp Mill Outflow **(PMO)** Pool (Reach 3)	A deep pool just downstream of the Pulp Mill Feeder Unit outflow (SM 0.55)
Pipe Fitting Area **(PFA)** (Reach 3)	A deep run directly upstream of the PMO (SM 0.57)
Wild Bill's Pool **(WBP)** (Reach 3)	A short run, pool, and tail out at SM 0.67
Falls Pool (Reach 3)	A large deep pool located at the base of the Falls (SM 0.73 to SM 0.75)
Slot Pool (Reach 4)	A large pool at SM 0.75 at the base of the Slot
Long Pool (Reach 5)	A long run, pool, and tail out at SM 1.12
Boom Log Area (Reach 5)	A small scour pool at SM 1.32
Campground Bridge Pool **(CBP)** (Reach 5)	A pool at SM 1.37 near the USFS Campground footbridge
Fish valve unit **(FVU)** area (Reach 5)	The stream area adjacent to the FVU
First, Second and Third Pools (Reach 6)	Pools in the lower segment of Reach 6
Beaver Lake Falls **(BLF)** area (Reach 6)	A deep pool at SM 1.95 just below the Beaver Lake Falls-Sawmill Creek confluence (SM 1.62)
Plunge Pool	A deep pool just below Blue Lake Dam (SM 1.83)

MATERIALS AND METHODS

SITE SELECTION

City of Sitka and MEC personnel and representatives from Alaska Department of Fish and Game (ADFG), U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) participated in site selection and cross section placement on April 20, 2004 (Table 3). Karl Wolf (relicensing fisheries consultant) pointed out specific areas of fish utilization and group consensus was used to finalize cross section location.

Table 3. List of individuals participating in field site selection visit.

Name	Group Representing
Dean Orbison	City and Borough of Sitka
Mike Prewitt	City and Borough of Sitka
Karl Wolfe	City and Borough of Sitka
Jon Ptacek	Miller Ecological Consultants, Inc.(City and Borough of Sitka)
Bob Chadwick	Alaska Department of Fish and Game
Shawn Johnson	Alaska Department of Fish and Game
Richard Enriquez	U.S. Fish and Wildlife Service
Kevin Brownlee	Alaska Department of Fish and Game
Katharine Miller	National Marine Fisheries Service

Cross Section Representation

The primary cross section placement objective was to describe specific locations where coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Oncorhynchus mykiss*) had been observed actively spawning (Table 4). The number of spawning cross sections is sufficient to encompass the majority of spawning locations while still maintaining a manageable quantity of sites requiring measurement. The cross sections in Reaches 1-3 were placed to represent all but a small fraction of coho and steelhead spawning areas observed over the previous three study years. (Spawning locations and percentages for each species were described in earlier consultation meetings and the supplement to the instream flow study plan distributed on April 9, 2004).

A single cross section was established in Reach 2 in an area generally representing salmonid rearing habitat. The limited area known to support coho salmon or steelhead rearing in reaches 1-3 restricted the number of areas suitable for placement of cross sections describing rearing habitat.

Cross sections in Reach 4 were placed to represent the dominate habitat types found in that section. A single cross-section in Reach 5 was placed to represent a typical pool type habitat in that reach known to support adult and juvenile rainbow trout.

Cross Section Nomenclature

Cross sections were given names ("Cross Section Codes"), according to the following conventions:

1. A site descriptor acronym was established for each reach as follows:

Concrete Area=CA;
Index Pool=IP;
Pulp Mill Outflow=PMO;
Falls Pool=FP;
Reach 4=RIV;
Reach 5=RV.

2. For each cross-section, these site descriptors were followed by an ordinal number beginning with the most downstream habitat cross section and proceeding upstream (CA1, CA2, etc.). For hydraulic controls, a "C" was used in place of a number. For example, for the set of cross sections at the Concrete Area, the most downstream cross section (hydraulic control) was labeled CAC, the next upstream cross section (habitat) was labeled CA1 and the most upstream (habitat) labeled CA2. The 13 cross sections measured on April 20-22, 2004, and their intended use as controls or to describe specific fish species/life stage habitats, are described in Table 4.

Table 4. Description of instream flow cross sections (cross section code in parentheses).

Reach	Cross Section	Species/Habitat
1	Index Pool (IP1)	Rainbow Juvenile
2	Concrete Area Control (CAC)	Hydraulic Control
2	Concrete Area 1 (CA1)	Coho Spawning
2	Concrete Area 2 (CA2)	Steelhead Spawning
3	Pulp Mill Outflow Control (PMOC)	Hydraulic Control
3	Pulp Mill Outflow 1 (PMO1)	Steelhead, Coho Spawning
3	Pulp Mill Outflow 2 (PMO2)	Steelhead, Rainbow Spawning
3	Falls Pool 1 (FP1)	Hydraulic Control, Steelhead Spawning
3	Falls Pool 2 (FP2)	Steelhead Spawning
3	Falls Pool 3 (FP3)	Coho Spawning
4	Reach 4, Riffle (RIV-1)	Riffle
4	Reach 4, Run (RIV-2)	Run
5	Reach 5 (RV-1)	Rainbow Juvenile

FIELD MEASUREMENTS

Field surveys of hydraulic data occurred from April 20-22, 2004. Personnel from MEC and the City conducted all field measurements.

At each habitat and hydraulic cross section established during the site selection visit, a measuring tape was stretched across the river and attached to a rebar, screw eye or other attachment (headpin) representing the end of that specific cross section. Linear distance (stationing) from the initial headpin ("zero point") was recorded for all measured parameters across each cross section. Ground points (wetted channel and overbank) and water surface elevations were surveyed using a Nikon automatic level. Water surface elevations were measured to the nearest 0.01 ft. and ground points were surveyed to the nearest 0.1 ft. All surveys followed general guidelines presented in Bovee (1997). Within the stream channel, depth and mean column velocity were measured at 1-5 foot intervals across the wetted portion of the river.

Two water velocity meters were available:

1. A Price-AA velocity meter (model recommend by ADFG personnel) without digital recorder; and
2. A Swoffer Model 2100 with direct readout. The Swoffer meter uses fiber optics and an electronic counting/averaging device to count propeller revolutions.

Bovee (1997) recommends the use of an electronic counting device to increase accuracy and efficiency of velocity measurements. Prior to water velocity measurements, we compared to the Price-AA velocity meter readings (based on click-counting) with the direct readout from the Swoffer meter to determine if there were significant differences between the two meters (Table 5).

Table 5. Comparison between Swoffer Model 2100 flow meter and Price-AA flow meter.

Comparison	Swoffer Model 2100 (ft/s)	Price-AA (ft/s)	Difference
1	1.08	1.02	0.06
2	2.27	2.20	0.07
3	0.64	0.73	-0.09

Note: Depths for all comparisons ranged from 1.0-1.2 ft.

Site selection participants agreed that the Swoffer meter accurately calculated velocities when compared to the Price-AA. The Swoffer velocity meter and topset rod were used for all velocity profile measurements.

At depths less than 2.5 ft. velocities were measured at 6/10 of the depth and at depths greater than 2.5 feet, velocities were measured at 2/10 and 8/10 of the depth and a mean column velocity calculated. At each depth and velocity measurement point on the cross section, dominant and subdominant substrate were visually determined and recorded according to standard particle size descriptions (Table 6). During low flow velocity measurements at RIV-2, a piece of moss became entangled in the meters' propeller. We did not have the equipment on site to remove all the moss from the unit so measurements

were stopped until the meter was functional. As a result we did not get a full set of velocity measurements during the low flow survey for this cross section.

Table 6. Substrate codes used during field measurements.

Substrate Code	Description
BR	Bedrock
SB	Small boulder
B	Boulder
LB	Large boulder
SC	Small cobble
C	Cobble
LC	Large cobble
SG	Small gravel
G	Gravel
LG	Large gravel
S	Sand

Water surface elevations and velocity profiles were measured at two different stream discharges. Stream discharge data were based on stage readings at the power plant (Lower Staff Gage) and at the USFS campground footbridge (Upper Staff Gage) (Table 7). The most significant tributary inflow was on the right bank (looking downstream) in Reach 4, between cross sections RIV-1 and RIV-2. For modeling purposes, cross sections downstream of RIV-1 were associated with Lower Staff Gage discharge data and those upstream of RIV-1 were associated with Upper Staff Gage discharge data (Table 8). Discharges for the low flow survey ranged from 53-58 cfs; those for the high flow survey ranged between 105-112 cfs.

Table 7. Staff gage readings collected during field measurements, April 2004.

Date	Time (24 hr)	Lower Staff Gage	Upper Staff Gage
20-Apr-04	0730	58	53
21-Apr-04	0800	58	53
21-Apr-04	1445	56	54
21-Apr-04	1620	108	105
21-Apr-04	1700	108	105
21-Apr-04	1815	109	
22-Apr-04	2000	112	105

Table 8. Discharge values used at each instream flow site.

Survey Site	Low Flow Survey		High Flow Survey	
	Date	Flow (cfs)	Date	Flow (cfs)
Index Pool	20-Apr-04	58	21-Apr-04	108
Concrete Area	20-Apr-04	58	22-Apr-04	109
Pulp Mill Outflow	21-Apr-04	58	22-Apr-04	109
Falls Pool	21-Apr-04	58	22-Apr-04	109
Reach 4, xsec1	21-Apr-04	56	21-Apr-04	108
Reach 4, xsec2	21-Apr-04	54	21-Apr-04	105
Reach 5	21-Apr-04	54	21-Apr-04	105

Distances between cross sections were measured from headpin to headpin using a cloth tape. Weighting factors for single cross sections were based on known fish utilization, as described onsite by Karl Wolf. For sites with multiple cross sections, weighting factors were determined by noting total distance containing similar stream channel parameters (depth, velocity, and substrate)

COMPUTER ANALYSIS

All field data were entered into a Microsoft Excel spreadsheet and checked for accuracy. The windows based PHABSIM version 1.10 software (USGS Mid-continent Ecological Science Center 2001) was used to conduct the initial hydraulic modeling calibrations.

Water surface elevations for all cross sections were calibrated using either the WSP or MANSQ programs within PHABSIM. Calibration of water surface elevations was accomplished by choosing the parameter value (β for MANSQ, and roughness modifier (RMOD) and N for WSP) which provided the "best fit" to the measured water surface elevations. Calibration was achieved when the difference between modeled water surface elevation and measured water surface elevations was less than ±0.02 foot.

Sites with multiple cross sections and hydraulic controls were modeled using WSP, whereas sites with single (or independent cross sections) were modeled using the MANSQ program. The WSP program requires that water surface elevations for hydraulic controls be defined prior to running the model. Therefore, cross sections using

WSP utilize field survey data (calibration discharges) or MANSQ (simulated discharges) to establish initial water surface elevations.

Stream velocities at unmeasured flows were simulated using the PHASIMS's embedded VELSIM program. This program uses field measured velocity sets to simulate velocities at flows higher and lower than those measured in the field. Based on recommendations regarding the application of velocity calibration sets from Waddle (2001), velocities at discharges less than the measured low flow were simulated using the low flow velocity set as the calibration point. Similarly, velocities at flows higher than the measured high flow were simulated using the high flow velocity set. For discharges between the low and high flow calibration sets, a velocity regression routine within VELSIM was used to simulate velocities. Due to previously-described equipment difficulties, the high flow velocity calibration set was used for all simulated flows at RIV-2.

Simulated velocities were evaluated using two different techniques. First, we visually evaluated velocities over the range of simulation flows to ensure that the values made sense (i.e. cell velocity was greater at 200 cfs than 25 cfs).

The second velocity evaluation technique was to examine the "velocity adjustment factor" (VAF), an output from VELSIM. This factor is an indicator of the difference between the simulated discharge and the computed discharge. The most important feature is not the magnitude of the VAF but the relationship between discharge and VAF. In most cases, VAF should increase as discharge increases; however, it is typical to see a "hiccup" in the VAF when switching between velocity calibration sets. This was evident at most sites between the low flow survey (54-58 cfs) and 75 cfs simulated discharge In addition to the low and high calibration flows, velocities were simulated at discharges of 25, 75, 125, 150 and 200 cfs.

RESULTS

CROSS-SECTION PROFILES

Index Pool

A single cross section (IP1) was placed in the tailout of the Index Pool (Figure 1). This cross section represents juvenile and adult rainbow trout habitat and is characterized by relatively uniform water depth (avg. depth at 58 cfs: 0.8 ft), large substrate (large/small cobble) and moderate velocities (1.5 ft/s at 58 cfs). Wetted channel is approximately 62 ft. wide at 58 cfs (Figure 2).

Figure 1. Index pool site at 58 cfs.

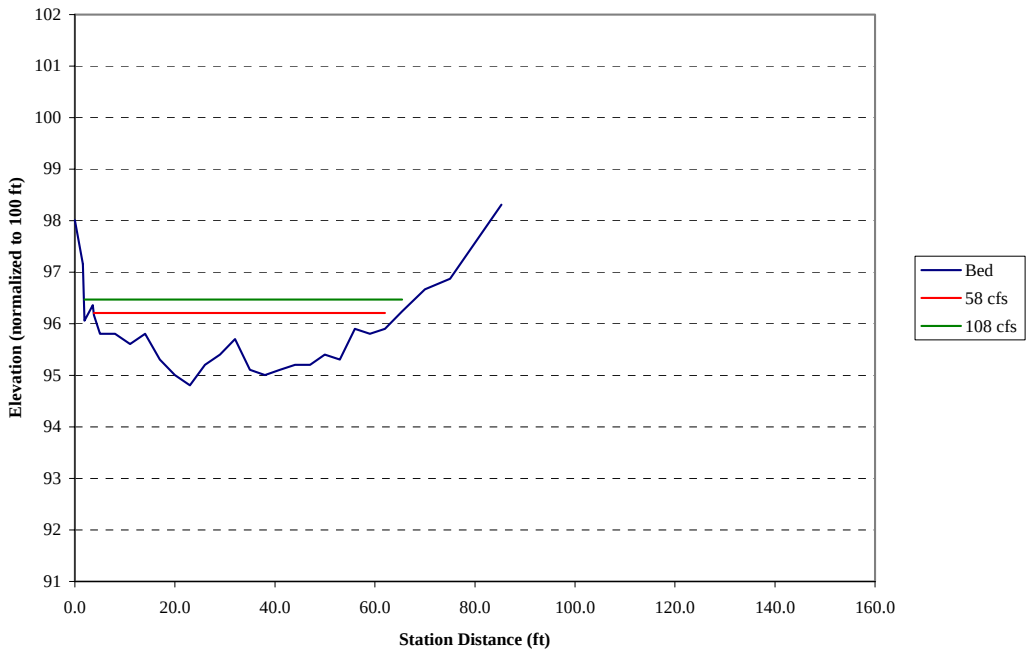

Figure 2. Cross section bed profile (looking upstream) of Index Pool (IP1) at 58 and 108 cfs.

Concrete Area

Three cross sections (CAC, CA1 and CA2) were placed in the Concrete Area to describe steelhead trout and coho salmon spawning habitats (Figure 3). This site offered a well-defined downstream hydraulic control. The river right bank was steep, with large boulder substrate (Figures 4 and 5). The river left side of CA2 was constrained by a vertical slab of concrete at all flows. The channel at CA1 was narrow (wetted channel: 38 ft at 58 cfs) with a deep trough on river right. Substrate was dominated by boulder/cobble; however, the area of fish utilization had areas of gravel interspersed among the cobble. Cross section CA2 contained steelhead trout spawning area on the river left side. Water velocity was slow (avg vel: 0.4 ft/s at 58 cfs) and deep (maximum depth: 2.9 ft) along this cross section. Substrate in the area of steelhead spawning was gravel.

