RECLAMATION
Managing Water in the West

Flow Characterization Study

Instream Flow Assessment
Big Timber Creek, Idaho

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

June 2004

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Prepared for:
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SUMMARY

The Bureau of Reclamation conducted flow characterization and habitat studies on Big Timber Creek, located in the Lemhi River sub-basin in Idaho, to identify stream flow needs to support relevant life history stages of summer steelhead (*Oncorhynchus mykiss*), spring chinook salmon (*O. tschawytscha*), and bull trout (*Salvelinus confluentus*). The study area encompassed the mainstem Big Timber Creek from its confluence with the Lemhi River upstream to Basin Creek. Seven study sites were selected to represent mesohabitat types within each stream reach distinguished by unique hydrology, channel morphology, slope, or land use characteristics. Big Timber flows were measured at one study site located upstream from major diversions using a stage recorder during the 2003 irrigation season. Unimpaired flows ranged from 16 cfs in late September to 295 cfs on May 31. Reclamation characterized flow needs for various life stages of the selected species in Big Timber Creek using the Physical Habitat Simulation (PHABSIM) model at each study site. Attempts to conduct field surveys at low, medium, and high flows at most sites were confounded by diversions downstream from the unimpaired site. In most cases, only medium and low flows were measured. However, these conditions typically occur during the summer irrigation season with the diversions. Habitat modeling results reflected differences in stream channel hydraulics among study sites. Cross-sectional profile and wetted area comparisons of study sites showed a narrower, more confined stream channel and less wetted surface area per any given flow in lower reaches of Big Timber Creek than upstream reaches. Thus, less flow was needed for suitable fish habitat in the lower reaches than the upper reaches given present stream channel morphology. For example, at the most downstream study site, flow required for adult salmonid passage was 13 cfs. This compared with the most upstream site where passage flow was 17 cfs. Study results can be used to determine a target flow or flows to improve passage, spawning, and rearing conditions for salmon, steelhead, and bull trout.

1.0 INTRODUCTION

The Bureau of Reclamation (Reclamation, BOR) participates with many other Federal, State, local, Tribal, and private parties in Endangered Species Act (ESA)-listed anadromous fish protection and restoration activities in selected parts of the Upper Salmon River Basin. Reclamation participation is related to avoid jeopardy to the survival of ESA- listed anadromous fish due to operation of dams in the Columbia River basin as explained in the Biological Opinion on Operation of the Federal Columbia River Power System (BiOp) issued by the National Marine Fisheries Service (NMFS) (currently National Oceanic Atmospheric Administration (NOAA) Fisheries) in December, 2000. Reclamation was assigned 16 Columbia River sub-basins through the BiOp-- four of those assigned sub-basins are in the Salmon and Clearwater River basins in Idaho. In the Upper Salmon River Basin, assigned sub-basins are the Lemhi River sub-basin and the "Upper Salmon River sub-basin", which is defined through the BiOp as the Salmon River basin upstream from the confluence of the Pahsimeroi and Salmon Rivers, but excludes the Pahsimeroi River basin.

Action 149 of the BiOp states Reclamation obligations related to stream flow issues: "BOR shall initiate programs in three priority sub-basins (identified in the Basinwide Recovery Strategy) per year over 5 years, in coordination with NMFS, Fish and Wildlife Service (FWS), the states and others, to address all flow, passage, and screening problems in each sub-basin over ten years."

Further, "The Federal Agencies have identified priority sub-basins where addressing flow, passage, and screening problems could produce short term benefits. This action initiates immediate work in three such sub-basins per year, beginning in the first year with the Lemhi, Upper John Day, and Methow sub-basins. Sub-basins to be addressed in subsequent years will be determined in the annual and 5-year implementation plans. NMFS will consider the level of risk to individual ESU's and spawning aggregations in the establishment of priorities for subsequent years. At the end of 5 years, work will be underway in at least 15 sub-basins. The objective of this action is to restore flows needed to avoid jeopardy to listed species, screen all diversions, and resolve all passage obstructions within 10 years of initiating work in each sub-basin. BOR is the lead agency for these initiatives and will facilitate their implementation. In addition, recognizing the critical importance of starting this work quickly, BPA will expand on measures under the Northwest Power Planning Council (NWPPC) program to complement BOR's action. To support this work, NMFS will supply BOR with passage and screening criteria and one or more methodologies for determining instream flows that will satisfy ESA requirement."

Priority streams have been identified in the Lemhi River sub-basin based on inventory and assessment needs. The objective of this study was to conduct habitat studies on the highest priority stream, Big Timber Creek, to identify stream flow needs to support relevant life history stages of summer steelhead (*Oncorhynchus mykiss*), spring chinook salmon (*O. tschawytscha*), and bull trout (*Salvelinus confluentus*). Information obtained from this study may be used by the public, State, and Federal agencies to direct management actions addressing stream flow needs of ESA-listed anadromous and resident native fish. Study results can be used to help determine target flow objectives to improve passage, spawning, and rearing conditions for salmon, steelhead, and bull trout.

1.1 Background

Rivers and streams in the Lemhi River sub-basin historically provided significant spawning and rearing habitat for anadromous spring/summer chinook salmon, sockeye salmon, and steelhead trout. However, anadromous fish populations have plummeted in the last 100 years and led in the 1990s to listing of these salmon and steelhead stocks as threatened under the ESA. Wild salmon and steelhead continue to migrate into the area and depend on spawning and rearing habitat in the basin. Bull trout also inhabit many of these rivers and streams. However, human development has modified the original flow and habitat conditions thereby affecting migration and/or access to suitable spawning and rearing habitat for all of these fish.

Many Federal, State, Tribal, local, and private parties work together to protect and restore ESA- listed anadromous and native fish species in the basin. One part of this work involves providing enough stream flow for these fish. Although sufficient stream flows are essential for fish to thrive, flows in the basin are also used for agricultural, domestic, commercial, municipal, industrial, recreational and other purposes. There is considerable information available that can be used to identify the amount of stream flow needed and used by people, however, there is little information about how much stream flow is needed to support various life history stages of ESA-listed fish. A reliable identification of stream flow needs for these fish will provide a basis that the public and Federal, State Tribal, and local parties can use to determine how to make the available water supply meet both the needs of ESA-listed fish and the needs of the people who live in these areas.