Figure 3. Concrete Area instream flow site at 58 cfs. Due to the picture viewpoint we were unable to adequately portray cross section locations for CAC and CA1.

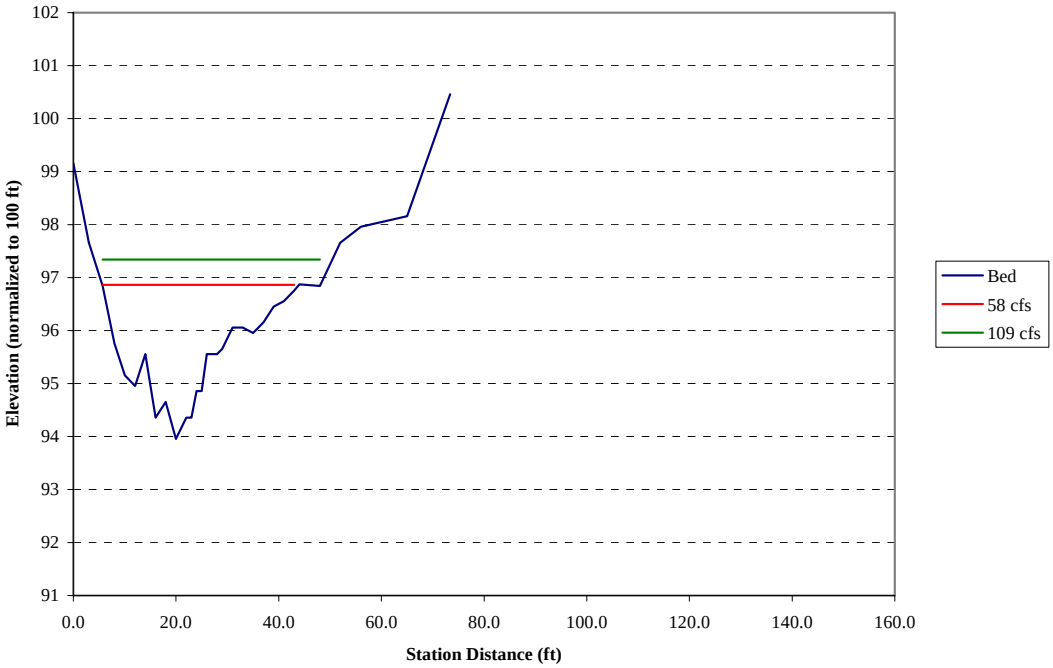

Figure 4. Cross section bed profile (looking upstream) at Concrete Area 1 (CA1) at 58 and 109 cfs.

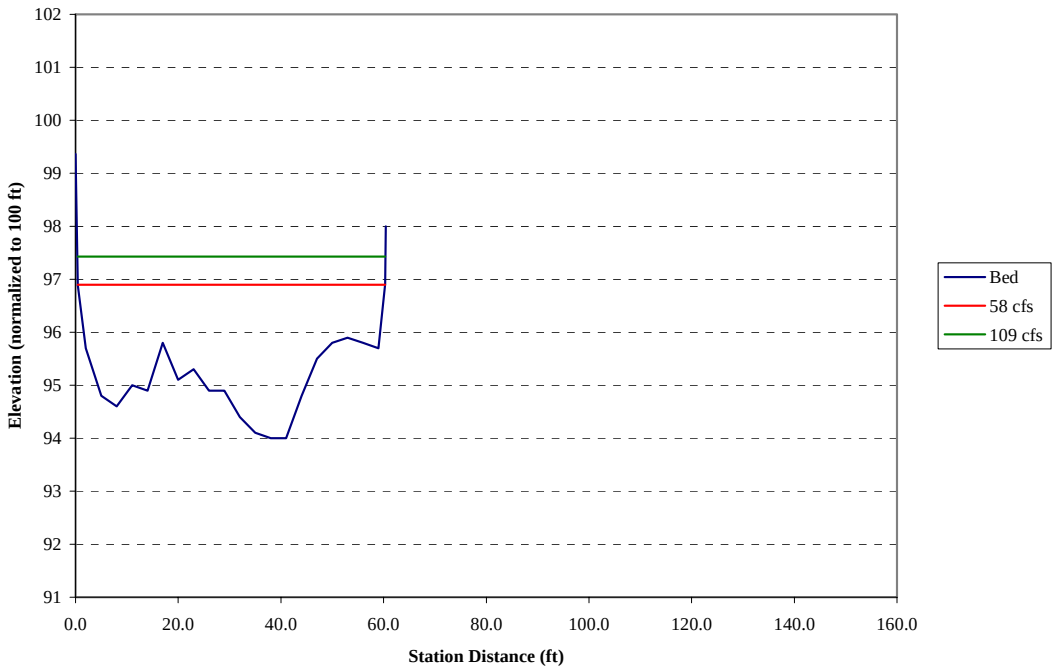

Figure 5. Cross section bed profile (looking upstream) at Concrete Area 2 (CA2) at 58 and 109 cfs.

Pulp Mill Outflow

The Pulp Mill Outflow site contained cross sections within two separate fish observation/sampling areas. Cross section PMO2 was within the Pipe Fitting Area; however, because the hydraulic control for this cross section was the tailout of the Pulp Mill Outflow pool, it was included in the Pulp Mill Outflow site. Cross section PMO1 was a wide (wetted width: 96 ft at 58 cfs) cross section located at the tailout of a large, deep pool (Figures 6 and 8). Cross section PMO2 was located in a deep (avg. depth: 2.3 ft at 58 cfs), narrow (wetted width: 35 ft) run with vertical walls (Figures 7 and 9).

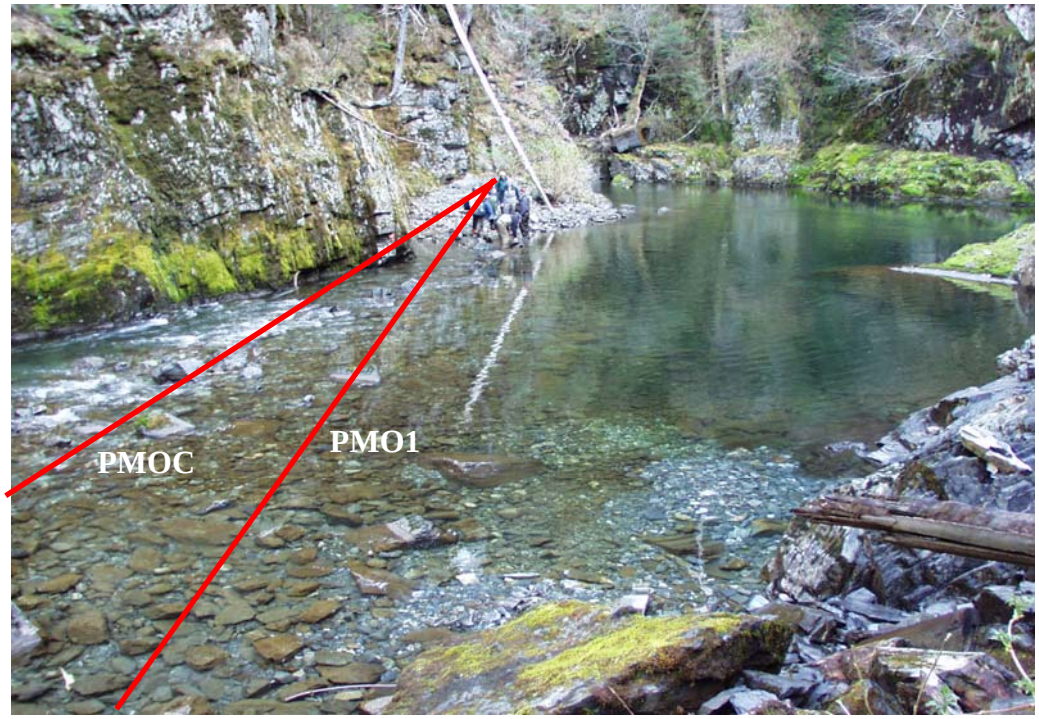

Figure 6. Downstream section of Pulp Mill Outflow instream flow site at 58 cfs.

Figure 7. Upstream section of Pulp Mill Outflow instream flow site at 58 cfs.

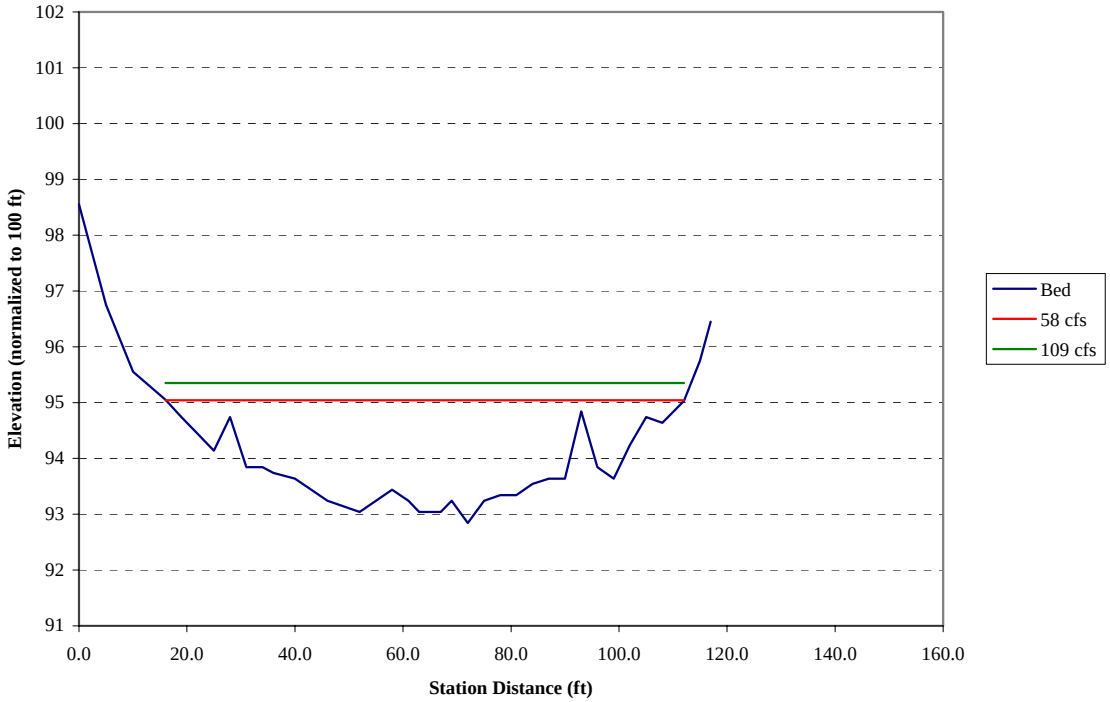

Figure 8. Cross section bed profile (looking upstream) at Pulp Mill Outflow 1 (PMO1) at 58 and 109 cfs.

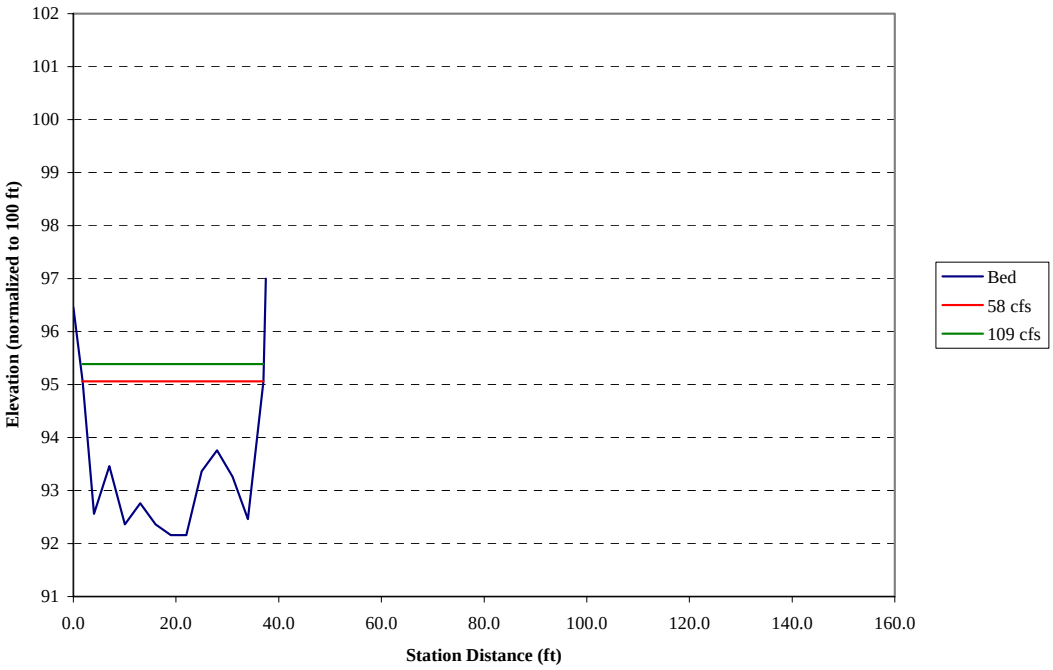

Figure 9. Cross section bed profile (looking upstream) at Pulp Mill Outflow 2 (PMO2) at 58 and 109 cfs.

Falls Pool

The Falls Pool instream flow site contained the majority of fish spawning observations. This site was characterized by a large, deep pool formed at the base of a waterfall which is being evaluated as a potential fish passage barrier (Figure 10). The hydraulic control for this site also represents steelhead spawning habitat so it will be included in the future habitat modeling. All cross sections were located in the tailout of Falls Pool; however, cross section FP3 was along a transition line where at high flows an eddy begins to form along the river left. Cross section FP1 possessed the highest velocities and shallowest depths (Figure 11) followed by FP2 (Figure 12) and FP3, which had the lowest velocities and deepest water depth (Figure 13). Larger substrate classes (boulder/large cobble) were the dominate substrate at cross sections FP1 and FP2. Cross section FP3 contained a significant quantity of gravel and small cobble.

Figure 10. Falls Pool instream flow site at 58 cfs. Due to the picture viewpoint we were unable to adequately portray cross section locations in the Falls Pool.

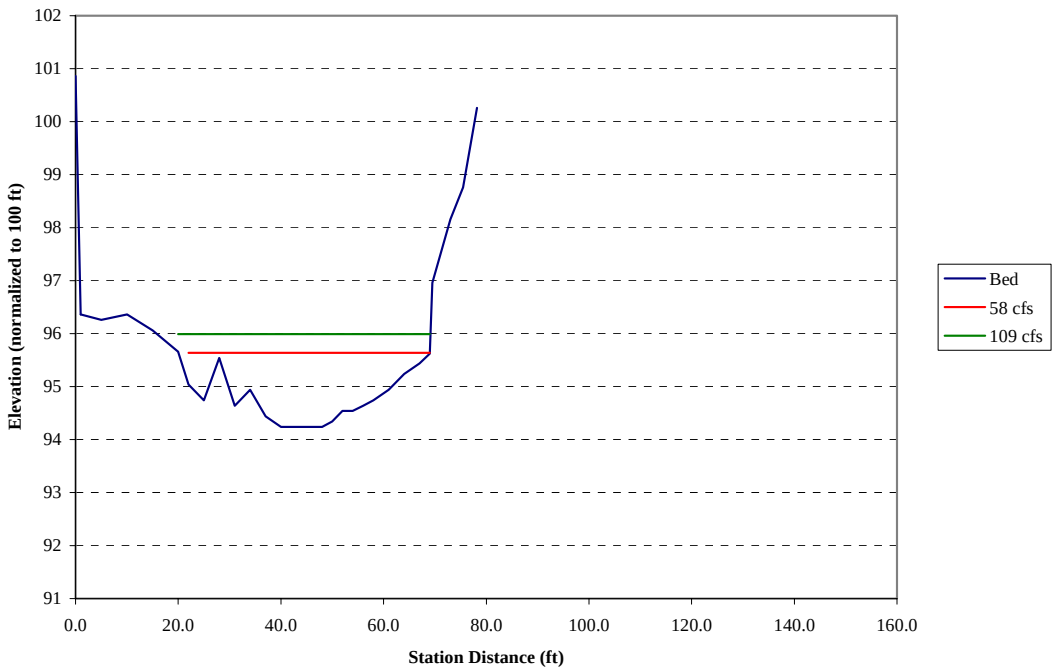

Figure 11. Cross section bed profile (looking upstream) at Falls Pool 1 (FP1) at 58 and 109 cfs.

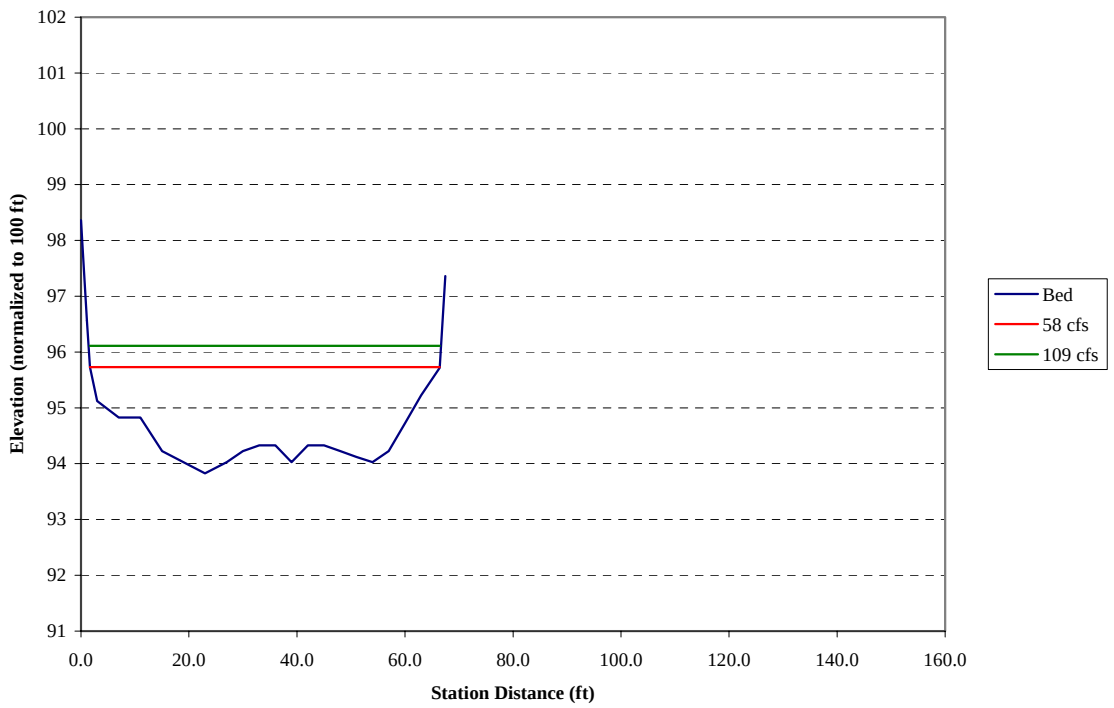

Figure 12. Cross section bed profile looking upstream at Falls Pool 2 (FP2) at 58 and 109 cfs.

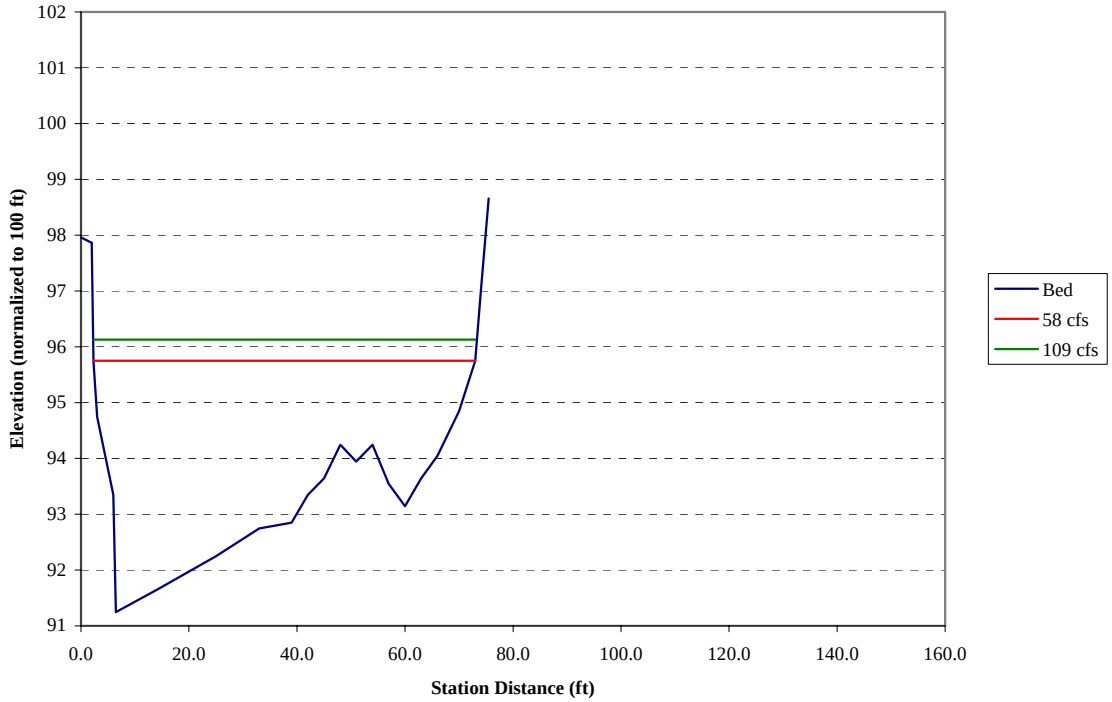

Figure 13. Cross section bed profile looking upstream at Falls Pool 3 (FP3) at 58 and 109 cfs.

Reach 4

Two cross sections were placed in Reach 4 to describe the available macrohabitat within the reach (Figures 14 and 15). Each cross section was surveyed independently and thus were treated as individual cross sections during hydraulic modeling. Cross section RIV-1 described shallow (avg. depth: 0.8 ft at 56 cfs) pocket water riffle habitat (Figure 16). Cross section RIV-2 described run habitat and is located immediately downstream of the Slot Pool (Figure 17).

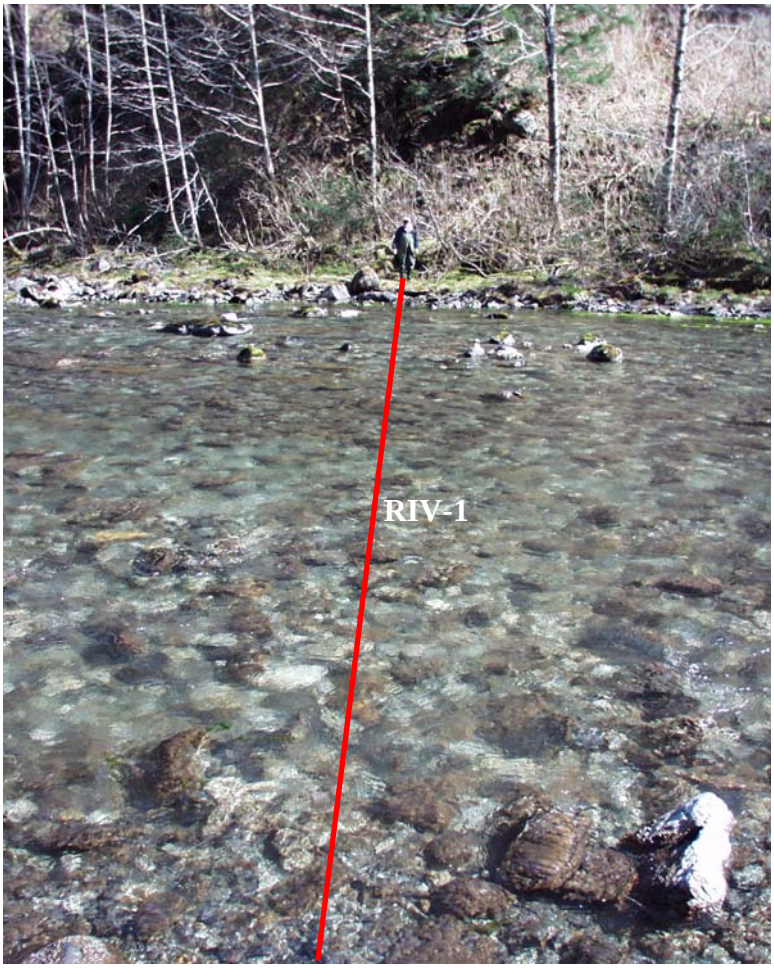

Figure 14. Reach 4, cross section RIV-1 at 56 cfs.

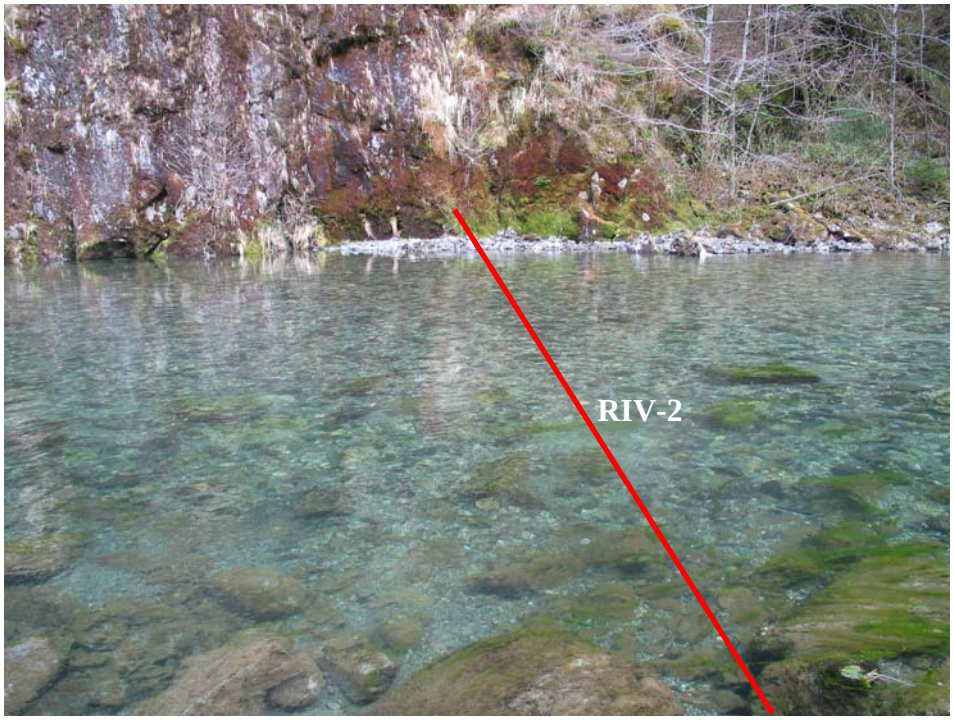

Figure 15. Reach 4, cross section RIV-2 at 54 cfs.

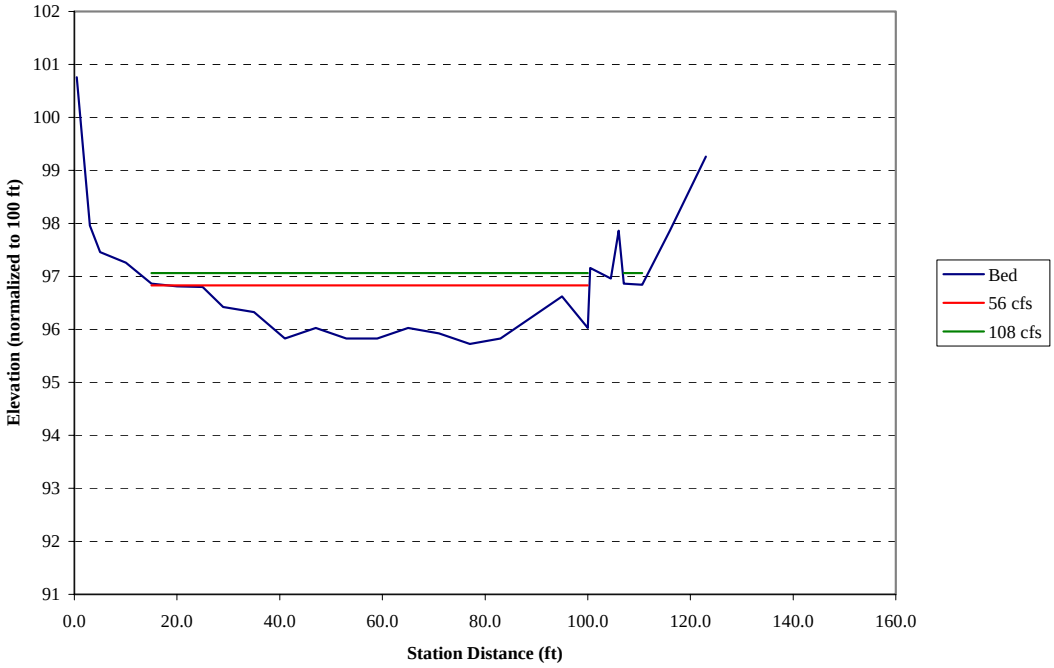

Figure 16. Cross section bed profile (looking upstream) at Reach 4, Riffle (RIV-1) at 56 and 108 cfs.

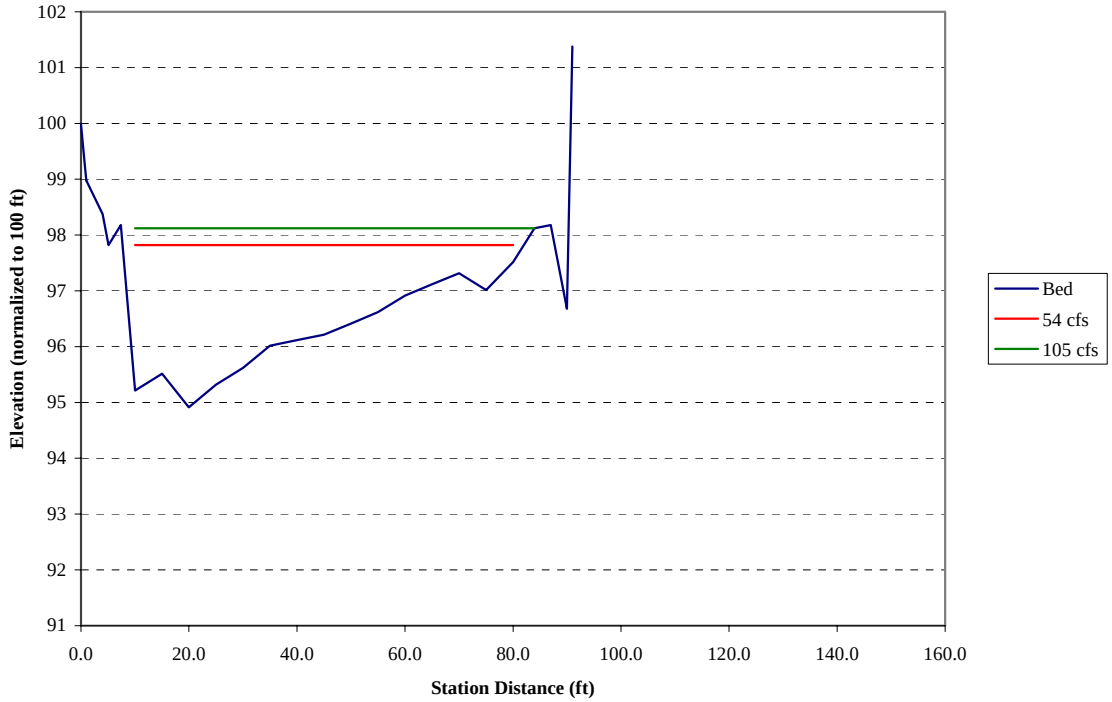

Figure 17. Cross section bed profile at Reach 4, Run (RIV-2) at 54 and 105 cfs.