Some river reaches are more vulnerable than others to limitations in available stream flow. Fishery biologists with the Idaho Department of Fish and Game (IDFG), Bureau of Land Management (BLM), U.S. Forest Service, and Shoshone-Bannock Tribes compiled professional biological recommendations and known anadromous and resident fish population densities and chinook redd counts. They used this information to prioritize 11 sub-basins and to develop a list of 30 river reaches in the basin for immediate inventory and assessment for mitigation efforts (IDFG draft report, 5/10/02). The geographic area covered in their report included the entire Upper Salmon River Basin upstream from the confluence of the Middle Fork and main stem of the Salmon River.

1.2 Species of Interest

Snake River summer-run steelhead are Federally listed as threatened under the ESA within the NOAA Fisheries designated ESU. In the Lemhi River sub-basin, summer steelhead are part of the Snake River Basin steelhead Evolutionary Significant Unit (ESU) which is listed as threatened (Federal Register Vol. 64, No. 57, March 25 1999). Critical habitat for this ESU was designated February 16, 2000 (Federal Register, Vol. 65, No. 32, February 16, 2000), and includes all accessible portions of the project area. This critical habitat designation has been withdrawn and is currently being reviewed by NOAA Fisheries, pursuant to a consent decree on April 30, 2002 (NMFS 2002).

Spring/summer chinook salmon are Federally listed as threatened under the ESA and by the State of Idaho. Chinook salmon are part of the federally threatened Snake River Chinook "Spring/Summer Run" ESU (Federal Register Vol. 57, April 22, 1992) in the Lemhi River sub-basin. Designated critical habitat for this ESU occurs in the Lemhi hydrologic unit (Federal Register Vol. 64, No. 205, October 25, 1999).

Bull trout are listed as threatened under the Federal ESA and as a species of concern by the State of Idaho. Bull trout are part of the Columbia River Basin bull trout distinct population segment (DPS) which is listed as threatened (Federal Register, Vol. 63, No. 111, June 10 1998). In 2002, FWS proposed critical habitat for bull trout in the Columbia River basin (Federal Register, Vol. 67, No. 230, November 29, 2002). In 2003, FWS reopened the comment period for the proposal to designate critical habitat for Columbia River DPS bull trout (Federal Register Vol. 68, No. 28, February 11, 2003). Final designation of critical habitat has been delayed due to a funding shortfall (Letter from R. Mark Wilson, FWS Montana Field Supervisor, June 17, 2003).

2.0 STUDY REGION

The following definitions apply to the following discussion:
Study area – The study area is defined as the stream reach impacted by flow alteration. Typically, only a small portion of a single stream makes up the study area.
Hydrologic segment – The portion of the study area that has a homogeneous flow regime. A study area may have one or more hydrologic segments (+/- 10% of the mean monthly flow (Q)).
Sub-segment (*Reach*) – A physical aspect of the channel within a hydrologic segment that affects the microhabitat versus flow relationship (e.g., channel morphology, slope, or land use).
Study site – A mesohabitat unit within a hydrologic segment or sub-segment.

The study area encompassed the mainstem Big Timber Creek from its confluence with the Lemhi River upstream to Basin Creek. Field reconnaissance, topographic maps, and interviews with IDFG indicated that Big Timber Creek could be divided into two hydrologic stream segments, defined as follows:

- Confluence with Lemhi River upstream to confluence with Little Timber Creek;
- Confluence with Little Timber Creek upstream to confluence with Basin Creek.

A hydrologic segment may be subdivided based on slope, channel morphology, or valley orientation (Bovee et al. 1998). Using U.S. Geological Survey (USGS) topographic maps, longitudinal gradient was plotted for Big Timber Creek within the study area (Figure 1). Within the two hydrologic segments, seven sub-segments, or reaches, were identified, distinguished primarily by differences in stream channel morphology and locations of major diversions. These were distributed sequentially proceeding upstream. Each sub-segment, or reach, is described below. Study sites selected to represent mesohabitat types within each sub-segment are identified on Figures 2 and 3.

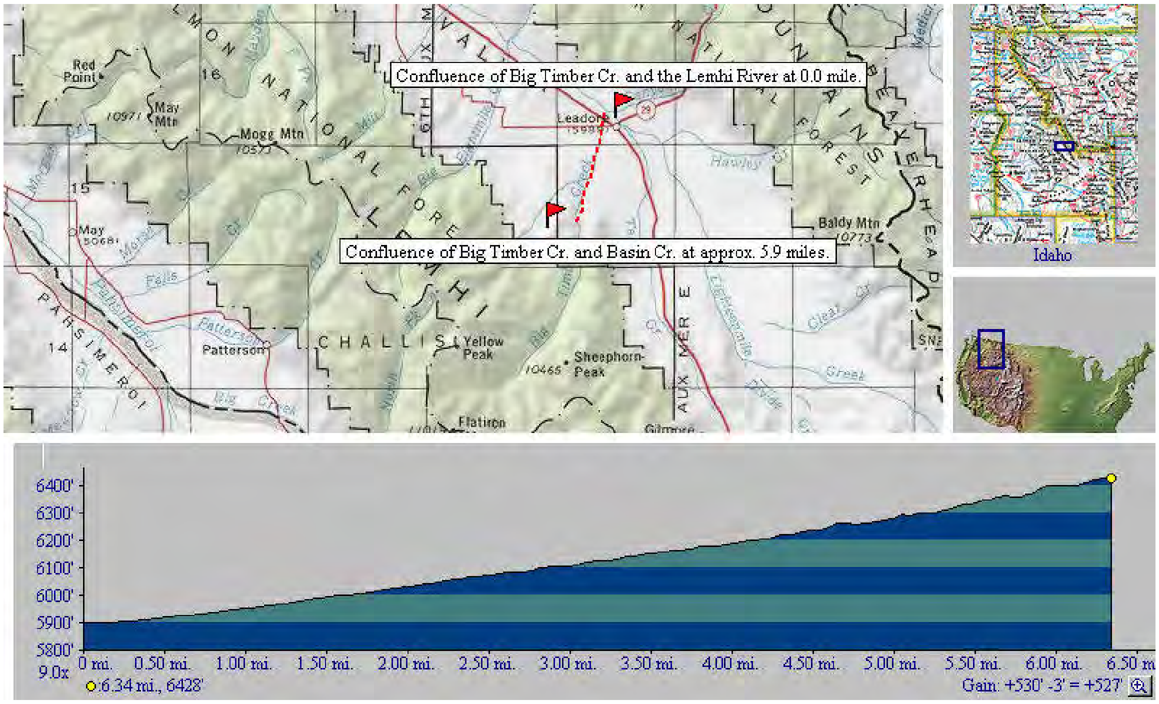

Figure 1. Big Timber Creek study area for flow characterization study.