Reach 5

The single Reach 5 cross section was placed to describe an area of rainbow trout utilization. Cross section RV-1 was located immediately downstream of the USFS campground foot bridge. At 54 cfs, a cobble bar separated the area of fish utilization on the river left from a large backwater existing on the river right (Figure 18). The river left channel had an average depth of 0.9 ft and average velocity of 1.5 ft/s at 54 cfs (Figure 19). The river right backwater was removed from analysis due to difficulties with modeling water velocities. Further discussion on problems with velocities is found in the Computer Analysis section of the Results.

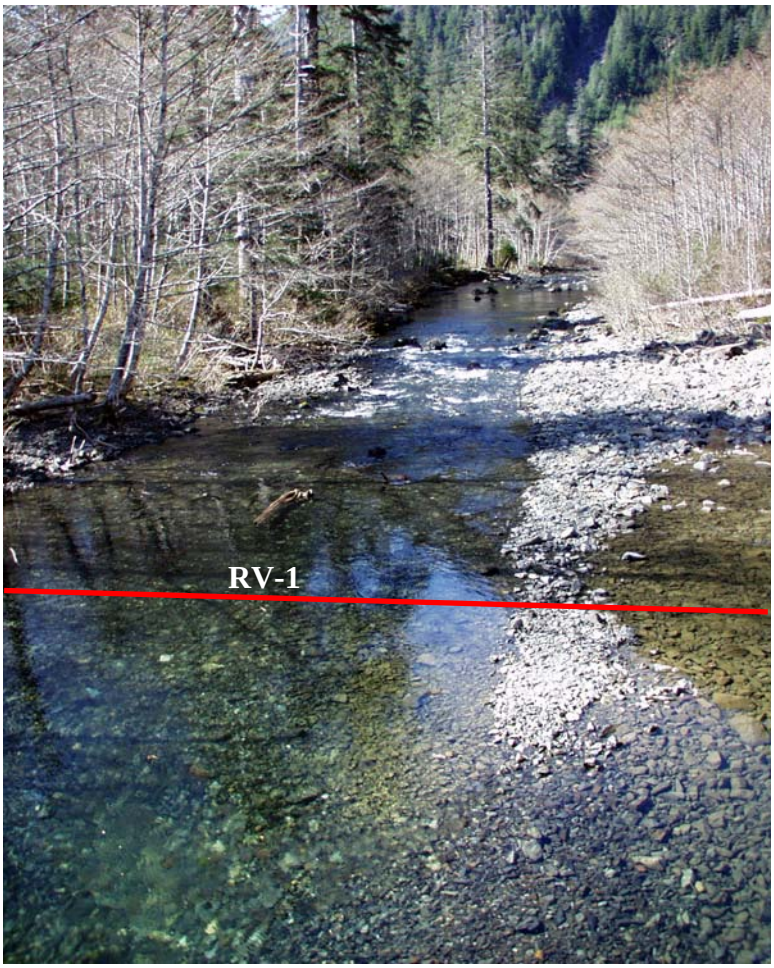

Figure 18. Reach 5 instream flow site at 54 cfs.

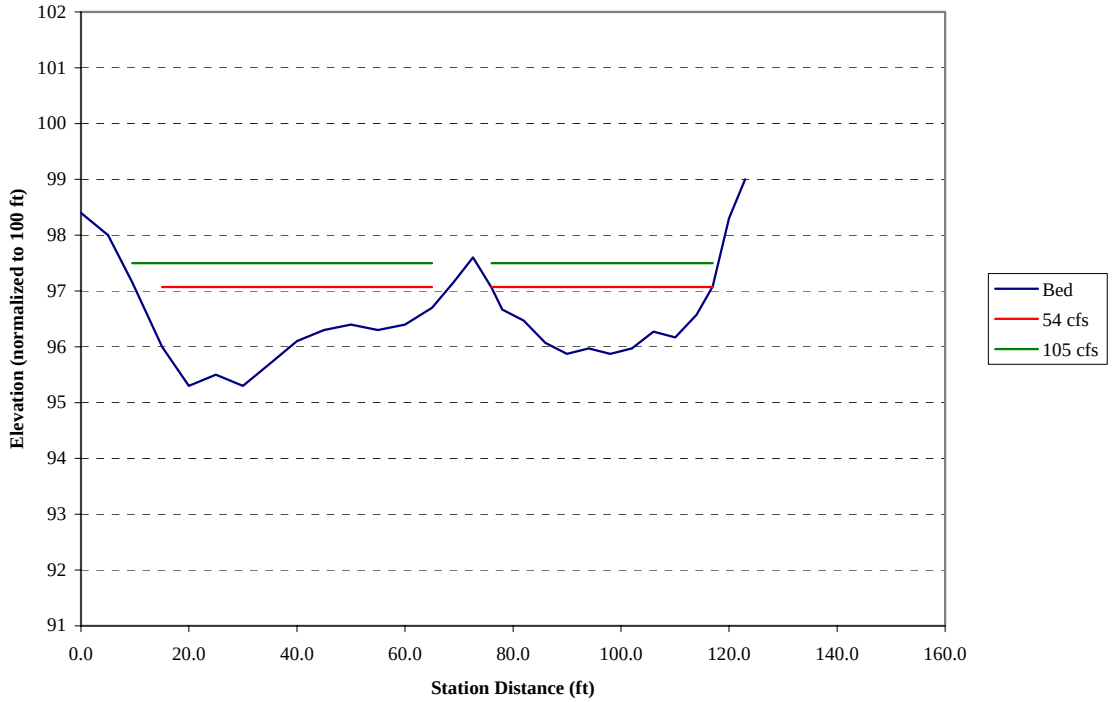

Figure 19. Cross section bed profile at Reach 5 (RV-1) at 54 and 105 cfs.

COMPUTER ANALYSIS

Overall, the quality of the field data was good, consistent and provided an applicable description of the habitats measured. Calibration of water surface elevations was successful over the range of flows measured (Table 9). Only cross section CA1 at 58 cfs had a difference between the modeled and measured water surface elevation greater than ±0.02 ft; however, this is the best representation achieved.

The river right backwater at RV-1 was removed from analysis because of the difficulties with the zero velocities found in that habitat. The area of fish utilization at this cross section is located in the river left portion of the channel and is unaffected by removing the backwater at surveyed flows.

Table 9. Difference between observed and simulated water surface elevations for instream flow sites.

Cross Section	Low Flow (53-58 cfs)	High Flow (105-112 cfs)
Index Pool (IP1)	0.000	0.001
Concrete Area 1 (CA1)	-0.036	-0.013
Concrete Area 2 (CA2)	0.013	0.009
Pulp Mill Outflow 1 (PMO1)	-0.014	-0.008
Pulp Mill Outflow 2 (PMO2)	0.000	0.005
Falls Pool 2 (FP2)	0.008	0.003
Falls Pool 3 (FP3)	0.000	0.005
Reach 4, Riffle (RIV-1)	0.000	-0.001
Reach 4, Run (RIV-2)	0.000	0.001
Reach 5 (RV-1)	0.000	0.000

Note: Cross sections CAC, PMOC and FP1 are hydraulic controls with water surface elevations as a given input and are not part of the calibration of the site.

Simulated water velocities followed the expected trend (increasing with increased discharges). However, velocity simulations did not match observed conditions in a few minor instances. These cases typically occurred along channel margins and areas associated with velocity obstructions (i.e. boulders). The overall quality of the modeling effort should not be affected by these instances. Figure 20 is an example of the velocity distribution for Falls Pool cross section FP2. Appendix B contains simulated velocities for the remaining cross sections.

Velocity simulations were also evaluated using the VAF output from VELSIM (see Figure 21 for example graph). The VAF versus discharge relationship showed a similar trend for all cross sections at all sites (Appendix C).

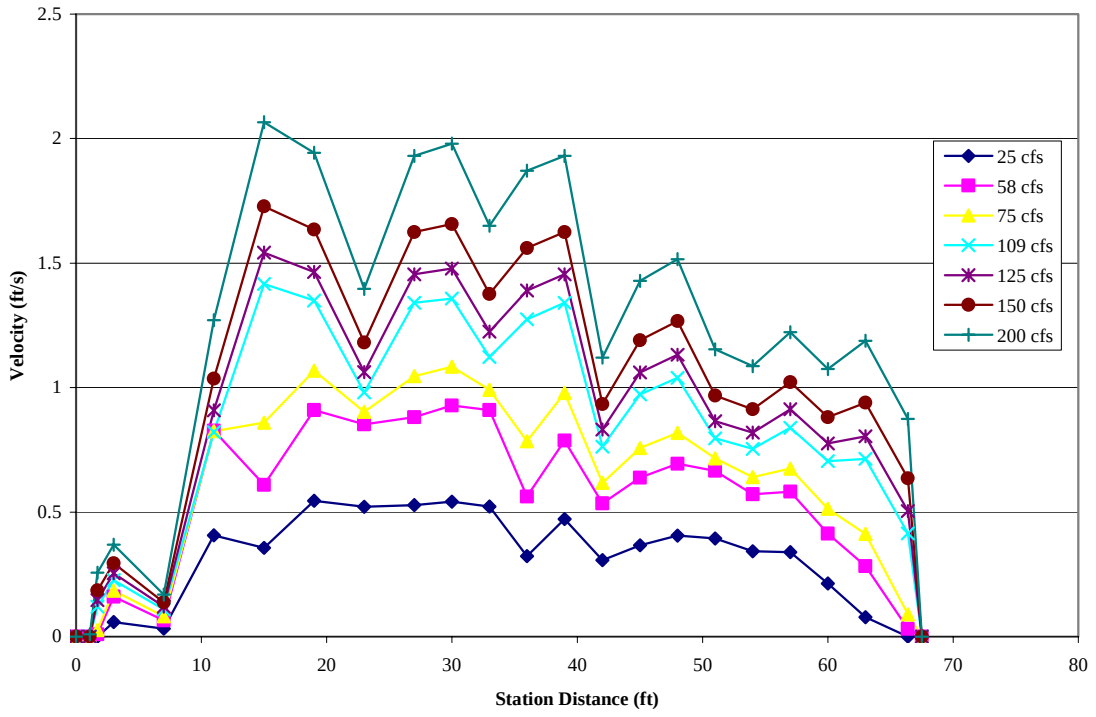

Figure 20. Simulated velocities at Falls Pool instream flow site, cross section FP2.

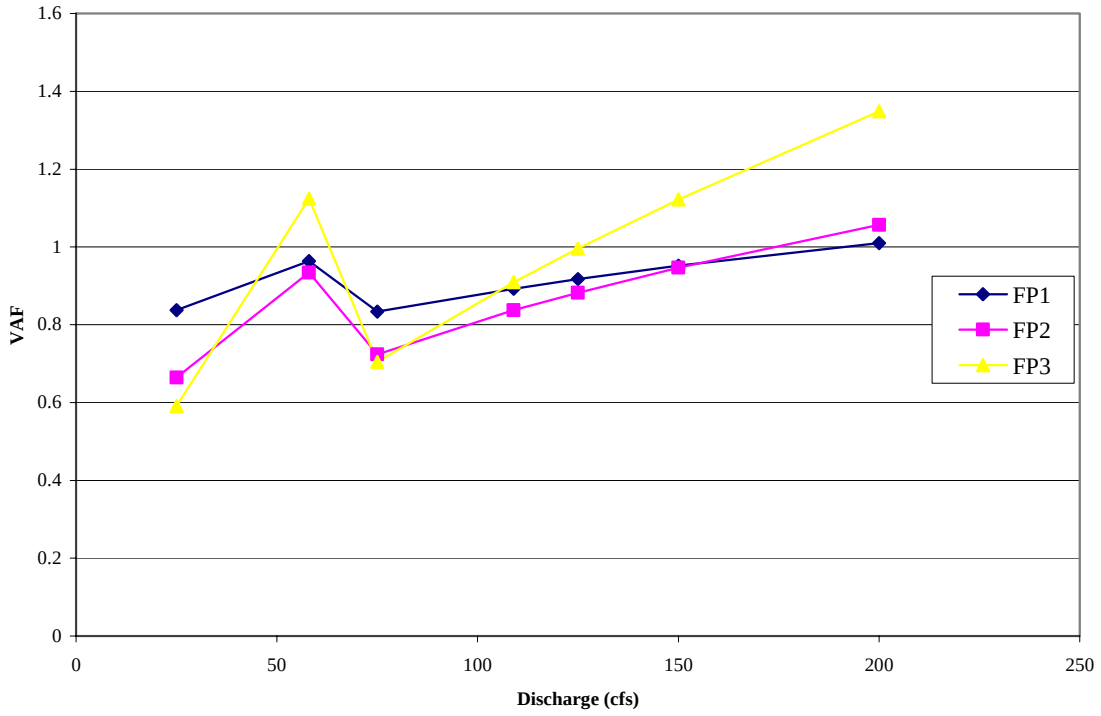

Figure 21. Velocity adjustment factors for all cross sections at the Falls Pool instream flow site.

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Bovee, K. D. 1997. Data collection procedures for the Physical Habitat Simulation system. U.S. Geological Survey, Mid-Continent Ecological Science Center, Fort Collins, Colorado.

Waddle, T.J., ed. 2001. PHABSIM for Windows: User's manual and exercises. U.S. Geological Survey, Midcontinent Ecological Science Center, Fort Collins, Colorado.

APPENDIX A - COORDINATE DATA

Figure A-1. Coordinate data for IP1, low flow survey.

Site	Index Pool			WSE:	96.21		
Transect	IP1						
Date	20-Apr						
Time	1609						
Descr.	Low Flow						
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity**	**Substrate**
TBMIP1	2.06			100.00			
		102.06					
0.0			4.05	98.01			
1.6			4.90	97.16			
1.9			6.00	96.06			
3.6			5.70	96.36			
3.8			5.89	96.17			
5.0				95.81	0.4	0.06	LC
8.0				95.81	0.4	0.44	LC
11.0				95.61	0.6	1.98	LC
14.0				95.81	0.4	1.02	SB
17.0				95.31	0.9	1.56	LC/SC
20.0				95.01	1.2	2.26	LC/SC
23.0				94.81	1.4	2.51	SC/LC
26.0				95.21	1	2.22	LC/SC
29.0				95.41	0.8	2.64	LC/SC
32.0				95.71	0.5	1.32	SB
35.0				95.11	1.1	0.57	LC/SC
38.0				95.01	1.2	1.18	LC/SC
41.0				95.11	1.1	1.98	SC/LC
44.0				95.21	1	1.79	SB/LG
47.0				95.21	1	1.75	SC/LC
50.0				95.41	0.8	1.42	SB
53.0				95.31	0.9	1.87	SC/LC
56.0				95.91	0.3	1.24	LC
59.0				95.81	0.4	0.77	SC/LC
62.0				95.91	0.3	0.88	LC/SC/SG
65.4			5.82	96.24			
70.0			5.39	96.67			
75.0			5.19	96.87			
85.3			3.75	98.31			

Figure A-2. Coordinate data for IP1, high flow survey.