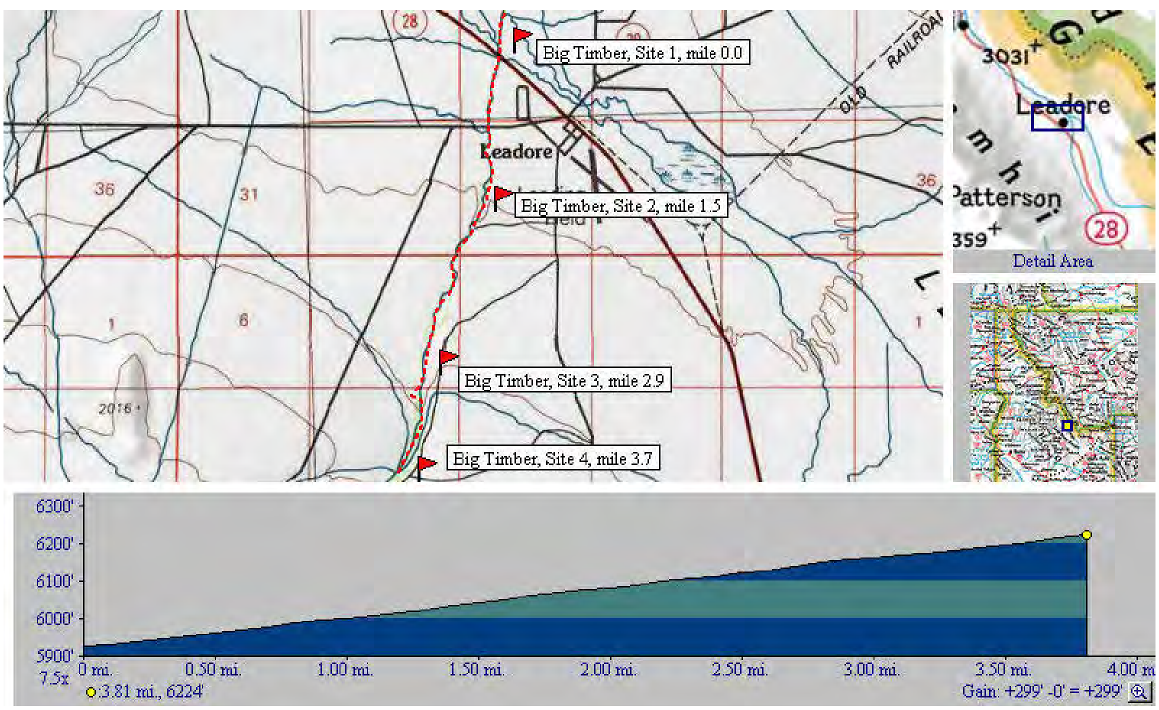

Figure 2. Big Timber Creek locations of study sites 1-4.

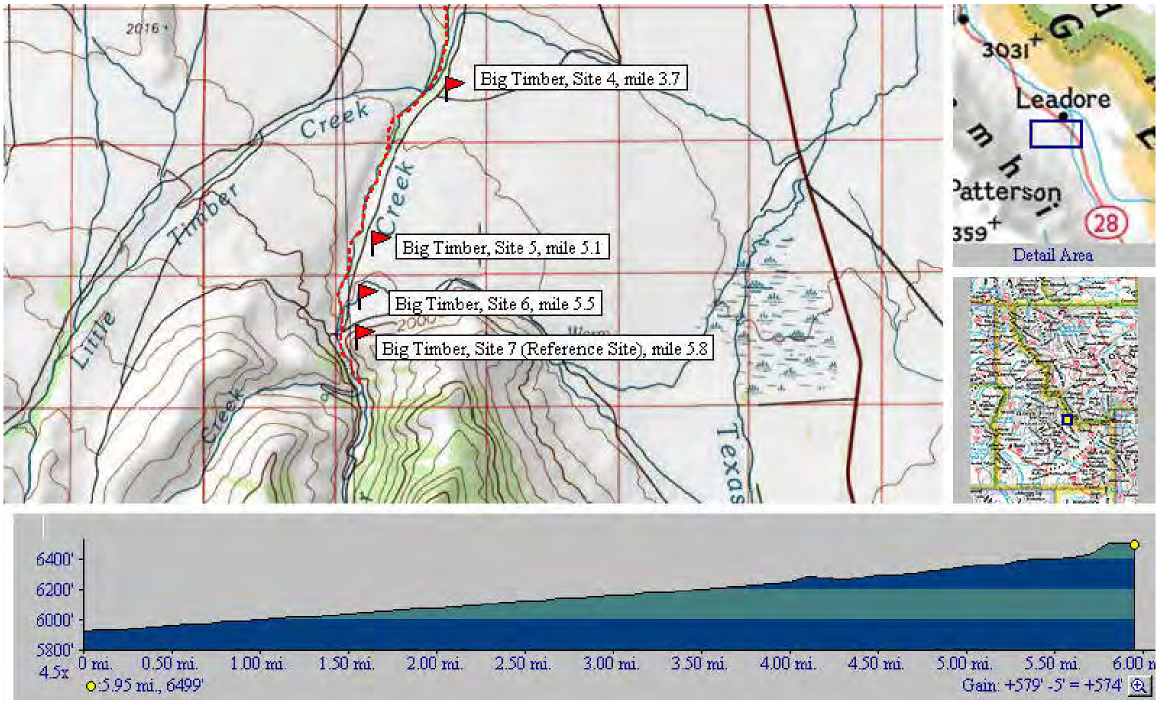

Figure 3. Big Timber Creek locations of study sites 4-7.

Reach 1: This reach extended from the confluence with the Lemhi River upstream to the first major diversion (N44.67760186 W113.3700417) that dewaters the stream channel during the irrigation season. The study site for this reach was located downstream from the dewatered channel where the stream was recharged by groundwater seeps on private property. The stream channel was narrower and shallower than the other reaches.

Reach 2: This reach extended from the diversion site at the upstream boundary for reach 1 upstream to another major diversion (N44.66095604 W113.3763557. The study site for this reach was represented by low gradient riffles and runs.

Reach 3: This reach was located between two major diversions that defined the upstream and downstream boundaries of reaches 2 and 4, respectively. The study site for this reach was located just downstream from a bridge crossing and represented by riffles and runs.

Reach 4: This reach extended from a relatively new major diversion (N44.660844 W113.377399) located upstream from the bridge crossing upstream to the confluence with Little Timber Creek (N44.64249705 W113.3831149). The study site for this reach represented a mixture of riffle, run, and pool habitat types.

Reach 5: This reach was located between the confluence with Little Timber Creek and the next major upstream diversion (N44.620541 W113.396212). This reach was characterized by beaver dams mixed with riffle, run, and pool habitats. Abundant riparian vegetation was dominated by willows. The study site represented riffles, runs, and pools within this reach.

Reach 6: This reach was located between the upstream diversion boundary for reach 5 upstream to the Cary Act Diversion (N44.61482736 W113.3967245) and Pipe Diversion (N44.613771 W113.397011)). This reach had similar habitat characteristics as reach 5, including blown-out beaver dams and excellent riparian vegetation. The study site in this reach represented a mixture of riffles, runs, and pools.

Reach 7: This reach was located between the Pipe Diversion upstream to Basin Creek (N44.608750 W113.393787). The study site represented natural flow conditions (reference site) immediately upstream from the major diversions on Big Timber Creek. Habitat types included plunge pools, riffles, and runs.

3.0 LIMITING FACTORS ANALYSIS

The main components in this analysis were existing hydrology and fish population data. Existing USGS natural streamflow estimates and measured streamflows during 2003 were used to determine recent historic hydrology. Existing fish population data were used as an index of fish populations in the study streams. Additionally, any existing water quality data, including water temperature, were evaluated to determine if water quality was limiting. Water temperature was monitored continuously at one location in Big Timber Creek by Reclamation between July and September, 2003 using Onset TidBit data loggers to assess whether summer water temperatures limited the fishery.

Federal ESA listed species addressed in this section include the anadromous Snake River spring/summer Chinook salmon ESU; Snake River steelhead ESU; and resident Columbia River Basin bull trout DPS.

3.1 Steelhead

The Lemhi River sub-basin summer steelhead are classified as A-run steelhead (early migrators and spawners). Specific data on spawning populations of steelhead within Lemhi River sub-basin are very limited. These fish arise from stocks that were introduced by IDFG but are now considered natural populations. Periodicity for steelhead in the Lemhi River Drainage is summarized in Table 1.

Table 1. Periodicity chart for steelhead in Lemhi River Drainage (EA Engineering 1991a).

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult												
Spawning												
Incubation												
Fry												
Juvenile												
Outmigrate												

Steelhead migrate inland towards spawning areas, overwinter in larger rivers, resume migration to natal streams in early spring, and then spawn (Nickelson et al. 1992).

Steelhead are widely distributed throughout the sub-basin, and juveniles are present year-round. The lower 27 miles of the mainstem Lemhi River from the mouth to Agency Creek serves mainly as a migration corridor. The 11-mile reach between Agency and Hayden Creeks provides rearing and limited spawning habitat. Tributary streams also provide spawning habitat. The IDFG collected resident rainbow/redband trout in Big Timber Creek below Rocky Creek confluence in 2003 (Murphy and Horsmon 2004). Mean density was 5.04 fish per 100 m^2 (1,076 ft^2). Steelhead were not collected.

Irrigation, grazing, and road construction have affected habitat conditions throughout the Lemhi sub-basin (NPPC 2001). Limiting factors on the mainstem river can be grouped based on three distinct river segments, each having its own limiting factors. The lower 27-mile mainstem reach is degraded because of the lack of riparian vegetation and lack of pools for rearing and adult holding. The next segment, an 11-mile reach between Agency and Hayden Creeks, provides habitat, but riparian degradation has led to elevated water temperatures and unstable banks. The third mainstem segment, 28 miles from Hayden Creek to Leadore, has fluctuating summer temperatures, unstabilized banks, and few high quality pools. Salmonid habitat threats in the tributary streams include bank erosion leading to sedimentation, elevated temperatures, and degraded riparian habitat. Irrigation withdrawals have resulted in dewatered lower reaches in most tributaries. Water does not flow into the Lemhi River from many of the tributaries except during spring runoff, substantially reducing downstream migrations of fish and creating migration barriers. Many irrigation diversions on lower reaches of tributaries are not screened to protect migrating fish.

3.2 Spring/Summer Chinook Salmon

The two "races" of spring/summer chinook salmon in the Salmon River are classified by the season of adult passage at Bonneville Dam on the Columbia River during upstream migration. Spring/summer chinook enter the Columbia River March through July. Chinook that pass from March 1 to May 31 are considered "spring chinook" and those that pass from June 1 to July 31 are considered "summer chinook." Spawning occurs in August through October. Eggs hatch in April and May, and the fry emerge approximately 1 month later. Juveniles rear for 1 year before out-migrating to the ocean (Simpson and Wallace 1982). Periodicity for Chinook salmon in the Lemhi River Drainage is summarized in Table 2.

The Lemhi River is believed to have supported substantial, relatively productive historic runs of this ESU. The "spring" race of chinook salmon spawn in the Lemhi River upstream of Hayden Creek. Over 95 percent of the salmon spawning and rearing in this sub-basin takes place in the upper 28 miles of the mainstem between Hayden Creek and Leadore. Most Snake River Spring/Summer Run Chinook salmon enter the sub-basin from May through September. Spawning occurs in late summer and early fall. All spawning is natural, as hatchery releases from Hayden Creek were suspended in 1982.

Table 2. Periodicity chart for Chinook salmon in Lemhi River Drainage (EA Engineering 1991a).

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult										■		
Spawning										■		
Incubation												■
Fry							■					
Juvenile												■
Outmigrate						■						

Juveniles reside in rearing areas for approximately 12 months before migrating downstream the following April and May (Bugert et al 1990; Cannamela 1992). The IDFG did not find Chinook salmon in Big Timber Creek during 2003 fish surveys (Murphy and Horsmon 2004).

Threats to chinook salmon are the same as those discussed for steelhead in the Lemhi sub-basin.