Site	Index Pool			WSE:	96.47		
Transect	IP1						
Date	21-Apr						
Time	1810						
Descr.	High Flow						
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity**	**Substrate**
TBMIP1	2.79			100.00			
		102.79					
1.6			6.39	96.40			
3.8						0	
5.0						0.41	
8.0						1.29	
11.0						2.04	
14.0						1.36	
17.0						2.42	
20.0						2.94	
23.0						2.38	
26.0						3.06	
29.0						3.48	
32.0						2.35	
35.0						2.98	
38.0						2.16	
41.0						2.87	
44.0						2.73	
47.0						2.77	
50.0						2.2	
53.0						2.14	
56.0						1.92	
59.0						1.94	
62.0						1.64	
68.5			6.25	96.54			

Figure A-3. Coordinate data for CAC, low flow survey.

Site	Concrete Area			WSE:	96.76		
Transect	CAC						
Date	20-Apr						
Time	1700						
Descr.	Low Flow						
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity**	**Substrate**
TBMCA2	2.52			99.74			
		102.26					
0.0			3.10	99.16			
1.5			4.8	97.46			
5.1			5.50	96.76			
8.0			5.6	96.66			
10.0			6.0	96.26			
13.5			6.9	95.36			
17.0			7.7	94.56			
21.0			7.6	94.66			
23.0			7.5	94.76			
26.0			7.4	94.86			
29.0			6.7	95.56			
32.0			6.6	95.66			
35.0			6.2	96.06			
38.0			5.9	96.36			
44.0			5.51	96.75			
48.0			5.3	96.96			
52.0			5.4	96.86			
56.0			5.5	96.76			
60.0			5.1	97.16			
66.0			5.0	97.26			
70.0			4.6	97.66			
75.0			4.3	97.96			
79.0			4.1	98.16			

Figure A-4. Coordinate data for CAC, high flow survey.

Site	Concrete Area			WSE:	97.27		
Transect	CAC						
Date	22-Apr						
Time	0845						
Descr.	High Flow						
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity**	**Substrate**
TBMCA1	1.87			100.00			
		101.87					
4.6			4.68	97.19			
60.7			4.53	97.34			

Figure A-5. Coordinate data for CA1, low flow survey.

Site	Concrete Area			WSE:	96.86				
Transect	CA1								
Date	20-Apr								
Time	1720								
Descr.	Low Flow								
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity, 0.2**	**Velocity, 0.8**	**Avg. Vel/0.6**	**Substrate**
TBMCA1	2.07			100.00					
		102.07							
TBMCA2			2.33	99.74					
TBMCA2	2.52								
		102.26							
TBMCA1			2.26	100.00					
0.0			3.1	99.16					
3.0			4.6	97.66					
5.7			5.42	96.84					
8.0				95.76	1.1			0.29	LB
10.0				95.16	1.7			0.5	SB
12.0				94.96	1.9			1.31	LB/SB
14.0				95.56	1.3			1.28	LB/SB
16.0				94.36	2.5			1.45	LB/SB
18.0				94.66	2.2			1.5	LB
20.0				93.96	2.9	1.18	0.86	1.02	SB/LC
22.0				94.36	2.5			1.13	LC/G
23.0				94.36	2.5			1.09	LG/G
24.0				94.86	2			1.12	SB/LG
25.0				94.86	2			0.86	LG/G
26.0				95.56	1.3			0.39	SB
27.0				95.56	1.3			0.95	SB/LC
28.0				95.56	1.3			0.72	G
29.0				95.66	1.2			1.16	SC/G
31.0				96.06	0.8			1.01	SB
33.0				96.06	0.8			1.08	LC/SC
35.0				95.96	0.9			1.07	LC/SC
37.0				96.16	0.7			0.31	SC/LG
39.0				96.46	0.4			0.34	C/G
41.0				96.56	0.3			0.16	SC/LG
43.0				96.76	0.1			0	
44.0			5.39	96.87					
48.0			5.42	96.84					
52.0			4.6	97.66					
56.0			4.3	97.96					
65.0			4.1	98.16					
73.4			1.8	100.46					

Figure A-6. Coordinate data for CA1, high flow survey.

Site	Concrete Area			WSE:	97.34				
Transect	CA1								
Date	22-Apr								
Time	0845								
Descr.	High Flow								
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity, 0.2**	**Velocity, 0.8**	**Avg. Vel/0.6**	**Substrate**
TBMCA1	1.87			100.00					
		101.87							
4.4			4.55	97.32					
5.7								0.74	
8.0								1.35	
10.0								0.92	
12.0								1.97	
14.0						2.06	2.11	2.09	
16.0						2.04	1.9	1.97	
18.0						1.95	1.81	1.88	
20.0						2.1	1.79	1.95	
22.0						1.79	1.32	1.56	
23.0						1.71	1.51	1.61	
24.0								1.56	
25.0								1.44	
26.0								0.99	
27.0								1.4	
28.0								0.76	
29.0								1.23	
31.0								1.39	
33.0								1.62	
35.0								0.79	
37.0								1.15	
39.0								1.17	
41.0								1.23	
43.0								0.69	
44.0								0.3	
50.4			4.51	97.36					

Figure A-7. Coordinate data for CA2, low flow survey.

Site	Concrete Area			WSE:	96.90					
Transect	CA2									
Date	20-Apr									
Time	1757									
Descr.	Low Flow									
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity, 0.2**	**Velocity, 0.8**	**Avg. Vel/0.6**	**Substrate**	**Comments**
TBMCA2	2.52			99.74						
		102.26								
0.0			2.9	99.36						
0.4			5.37	96.89						
2				95.70	1.2			0	SB	
5.0				94.80	2.1			0	SB	
8.0				94.60	2.3			0.13	LB	
11.0				95.00	1.9			0.11	SB	
14.0				94.90	2			0.22	SB/LC	
17.0				95.80	1.1			0.52	SB	
20.0				95.10	1.8			0.71	SB	
23.0				95.30	1.6			0.54	SB	
26.0				94.90	2			0.72	LC/SC	
29.0				94.90	2			0.67	SB	
32.0				94.40	2.5			0.54	LC/SC	
35.0				94.10	2.8	1.29	0.79	1.04	LC	
38.0				94.00	2.9	1.03	0.53	0.78	SB/LC	
41.0				94.00	2.9	0.78	0.53	0.66	SC/LG	
44.0				94.80	2.1			0.47	G	
47.0				95.50	1.4			0.12	G	
50.0				95.80	1.1			0.08	G	
53.0				95.90	1			0	G	
56.0				95.80	1.1			0	G	
59.0				95.70	1.2			0	G	
60.3			5.35	96.91						
60.4										vertical wall

Figure A-8. Coordinate data for CA2, high flow survey.

Site	Concrete Area			WSE:	97.43					
Transect	CA2									
Date	22-Apr									
Time										
Descr.	High Flow									
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity, 0.2**	**Velocity, 0.8**	**Avg. Vel/0.6**	**Substrate**	**Comments**
TBMCA1	1.87			100.00						
		101.87								
0.4			4.48	97.39						
2								0		
5.0								0.11		
8.0								0.14		
11.0								0.07		
14.0								0.2		
17.0								1.01		
20.0								1.07		
23.0								1.4		
26.0								1.07		
29.0								1.48		
32.0						1.94	0.8	1.37		
35.0						1.53	0.74	1.135		
38.0						1.55	1.18	1.365		
41.0						1.77	0.82	1.30		
44.0								0.68		
47.0								0.59		
50.0								0		
53.0								0.27		
56.0								0		
59.0								0		
60.3			4.40	97.47						

Figure A-9. Coordinate data for PMOC, low flow survey.

Site	Pulp Mill Outflow			WSE:	95.01		
Transect	PMOC						
Date	21-Apr						
Time	0830						
Descr.	Low Flow						
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity**	**Substrate**
TBMPM1	0.16			100.00			
		100.16					
TBMPM2			1.85	98.31			
TBMPM2	1.84			98.31			
		100.15					
TBMPM1			0.15	100.00			
0.0			1.6	98.55			
5.0			3.3	96.85			
10.0			4.1	96.05			
15.0			4.6	95.55			
20.0			5.11	95.04			
25.0			5.3	94.85			
30.0			5.9	94.25			
35.0			6.2	93.95			
40.0			6	94.15			
45.0			5.8	94.35			
50.0			6.1	94.05			
55.0			5.9	94.25			
58.0			5.8	94.35			
60.0			6.1	94.05			
62.0			5.2	94.95			
65.0			5.8	94.35			
68.0			5.9	94.25			
71.0			5.9	94.25			
75.0			5.7	94.45			
80.0			5.7	94.45			
85.0			6	94.15			
88.0			6.1	94.05			
89.0			4.8	95.35			
91.0			5.8	94.35			
95.0			5.9	94.25			
99.0			6.1	94.05			
102.0			6.5	93.65			
105.0			5.6	94.55			
107.0			4.2	95.95			
110.0			5.7	94.45			
114.0			5.6	94.55			
120.0			5.4	94.75			
123.0			5.17	94.98			
125.0			4.2	95.95			
129.0			4.8	95.35			
132.0			4.3	95.85			
136.0			2.9	97.25			

Figure A-10. Coordinate data for PMOC, high flow survey.

Site	Pulp Mill Outflow			WSE:	95.32		
Transect	PMOC						
Date	22-Apr						
Time	0930						
Descr.	High Flow						
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity**	**Substrate**
TBMPM1	0.21			100.00			
		100.21					
16.0 rwe			4.85	95.36			
129.0 lwe			4.94	95.27			

Figure A-11. Coordinate data for PMO1, low flow survey.

Site	Pulp Mill Outflow			WSE:	95.04		
Transect	PMO1						
Date	21-Apr						
Time	0845						
Descr.	Low Flow						
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity**	**Substrate**
TBMPM2	1.84			98.31			
		100.15					
0.0			1.60	98.55			C/SB
5.0			3.40	96.75			C/SB
10.0			4.60	95.55			SB/C
16.0			5.1	95.05			
19.0				94.74	0.3	0	SG
22.0				94.44	0.6	0.05	S/SG
25.0				94.14	0.9	0.13	S/SG
28.0				94.74	0.3	0.12	Fabric/B
31.0				93.84	1.2	0.26	Fabric/B
34.0				93.84	1.2	0.42	LC/SC/SG
36.0				93.74	1.3	0.87	SB/LC/SG
40.0				93.64	1.4	0.19	LC/SC/SG
46.0				93.24	1.8	0.8	LC/SC/G
52.0				93.04	2	0.57	LC/G/SG
58.0				93.44	1.6	0.75	C/G
61.0				93.24	1.8	0.59	SB/C/G
63.0				93.04	2	0.52	SC/G
65.0				93.04	2	0.79	G/SC
67.0				93.04	2	0.45	G/SC
69.0				93.24	1.8	0.66	SC/G
72.0				92.84	2.2	0.22	SB/LC/G
75.0				93.24	1.8	0.35	LC/SC
78.0				93.34	1.7	0.59	SB/SC
81.0				93.34	1.7	0.4	SC/LC
84.0				93.54	1.5	0.46	LC/SC
87.0				93.64	1.4	0.49	SC
90.0				93.64	1.4	0.41	B
93.0				94.84	0.2	0	C
96.0				93.84	1.2	0.98	B/SC
99.0				93.64	1.4	0.23	C
102.0				94.24	0.8	0.78	C
105.0				94.74	0.3	0.97	C/SC
108.0				94.64	0.4	0	C/SC
112.0			5.12	95.03			
115.0			4.4	95.75			
117.0			3.7	96.45			

Figure A-12. Coordinate data for PMO1, high flow survey.

Site	Pulp Mill Outflow			WSE:	95.35	
Transect	PMO1					
Date	22-Apr					
Time	0930					
Descr.	High Flow					
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity**
TBMPM1	0.21			100.00		
		100.21				
11.5 rwe			4.84	95.37		
114.8 lwe			4.89	95.32		
16.0						0
19.0						0
22.0						0
25.0						0.25
28.0						0.33
31.0						0.46
34.0						0.39
37.0						1.02
40.0						0.34
46.0						1.11
52.0						1
58.0						1.34
61.0						1.31
63.0						1.15
65.0						1.32
67.0						1.29
69.0						1.42
72.0						0.89
75.0						1.15
78.0						1.13
81.0						1.31
84.0						1.16
87.0						1.33
90.0						0.91
93.0						1.27
96.0						1.44
99.0						1.14
102.0						1.34
105.0						1.71
108.0						1.07
112.0						0

Figure A-13. Coordinate data for PMO2, low flow survey.

Site	Pulp Mill Outflow			WSE:	95.06					
Transect	PMO2									
Date	21-Apr									
Time	0930									
Descr.	Low Flow									
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity, 0.2**	**Velocity, 0.8**	**Avg. Vel/0.6**	**Substrate**	**Comments**
TBMPM2	1.84			98.31						
		100.15								
37.0			5.09	95.06						vertical wall
34.0				97.55	2.6	0.63	0	0.32	G	
31.0				98.35	1.8			0.00	SB/LB	
28.0				98.85	1.3			0.10	B	
25.0				98.45	1.7			1.17	B	
22.0				97.25	2.9	1.2	0.1	0.65	G	
19.0				97.25	2.9	1.09	0.7	0.90	SC/G	
16.0				97.45	2.7	1.08	0.89	0.99	SB/G	
13.0				97.85	2.3			1.41	B/G	
10.0				97.45	2.7	1.42	0.86	1.14	C/G	
7.0				98.55	1.6			1.12	B	
4.0				97.65	2.5			1.12	C	
1.8				95.06				0.00		no line of sight
0.0				96.46						+1.4 ft on rod

Figure A-14. Coordinate data for PMO2, high flow survey.

Site	Pulp Mill Outflow			WSE:	95.39					
Transect	PMO2									
Date	22-Apr									
Time	1035									
Descr.	High Flow									
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity, 0.2**	**Velocity, 0.8**	**Avg. Vel/0.6**	**Substrate**	**Comments**
TBMPM1	0.21			100.00						
		100.21								
37.0			4.82	95.39						
34.0						2.08	0.03	1.06		
31.0								0.00		
28.0								0.29		
25.0								2.24		
22.0						1.93	0.24	1.09		
19.0						2.29	2.1	2.20		
16.0								1.90		
13.0						2.2	1.94	2.07		
10.0						1.85	1.74	1.80		
7.0								2.04		
4.0						2.01	1.43	1.72		
1.8										
0.0										

Figure A-15. Coordinate data for FP1, low flow survey.

Site	Falls Pool			WSE:	95.64				
Transect	FP1								
Date	21-Apr								
Time	1015								
Descr.	Low Flow								
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity, 0.2**	**Velocity, 0.8**	**Avg. Vel/0.6**	**Substrate**
TBMFP1	1.14			100.00					
		101.14							
TBMFP2			3.79	97.35					
TBMFP2	3.91								
		101.26							
TBMFP1			1.25	100.01					
0.0			0.4	100.86					B
1.0			4.9	96.36					B
5.0			5	96.26					B
10.0			4.9	96.36					LC
15.0			5.2	96.06					G/SB
20.0			5.60	95.66					SB
22.0				95.04	0.6			0.15	B/SC/G
25.0				94.74	0.9			1.56	SB/SC
28.0				95.54	0.1			0	B
31.0				94.64	1			2.26	SB/LC
34.0				94.94	0.7			1.8	B
37.0				94.44	1.2			1.46	C
40.0				94.24	1.4			1.6	LC/SC/LG
42.0				94.24	1.4			1.67	B/SC
44.0				94.24	1.4			1.67	SC/LG
46.0				94.24	1.4			1.65	LC/SC
48.0				94.24	1.4			1.43	SC/LG
50.0				94.34	1.3			1.45	SC/LG/B
52.0				94.54	1.1			1.33	LC/SC/G
54.0				94.54	1.1			1.67	LC/LG
56.0				94.64	1			1.33	B/LC
58.0				94.74	0.9			1.46	B/LC
61.0				94.94	0.7			0.6	B/LC
64.0				95.24	0.4			0.53	SB
67.0				95.44	0.2			0.79	SB
69.0			5.64	95.62					
69.5			4.3	96.96					
73.0			3.1	98.16					
75.5			2.5	98.76					
78.2			1	100.26					

Figure A-16. Coordinate data for FP1, high flow survey.