3.3 Bull Trout

Bull trout in the Lemhi sub-basin are considered fluvial stock, as they migrate between streams and larger rivers. Bull trout typically spawn in September and October but may begin their spawning migration as early as April. Spawning occurs in clean gravels, with areas of groundwater upwelling preferred. Fry emerge from early April through May. Small juveniles tend to remain in the gravels and cobbles. After reaching 4 inches in length, they move to backwater and sidewater channels, eddies, or pools (Goetz 1989). Periodicity for bull trout in the Lemhi River Drainage is summarized in Table 3.

Table 3. Periodicity chart for bull trout in Lemhi River Drainage (EA Engineering 1991a).

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult										■		
Spawning										■		
Incubation												■
Fry										■		
Juvenile												■

Within the project area, bull trout are widely distributed. They are present year-round. Bull trout are found in Big Eightmile, Big Timber, Eighteen Mile, Geertson, Hauley, Hayden, Kenny, Bohannon, Kirtley, Little Eight Mile, Mill, Pattee, and Texas Creeks; their tributaries; and in the Lemhi River (NPPC 2001). The IDFG collected juvenile and adult bull trout from mainstem Big Timber Creek upstream from Basin Creek confluence in 2003 (Murphy and Horsmon 2004). They were the most abundant species found in the Big Timber Creek watershed, with densities as high as 19.18 fish per 100 m^2 (1,076 ft^2), indicating excellent water quality and high quality habitat.

Threats to bull trout and their habitat are the same as listed for steelhead in the Lemhi Subbasin. Of particular concern to fluvial bull trout is dewatering of lower tributary reaches and un-screened diversion structures that inhibit downstream migration into mainstem waters.

3.4 Hydrology

Natural streamflow estimates characterize seasonal flow variability in each stream segment . Large fluctuations in flow during the year are products of variable weather and the free-flowing condition of Big Timber Creek upstream from the major diversions Table 4 shows monthly flow exceedances and mean annual flows in Big Timber Creek for Study Site 4 downstream from the confluence with Little Timber Creek and Study Site 7 that represented natural flow conditions immediately upstream from the major diversions. An exceedance flow is defined as the flow that is equaled or exceeded a certain percentage of time. Flows were calculated for 20, 50, and 80 percent exceedance. These values were based on regional regression equations developed by USGS in Boise for the Forest Service (Hortness and Berenbrock 2001). Table 5 summarizes flows measured by USGS using a stage recorder during the 2003 irrigation season at Study Site 7. Figures 4 and 5 are graphical representations of tabular flows for Big Timber Creek discharge (cfs) in summer, 2003 using continuous gaging data and exceedance estimates. Flows ranged from 16 cfs in late September to 295 cfs on May 31. Flows will continue to be monitored at the stream gage on Big Timber Creek during 2004 and will eventually be accessible from the following website:
http://id.water.usgs.gov/projects/salmon_streamflow.

The hydrology of much of Big Timber Creek has changed dramatically since the mid-1840s because of diversions that resulted in a lack of connectivity to the floodplain. During irrigation season most of the water is diverted off-channel through diversion headgates and either used for flood or sprinkler irrigation. Big Timber Creek is entirely or significantly diverted for irrigation purposes between late April and the end of October (IDEQ 1999). As a result, most available water in Big Timber Creek only reaches the Lemhi River during spring runoff.

Table 4. Monthly exceedance flows on Big Timber Creek using USGS regional regression equations.

Month		Flow value (cfs)	
		Study Site 4	Study Site 7
October	Q.80 =	8.8	6.41
	Q.50 =	14.9	10.9
	Q.20 =	22.5	16.6
November	Q.80 =	11.2	8.1
	Q.50 =	13.9	10.1
	Q.20 =	20.2	14.9
December	Q.80 =	9.46	6.87
	Q.50 =	11.9	8.69
	Q.20 =	17.2	12.6
January	Q.80 =	8.94	6.47
	Q.50 =	10.8	7.89
	Q.20 =	15.5	11.4
February	Q.80 =	8.83	6.36
	Q.50 =	11.2	8.12
	Q.20 =	15.7	11.6
March	Q.80 =	9.14	6.58
	Q.50 =	13.1	9.52
	Q.20 =	18.5	13.6
April	Q.80 =	15.4	11.3
	Q.50 =	25	18.9
	Q.20 =	49.6	38.8
May	Q.80 =	58.7	49
	Q.50 =	116	97.3
	Q.20 =	217	184
June	Q.80 =	139	110
	Q.50 =	223	178
	Q.20 =	353	284
July	Q.80 =	31.9	24.2
	Q.50 =	59.9	45.2
	Q.20 =	101	76.3
August	Q.80 =	18.5	14.1
	Q.50 =	27.5	20.9
	Q.20 =	45	34.4
September	Q.80 =	15	11.3
	Q.50 =	21.3	15.9
	Q.20 =	32	24.1
Average annual	Qaverage =	36.9	27.8

Table 5. Water resource records for Big Timber Creek upstream from diversion structures, 2003.

U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION NUMBER 13303500 BIG TIMBER CREEK ABV DIVERSIONS NR LEADORE ID SOURCE AGENCY USGS STATE 16 COUNTY 059