Site	Falls Pool			WSE:	95.99				
Transect	FP1								
Date	22-Apr								
Time	1100								
Descr.	High Flow								
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity, 0.2**	**Velocity, 0.8**	**Avg. Vel/0.6**	**Substrate**
TBMFP1	1.24			100.00					
		101.24							
68.7			5.25	95.99					
16.2			5.25	95.99					
20.0								0.6	
22.0								1.19	
25.0								2.71	
28.0								1.78	
31.0								2.13	
34.0								2.45	
37.0								2.17	
40.0								2.29	
42.0								2.36	
44.0								2.37	
46.0								2.43	
48.0								2.03	
50.0								2.21	
52.0								2.17	
54.0								2.41	
56.0								2.13	
58.0								1.67	
61.0								1.2	
64.0								1.2	
67.0								0.62	
69.0								0	

Figure A-17. Coordinate data for FP2, low flow survey.

Site	Falls Pool			WSE:	95.73				
Transect	FP2								
Date	21-Apr								
Time	1045								
Descr.	Low Flow								
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity, 0.2**	**Velocity, 0.8**	**Avg. Vel/0.6**	**Substrate**
TBMFP2	3.91			97.35					
		101.26							
0.0			2.9	98.36					
1.1			4.7	96.56					
1.7			5.53	95.73					
3.0				95.13	0.6			0.17	SB
7.0				94.83	0.9			0.07	LC
11.0				94.83	0.9			0.88	SB
15.0				94.23	1.5			0.65	C/G
19.0				94.03	1.7			0.97	C
23.0				93.83	1.9			0.91	SC
27.0				94.03	1.7			0.94	SC
30.0				94.23	1.5			0.99	LC/SG
33.0				94.33	1.4			0.97	SC/LG
36.0				94.33	1.4			0.6	SC/G
39.0				94.03	1.7			0.84	B/G
42.0				94.33	1.4			0.57	SC/G
45.0				94.33	1.4			0.68	SC/G
48.0				94.23	1.5			0.74	SC/G
51.0				94.13	1.6			0.71	SC
54.0				94.03	1.7			0.61	G
57.0				94.23	1.5			0.62	B/G
60.0				94.73	1			0.44	B/LC
63.0				95.23	0.5			0.3	C
66.4			5.54	95.72					
67.5			3.9	97.36					

Figure A-18. Coordinate data for FP2, high flow survey.

Site	Falls Pool			WSE:	96.11				
Transect	FP2								
Date	22-Apr								
Time	1120								
Descr.	High Flow								
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity, 0.2**	**Velocity, 0.8**	**Avg. Vel/0.6**	**Substrate**
TBMFP1	1.24			100.00					
		101.24							
66.8			5.15	96.09					
1.7			5.12	96.12					
1.7								0	
3.0								0.27	
7.0								0.13	
11.0								0.98	
15.0								1.69	
19.0								1.61	
23.0								1.17	
27.0								1.6	
30.0								1.62	
33.0								1.34	
36.0								1.52	
39.0								1.6	
42.0								0.91	
45.0								1.16	
48.0								1.24	
51.0								0.95	
54.0								0.9	
57.0								1	
60.0								0.84	
63.0								0.85	
66.4								0	

Figure A-19. Coordinate data for FP3, low flow survey.

Site	Falls Pool			WSE:	95.75				
Transect	FP3								
Date	21-Apr								
Time	1115								
Descr.	Low Flow								
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity, 0.2**	**Velocity, 0.8**	**Avg. Vel/0.6**	**Substrate**
TBMFP2	3.91			97.35					
		101.26							
0.0			3.3	97.96					
2.0			3.4	97.86					
2.3			5.52	95.74					
3.0				94.75	1			0.27	BR
6.0				93.35	2.4			0.75	BR
6.5				91.25	4.5	1.09	0.3	0.70	BR
14.0				91.65	4.1	0.75	0.36	0.56	SB/G
25.0				92.25	3.5	0.2	0.45	0.33	C/G
33.0				92.75	3	0.08	0.03	0.06	SB/G
39.0				92.85	2.9	0.02	0.02	0.02	G/C
42.0				93.35	2.4			0.02	G/SC
45.0				93.65	2.1			0.17	G/SC
48.0				94.25	1.5			0.07	G/SC
51.0				93.95	1.8			0.01	G/SC
54.0				94.25	1.5			0.02	G
57.0				93.55	2.2			0.05	G/SB
60.0				93.15	2.6	0	0.02	0.01	SG
63.0				93.65	2.1			0.07	SG
66.0				94.05	1.7			0.05	SG
70.0				94.85	0.9			0.03	SG
73.0			5.51	95.75					
74.0			4.3	96.96					
75.5			2.6	98.66					

Figure A-20. Coordinate data for FP3, high flow survey.

Site	Falls Pool			WSE:	96.13				
Transect	FP3								
Date	22-Apr								
Time	1145								
Descr.	High Flow								
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity, 0.2**	**Velocity, 0.8**	**Avg. Vel/0.6**	**Substrate**
TBMFP1	1.24			100.00					
		101.24							
2.4			5.11	96.13					
73.0			5.12	96.12					
3.0								0.41	
6.0								1.67	
6.5						1.33	0.92	1.13	
14.0						1.15	0.7	0.93	
25.0						0.45	0.11	0.28	
33.0						0.64	0.83	0.74	
39.0						0.4	0.38	0.39	
42.0						0.32	0.16	0.24	
45.0								0.67	
48.0								0.52	
51.0								0.49	
54.0								0.33	
57.0								0.08	
60.0						0.24	0.01	0.13	
63.0								0.09	
66.0								0	
70.0								0	
73.0								0	

Figure A-21. Coordinate data for RIV-1, low flow survey.

Site	Reach 4			WSE:	96.83				
Transect	RIV1								
Date	21-Apr								
Time	1215								
Descr.	Low Flow								
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity, 0.2**	**Velocity, 0.8**	**Avg. Vel/0.6**	**Substrate**
TBMRIV1	2.06			100.00					
		102.06							
0.5			1.3	100.76					
3.0			4.1	97.96					
5.0			4.6	97.46					
10.0			4.8	97.26					
15.0			5.2	96.86					
20.0			5.25	96.81					
25.0			5.26	96.80					
29.0				96.43	0.4			0.35	SC/LG
35.0				96.33	0.5			0.66	SC/LG
41.0				95.83	1			1.03	SB/C
47.0				96.03	0.8			1.69	B
53.0				95.83	1			1.86	LC/G
59.0				95.83	1			0.99	LC/SC
65.0				96.03	0.8			0.65	LC/SC
71.0				95.93	0.9			1.78	LC/LG
77.0				95.73	1.1			1.72	LC
83.0				95.83	1			0.77	LC/SC
89.0				96.23	0.6			1.02	LS/SC
95.0				96.63	0.2			1.01	SB
100.0				96.03	0.8			0	SC
100.5			4.9	97.16					
104.5			5.1	96.96					
106.0			4.2	97.86					
107.0			5.2	96.86					
110.6			5.22	96.84					
116.0			4.2	97.86					
123.0			2.8	99.26					

Figure A-22. Coordinate data for RIV-1, high flow survey.

Site	Reach 4			WSE:	97.06				
Transect	RIV1								
Date	21-Apr								
Time	1730								
Descr.	High Flow								
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity, 0.2**	**Velocity, 0.8**	**Avg. Vel/0.6**	**Substrate**
TBMRIV1	1.75			100.00					
		101.75							
11.0			4.71	97.04					
110.0			4.68	97.07					
20.0								0	
25.0								2	
29.0								0.93	
35.0								1.83	
41.0								1.6	
47.0								3	
53.0								2.52	
59.0								2.17	
65.0								1.09	
71.0								2	
77.0								2.46	
83.0								0.47	
89.0								0.25	
95.0								2.03	
100.0								0	

Figure A-23. Coordinate data for RIV-2, low flow survey.

Site	Reach 4			WSE:	97.82				
Transect	RIV2								
Date	21-Apr								
Time	1315								
Descr.	Low Flow								
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity, 0.2**	**Velocity, 0.8**	**Avg. Vel/0.6**	**Substrate**
TBMRIV2	1.58			100.00					
		101.58							
0.0			1.60	99.98					
1.0			2.6	98.98					
4.0			3.2	98.38					
5.1			3.76	97.82					
7.4			3.4	98.18					
10.0					0.7				B/LB
15.0					2.4				LB/LC
20.0					2.8				SC/G
25.0					2.6				SC
30.0					2.2				SC/LG
84.0			3.76	97.82					
87.0			3.4	98.18					
90.0			4.9	96.68					
91.0			0.2	101.38					

Figure A-24. Coordinate data for RIV-2, high flow survey.

Site	Reach 4			WSE:	98.12				
Transect	RIV2								
Date	21-Apr								
Time	1645								
Descr.	High Flow								
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity, 0.2**	**Velocity, 0.8**	**Avg. Vel/0.6**	**Substrate**
TBMRIV2	1.60			100.00					
		101.60							
3.6			3.49	98.11					
10.0				95.22	2.9			0.44	
15.0				95.52	2.6	0.71	0.3	0.51	
20.0				94.92	3.2	0.74	0.36	0.55	
25.0				95.32	2.8	0.86	0.7	0.78	
30.0				95.62	2.5			0.87	
35.0				96.02	2.1			1	
40.0				96.12	2			0.9	
45.0				96.22	1.9			0.98	
50.0				96.42	1.7			0.96	
55.0				96.62	1.5			0.86	
60.0				96.92	1.2			0.87	
65.0				97.12	1			0.85	
70.0				97.32	0.8			0.78	
75.0				97.02	1.1			0.53	
80.0				97.52	0.6			0.53	
84.0			3.48	98.12					

Figure A-25. Coordinate data for RV-1, low flow survey.

Site	Reach 5			WSE:	97.07				
Transect	RV1								
Date	21-Apr								
Time	1500								
Descr.	Low Flow								
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity, 0.2**	**Velocity, 0.8**	**Avg. Vel/0.6**	**Substrate**
TBMRV1	2.20			100.00					
		102.20							
0.0			3.8	98.40					LC
5.0			4.2	98.00					LC
9.5			5.04	97.16					LC
15.0			6.2	96.00				0	LC
20.0			6.9	95.30				0	LC
25.0			6.7	95.50				0	LC
30.0			6.9	95.30				0	LC
35.0			6.5	95.70				0	LC
40.0			6.1	96.10				0	LC
45.0			5.9	96.30				0	LC
50.0			5.8	96.40				0	LC
55.0			5.9	96.30				0	LC
60.0			5.8	96.40				0	LC
65.0			5.5	96.70				0	LC
69.0			5.04	97.16					LC
72.6			4.6	97.60					LC
76.0			5.14	97.06					LC
78.0				96.67	0.4			0.9	LC/SC
82.0				96.47	0.6			1.11	SC/G
86.0				96.07	1			1.79	SC/G
90.0				95.87	1.2			1.72	SC/G
94.0				95.97	1.1			2.08	LC/SC
98.0				95.87	1.2			2.07	LC/SC
102.0				95.97	1.1			1.86	LC/G
106.0				96.27	0.8			1.58	LC/SC
110.0				96.17	0.9			1.21	LC/G
114.0				96.57	0.5			1.05	SC/G
117.0			5.12	97.08					LC/SC
120.0			3.9	98.30					LC/SC
123.0			3.2	99.00					LC/SC

Figure A-26. Coordinate data for RV-1, high flow survey.

Site	Reach 5			WSE:	97.50				
Transect	RV1								
Date	21-Apr								
Time	1615								
Descr.	High Flow								
Station	**BS**	**HI**	**FS**	**Elev**	**Depth**	**Velocity, 0.2**	**Velocity, 0.8**	**Avg. Vel/0.6**	**Substrate**
TBMRV1	2.23			100.00					
		102.23							
7.8 rwe			4.61	97.62					
72.5 lwe			4.62	97.61					
74.4 rwe			4.76	97.47					
119.0 lwe			4.70	97.53					
78.0								0.78	
82.0								2.14	
86.0								2.55	
90.0								2.64	
94.0								2.9	
98.0								2.79	
102.0								2.5	
106.0								2.33	
110.0								1.95	
114.0								1.89	

APPENDIX B - SIMULATED VELOCITIES

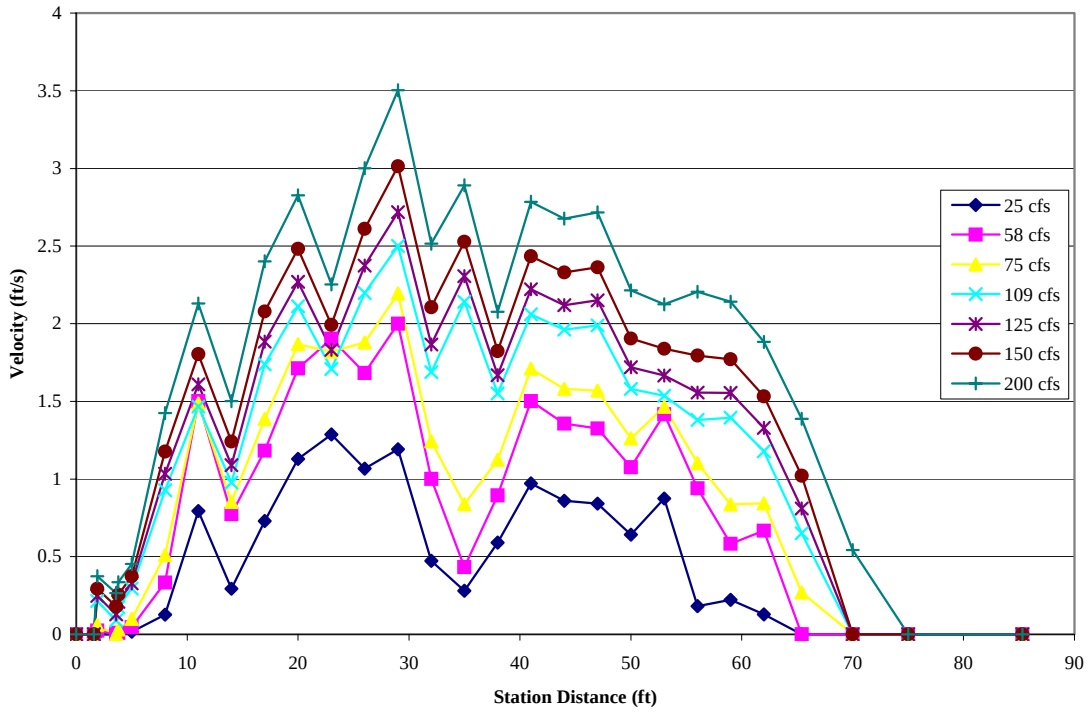

Figure B-1. Simulated velocities at Index Pool instream flow site, cross section IP1.