LATITUDE 443700 LONGITUDE 1132400 NAD27 DRAINAGE AREA 57.00 CONTRIBUTING DRAINAGE AREA 57* DATUM 6420. NGVD29

Date Processed: 2004-01-05 09:38 By dfgreen

Discharge, cubic feet per second

WATER YEAR OCTOBER 2002 TO SEPTEMBER 2003

DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	257	43	21	17
2	---	---	---	---	---	---	---	---	208	42	20	17
3	---	---	---	---	---	---	---	---	168	41	22	17
4	---	---	---	---	---	---	---	---	153	40	22	17
5	---	---	---	---	---	---	---	---	136	39	21	17
6	---	---	---	---	---	---	---	---	119	37	20	17
7	---	---	---	---	---	---	---	---	113	36	20	19
8	---	---	---	---	---	---	---	---	108	35	19	17
9	---	---	---	---	---	---	---	---	109	34	19	17
10	---	---	---	---	---	---	---	---	109	33	19	18
11	---	---	---	---	---	---	---	---	103	32	18	18
12	---	---	---	---	---	---	---	---	97	31	18	17
13	---	---	---	---	---	---	---	---	89	30	18	17
14	---	---	---	---	---	---	---	---	82	30	18	17
15	---	---	---	---	---	---	---	---	77	29	18	17
16	---	---	---	---	---	---	---	---	74	28	18	17
17	---	---	---	---	---	---	---	---	73	27	18	17
18	---	---	---	---	---	---	---	---	70	26	18	17
19	---	---	---	---	---	---	---	---	68	26	18	17
20	---	---	---	---	---	---	---	---	68	25	17	17
21	---	---	---	---	---	---	---	---	65	25	18	17
22	---	---	---	---	---	---	---	36	58	24	18	16
23	---	---	---	---	---	---	---	49	54	24	20	16
24	---	---	---	---	---	---	---	70	54	24	18	16
25	---	---	---	---	---	---	---	102	51	25	18	16
26	---	---	---	---	---	---	---	135	47	25	17	16
27	---	---	---	---	---	---	---	153	44	24	18	16
28	---	---	---	---	---	---	---	176	44	23	18	16
29	---	---	---	---	---	---	---	226	43	22	18	16
30	---	---	---	---	---	---	---	258	43	22	18	16
31	---	---	---	---	---	---	---	295	---	21	17	---
TOTAL	---	---	---	---	---	---	---	---	2784	923	580	505
MEAN	---	---	---	---	---	---	---	---	92.8	29.8	18.7	16.8
MAX	---	---	---	---	---	---	---	---	257	43	22	19
MIN	---	---	---	---	---	---	---	---	43	21	17	16
MED	---	---	---	---	---	---	---	---	76	28	18	17
AC-FT	---	---	---	---	---	---	---	---	5520	1830	1150	1000
CFSM	---	---	---	---	---	---	---	---	1.63	0.52	0.33	0.30

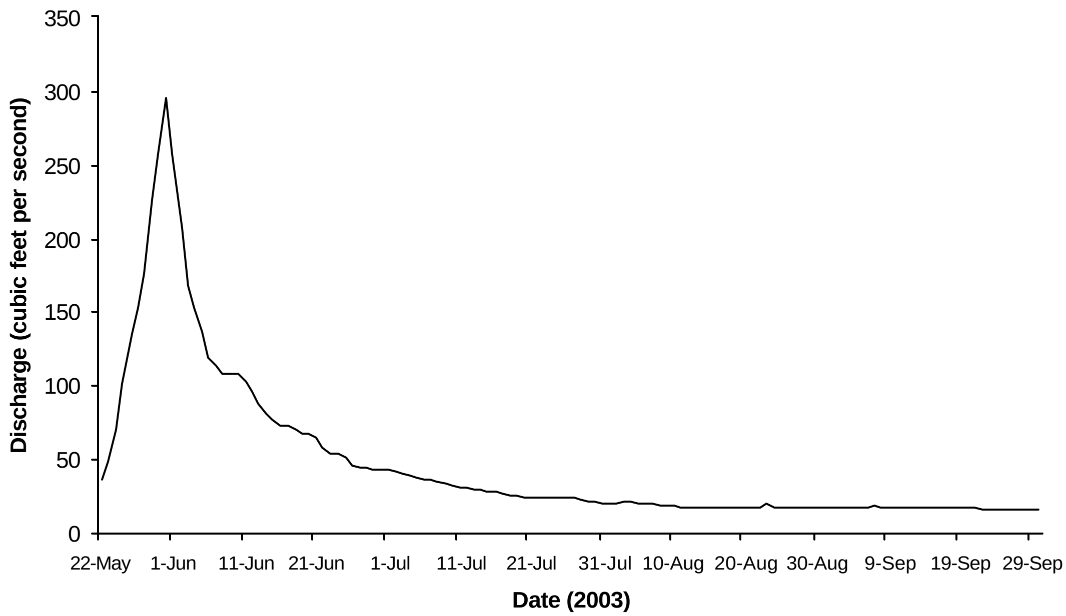

Figure 4. Graphical representation of data in Table 5 for unimpaired discharge (cfs) measured in Big Timber Creek upstream from diversions (2003).

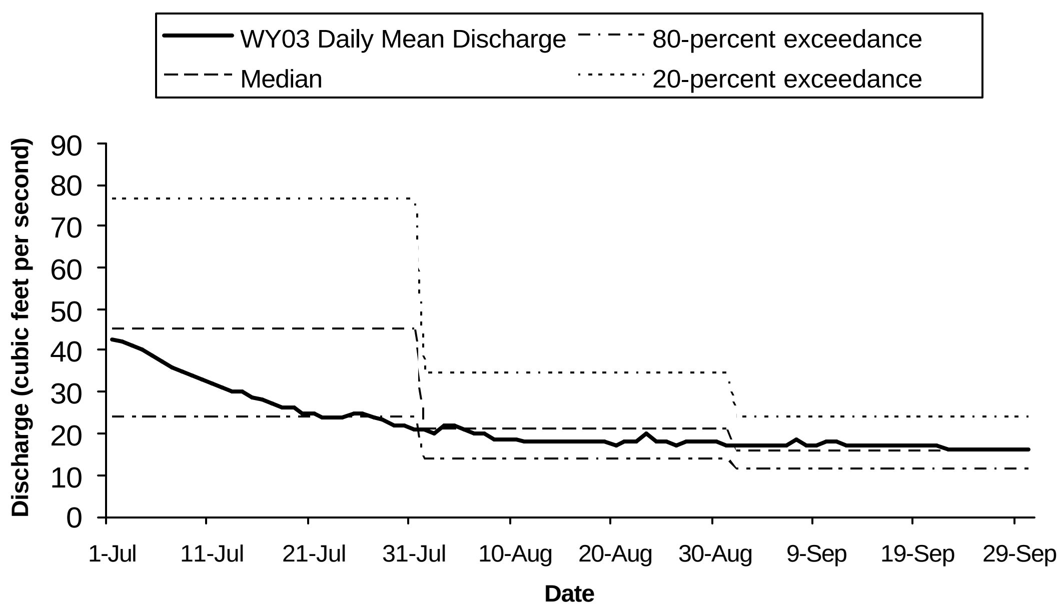

Figure 5. Graphical representation of Tables 4 and 5 for Big Timber Creek discharge (cfs) in summer, 2003 using continuous gaging data and exceedance estimates.

3.5 Water Quality

Water bodies are designated in Idaho to protect water quality for existing or designated uses. Big Timber Creek from its source to Little Timber Creek is designated by *Idaho Administrative Code 58.01.02 - Water Quality Standards* as:

a. Cold water: water quality appropriate for the protection and maintenance of a viable aquatic life community for cold water species (4-5-00); and
b. Salmonid spawning: waters which provide or could provide a habitat for active self-propagating populations of salmonid fishes (7-1-93).

Although Big Timber Creek is not listed on Idaho's 1998 303(d) list, the potential exists for elevated summer temperatures. Stream temperature is driven by the interaction of many variables, including shade, geographic location, vegetation, climate, topography, and flow. Based on *Idaho Administrative Code 58.01.02 - Water Quality Standards*, SURFACE WATER QUALITY CRITERIA FOR AQUATIC LIFE USE DESIGNATIONS, Idaho waters designated for cold water aquatic life are not to vary from the following characteristic: water temperatures of 22°C (72°F) or less with a maximum daily average of no greater than 19°C (66°F). (8-24-94). Hourly temperatures measured July 17, 2003 to September 18, 2003 for Big Timber Creek in the vicinity of Reach 4 are plotted in Figure 6. The maximum temperature reading was 21.1°C (70°F) on July 21. Average temperature was 14.0°C (57°F), which met this standard. Abundant riparian vegetation along Big Timber Creek likely shaded the stream and kept water temperatures from reaching extremely high levels during summer, 2003.

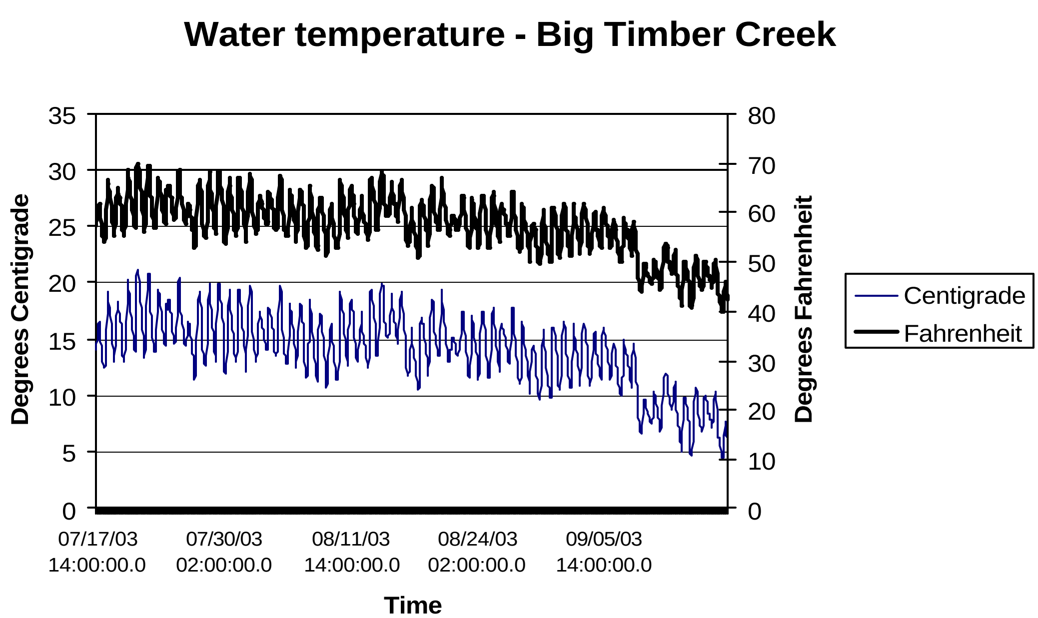

Figure 6. Water temperatures in Big Timber Creek during summer of 2003 measured by Reclamation near Reach 4.

Flow levels are affected by weather, snowpack, rainfall, and water withdrawal. Diverted water can reduce water quality. Shallower, slower water tends to warm faster than deeper, faster water. Warmer water holds less dissolved oxygen than cooler water. The combination of warm water with less dissolved oxygen, especially water temperatures above 20°C (68°F) and dissolved oxygen below 5 milligrams per liter, can stress salmonids (Bjornn and Reiser 1991). The temperature at which 50% mortalities (LC-50) occur in juvenile Chinook salmon is 25°C (77°F), when acclimated to 15°C (59°F) (Armour 1991). The upper lethal limit is 24°C (75°F) for steelhead (Bell 1991). In general, problem eutrophication is a partial result of irrigation return flow (non-point source) and possibly cattle feedlots (point source). However, agricultural runoff presents a low level of potential impact to water quality.

Water withdrawals have degraded the aquatic resources in the Lemhi River sub-basin by reducing flow in the river channels. Water use for irrigation is heavy, with water appropriations exceeding natural flows at times, most notably in the summer. Water appropriation varies by season, with less proportion of consumptive use in winter and most in summer. Artificially low streamflow limits the movement of fish, reduces the amount of physical habitat available for fish to live in, and reduces quality of habitat.

3.6 Summary

Based on this analysis, the primary limiting factors for fisheries in Big Timber Creek appear to be summer temperature and flow. Self-sustaining fish populations exist for the species of interest with no reported fish die-offs, and there is an available water supply throughout the year upstream from the major diversions. However, warm summer water temperatures are affected partly by water withdrawals, which also affect stream flows. Although high summer water temperature may limit the fisheries in late July and early August, fish populations continue to exist within available physical habitat throughout the year.

4.0 METHODS

The approach for characterizing flow needs in Big Timber Creek involved planning and execution of a Physical Habitat Simulation (PHABSIM) study in the stream segments identified above. The Technical Service Center (TSC) of Reclamation in Denver, Colorado was responsible for (1) collecting and compiling existing hydrology and biological data for salmon, steelhead, and bull trout using these streams; (2) conducting the study; and (3) providing Reclamation's Snake River Area Office in Boise, Idaho with a final report and associated data. These tasks are briefly outlined below.