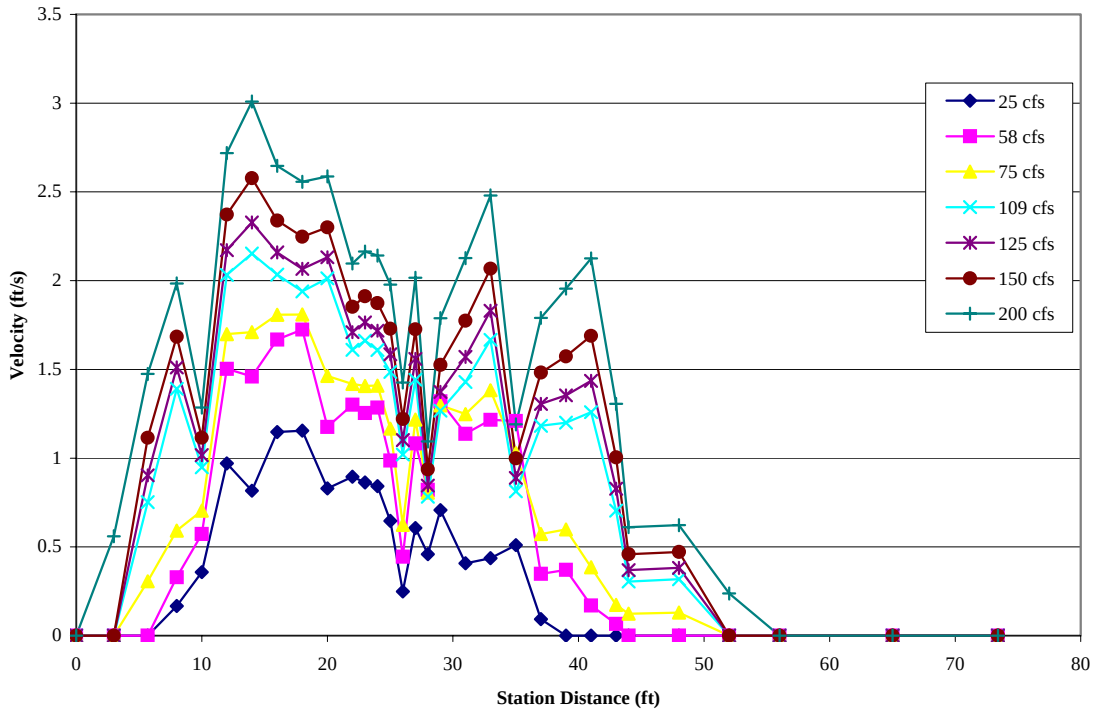

Figure B-2. Simulated velocities at Concrete Area instream flow site, cross section CA1.

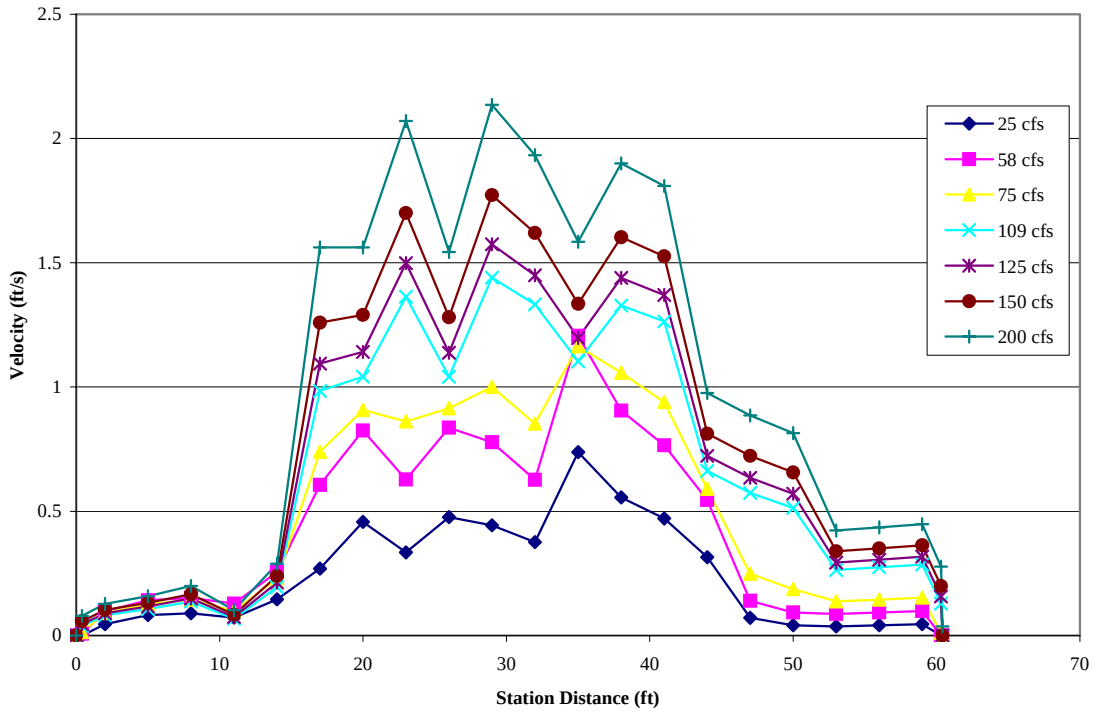

Figure B-3. Simulated velocities at Concrete Area instream flow site, cross section CA2.

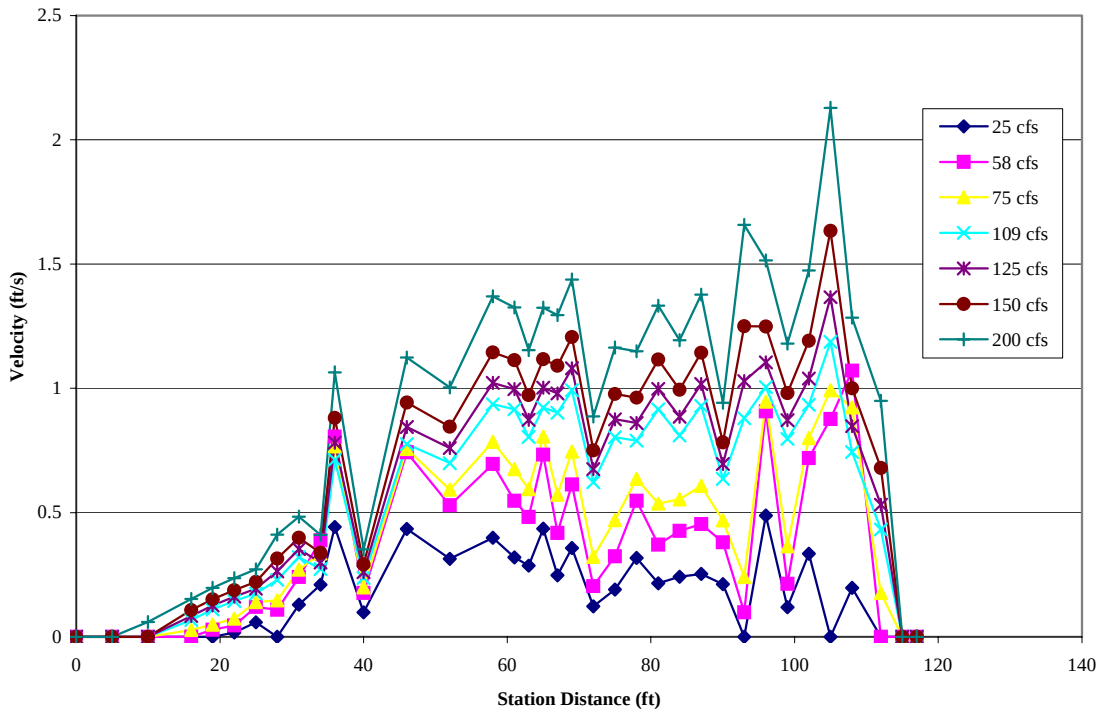

Figure B-4. Simulated velocities at Pulp Mill Outflow instream flow site, cross section PMO1.

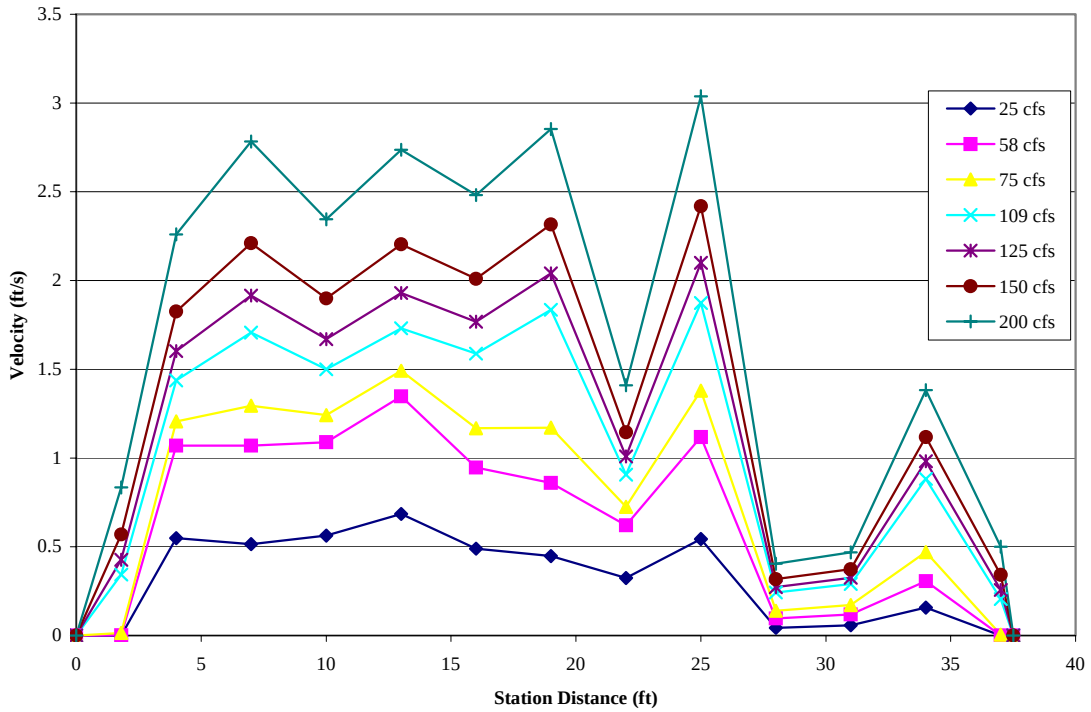

Figure B-5. Simulated velocities at Pulp Mill Outflow instream flow site, cross section PMO2.

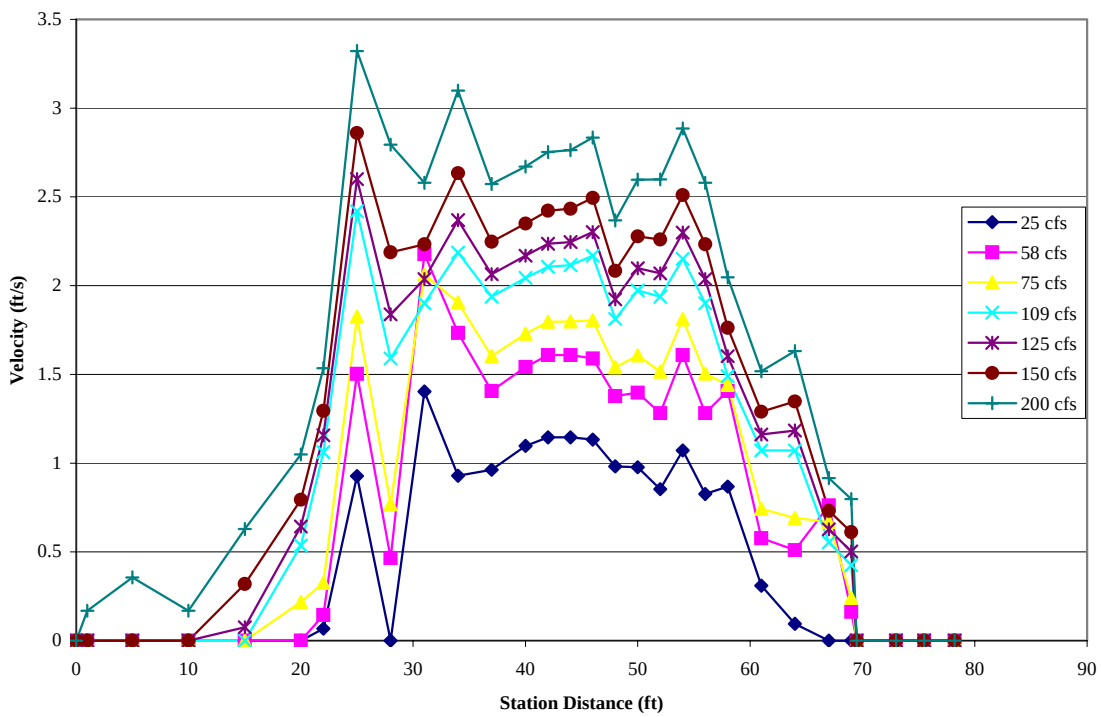

Figure B-6. Simulated velocities at Falls Pool instream flow site, cross section FP1.

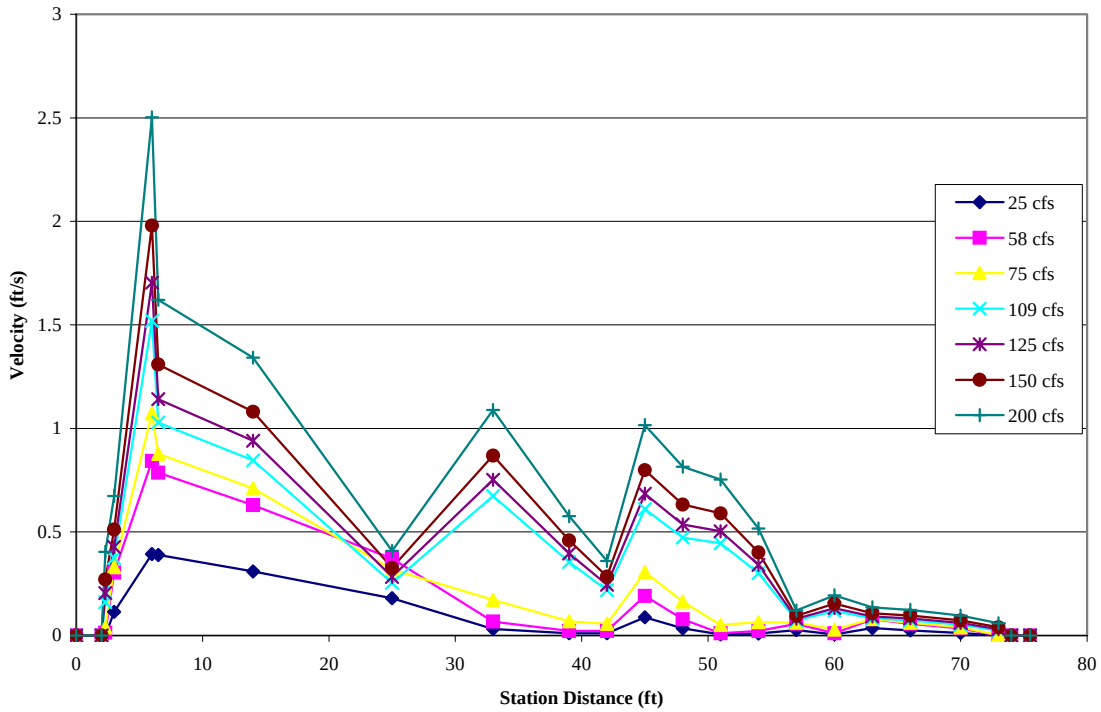

Figure B-7. Simulated velocities at Falls Pool instream flow site, cross section FP3.

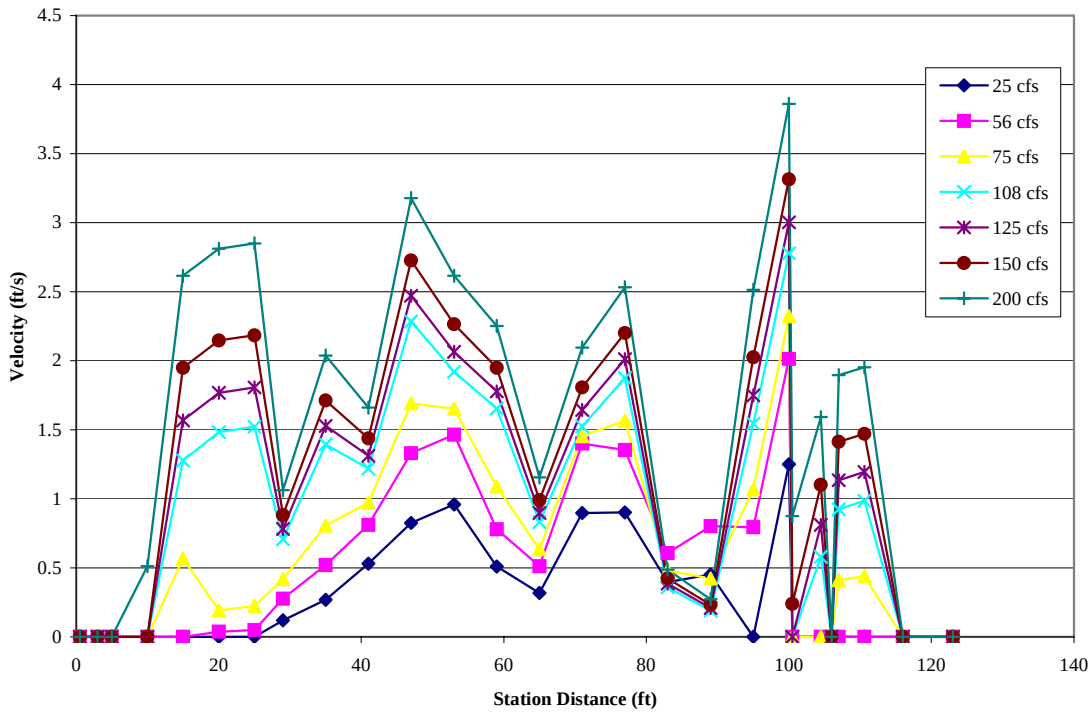

Figure B-8. Simulated velocities at Reach 4 instream flow site, cross section RIV-1.

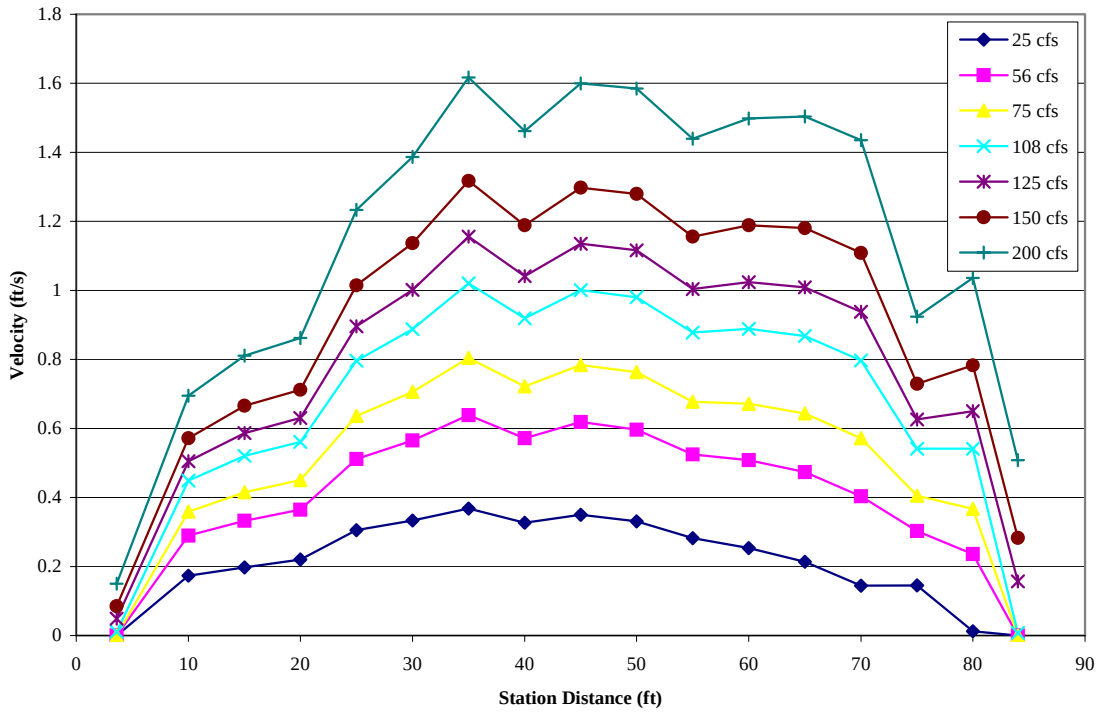

Figure B-9. Simulated velocities at Reach 4 instream flow site, cross section RIV-2.

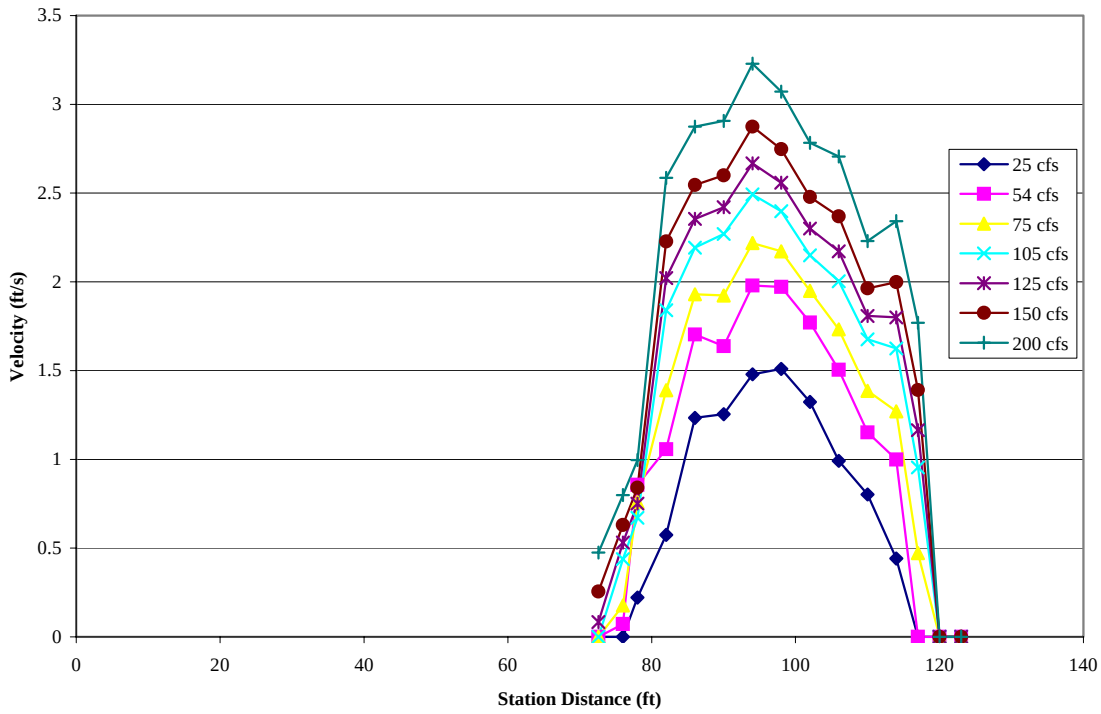

Figure B-10. Simulated velocities at Reach 5 instream flow site, cross section RV-1.

APPENDIX C - VELOCITY ADJUSTMENT FACTORS

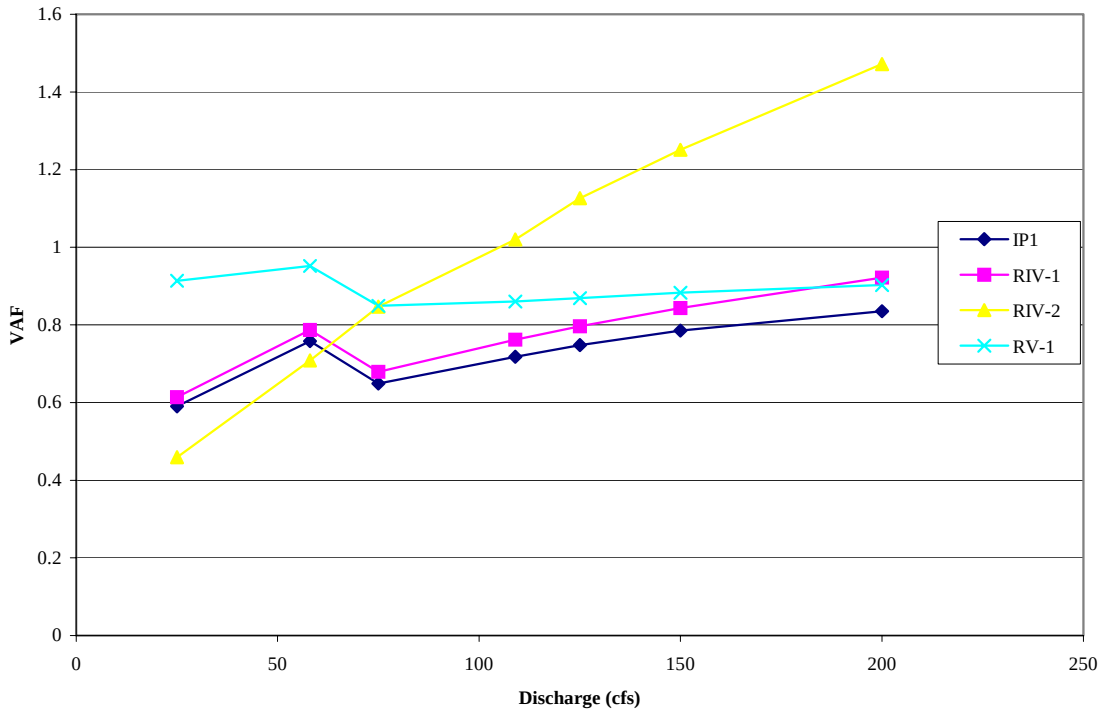

Figure C-1. Velocity adjustment factors for instream flow sites with individual cross sections (Index Pool, Reach 4, and Reach 5).

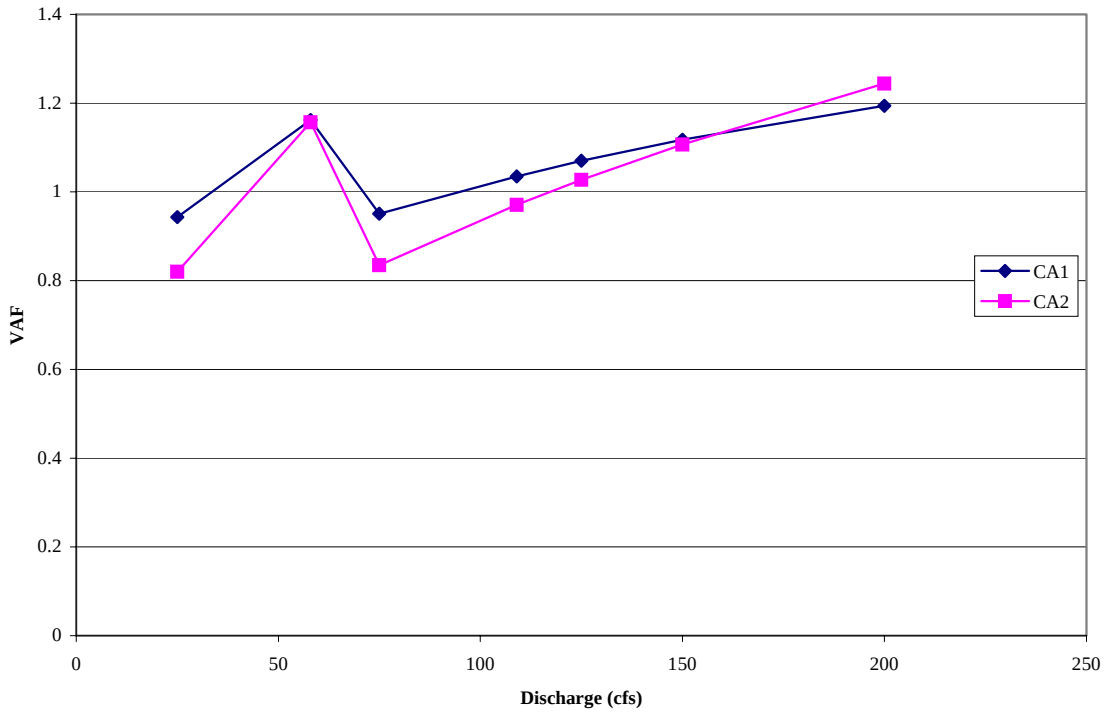

Figure C-2. Velocity adjustment factors for Concrete Area instream flow site.

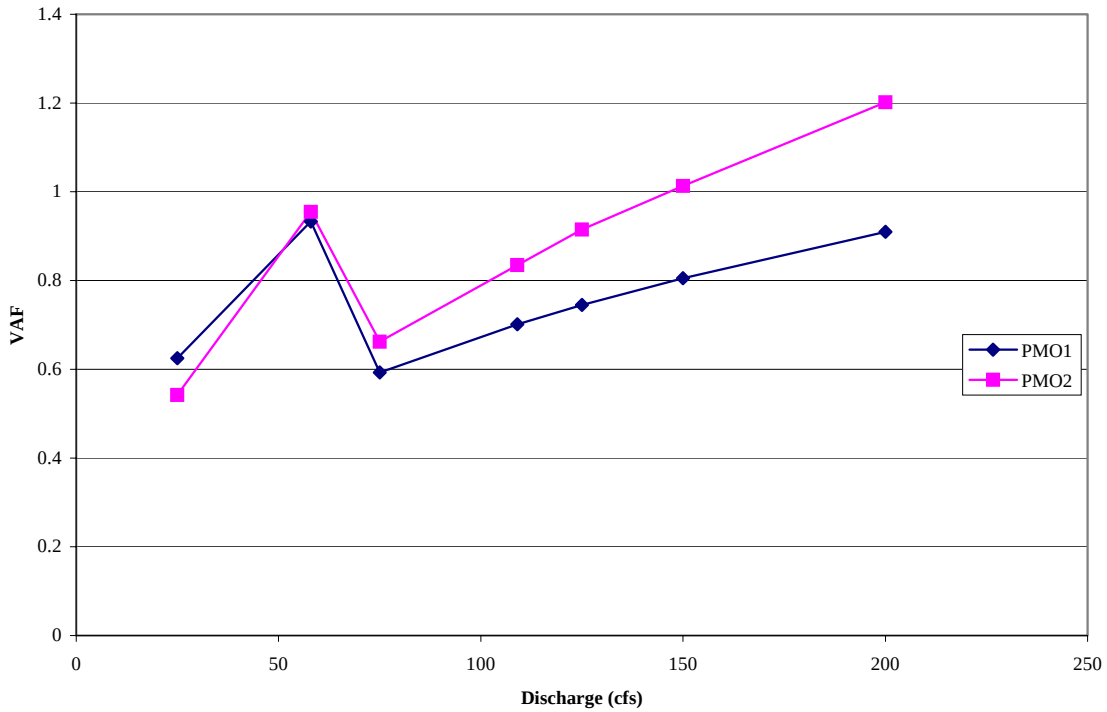

Figure C-3. Velocity adjustment factors for Pulp Mill Outflow instream flow site.