4.1 Microhabitat Analysis

PHABSIM predicts changes in the relationships between in-stream flows and fish habitat for individual species and life stages and is best used for decision-making when alternative discharges are being evaluated (Bovee et al. 1998). It is useful for comparing the relative effects of various in-stream flow release schedules. Stream flow and habitat data are used in a group of models called PHABSIM. Hydraulic models are used to calculate water surface elevations and depths and to simulate velocities for specific flows. Depth, velocity, substrate material, and cover data are used to determine available habitat. The model outputs proportions of suitable and unsuitable reaches of the stream and shows how often a specified quantity of suitable habitat is available. This methodology is scientifically tested and is generally an accepted technique for determining flows needed for fish. The habitat requirements of a number of species are not known; therefore, application can be limited unless emphasis is placed on developing habitat suitability criteria (HSC) for species of interest. The output of the model must be measured against biological knowledge.

Studies utilizing PHABSIM require extensive data collection and analyses. The steps in a PHABSIM study are briefly outlined below.

4.1.1 Mesohabitat Classification and Inventory

Specific procedures at each study site included:

- Locate study segments for study site selection.

- Map habitat features for stream segment. Habitat mapping, or mesohabitat typing, started at the upper segment boundary and proceeded downstream. The "cumulative-lengths approach" described by Bovee (1997) was used for habitat mapping. Habitat types were defined based on the purpose of hydraulic modeling to capture hydraulic changes (e.g., backwater and slopes).

- Thus, Reclamation used the following mesohabitat classification scheme:
    - low gradient riffles (slope),
    - moderate gradient riffles (slope),
    - high gradient riffles (slope),
    - runs (slope), and
    - pools (backwater).

Linear distance of each major habitat type was recorded and the total of each habitat type and total length mapped were recorded at the end of each segment. The mapped data were used to determine percentages of each habitat type.

- Study sites were selected based on habitat mapping**.**

4.1.2 Collection of hydraulic data

PHABSIM requires hydraulic and habitat suitability data to determine the instream flow requirements for the species and/or life history stage of interest. Several hydraulic sub-models can be used with PHABSIM including STGQ, WSP, and MANSQ. Field data collection was designed to accommodate any of these models. PHABSIM data collection included several steps: study segment location, habitat mapping, transect (cross section) placement and data collection.

- Transects were placed in all habitat types that represented over 5 percent of the total available habitat. Transects were placed in homogeneous habitat types with the number of transects dependent upon the physical and hydraulic features of each habitat type. The number of transects necessary to capture the depth, velocity, cover and substrate distribution and variability is in large part a function of the specific river being worked on, the mesohabitat type being sampled, and the HSCs.
- Additional non-habitat simulation transects were placed at hydraulic controls (HC) by professional judgment to aid in hydraulic calibrations. The shallowest path across riffles or shallow runs within the study site was used to address passage issues for juvenile and adult salmonids.
- At each set of transects in each habitat type the following data were collected: establishment of horizontal reference points, distance between transects, field notes referencing general habitat and stream conditions in the transect areas, and reference photos of habitat and of each transect within each habitat type.

Field data were collected according to Bovee (1997) using standard surveying equipment above the water surface and using depth measured from a wading rod for wet areas. Reclamation personnel coordinated field survey procedures with the USGS flow study conducted in the upper Salmon River for quality control. We attempted to conduct the surveys at low medium, and high discharges. Vertical elevations were established throughout each habitat type by using differential leveling with a total station instrument (Bovee 1997). A benchmark was established (with rebar) and assigned the arbitrary elevation of 100.00 feet. All differential leveling was referenced to this benchmark. Water surface elevations (WSL) were measured to the nearest 0.01 ft near the water's edge along each transect at all discharges. Channel cross sections were measured (vertical and horizontal) to the nearest 0.1 ft between headpins at each transect during low discharge. Discharge measurements at each transect were taken at the three discharges.

4.1.3 Depth, Velocity, Substrate, and Cover

Depths, mean velocities, substrates, and cover were measured at various points along each transect. Stationing across transects was oriented with 0.0 on the left bank looking upstream for modeling purposes. Depths were measured using a top setting wading rod. Streambed elevations and water depths were measured to the nearest 0.1 ft. Mean column water was measured to the nearest 0.1 ft/sec using a Marsh McBirney Flo-Mate 2000 velocity meter attached to the wading rod. Substrate and cover for PHABSIM were visually assessed using a system developed by EA Engineering (1991b) (Table 6). A temporary staff gage was installed at each site so that fluctuations in WSL could be monitored during data collection.

Table 6. Big Timber Creek instream substrate and cover coding system.[1]

Code	SUBSTRATE	diameter (in)	diameter (mm)
1	Detritus	organic matter	
2	Silt	<0.0024	0-0.062
3	Sand	0.0024 - 0.125	0.062-3.2
4	Small Gravel	0.125 – 1.0	3.2-25
5	Coarse Gravel	1-3	25-76
6	Cobble	3-10	76-256
7	Boulder	>10	>256
8	Bedrock		
9	Aquatic Veg		
	COVER		
1	Woody debris		
2	Undercut	undercut bank	
3	Cobble/Boulder	(>3”)	
4	Aquatic vegetation		
5	Large gravel	(2-3”)	
6	Canopy	canopy or overhead structure	
7	Emergent vegetation		
8	No cover		

[1] Source: EA Engineering (1991b)

Velocity calibration sets were collected at three different time periods between June and September, 2003 in an attempt to cover a range of flows.

Additional transect-specific data (i.e., flow and water surface elevations) were also collected during each of the velocity surveys at each site. These stage-discharge measurements provided the data necessary for model calibration and extended the range for hydraulic simulations. The applicability of the range of flows simulated to actual flows in the stream is dependent on the flows measured.

4.1.4 Habitat Suitability Criteria (HSC)

Species HSCs are required for PHABSIM analysis. Habitat suitability criteria, or curves, are interpreted using a suitability index (SI) on a scale of 0 to 1, with 0 being unsuitable and 1 being most utilized or preferred. Habitat suitability criteria that accurately reflect the habitat requirements of the species of interest are essential to developing meaningful and defensible instream flow recommendations. The recommended approach is to develop site specific criteria for each species and life stage of interest. An alternative involves using existing curves and literature to develop suitability criteria for the species of interest. No site-specific HSCs are available in the Lemhi River sub-basin and time and budgetary constraints precluded developing HSCs specific to Big Timber Creek. While such information may become available in the future through a separate study, the TSC worked with other interested parties and agencies in the interim to evaluate existing criteria curves appropriate for the Lemhi River sub-basin and decided to use HSCs that were developed for the upper Salmon River and Clearwater Basins by EA Engineering (1991b) for the Bureau of Indian

Affairs, and which represented the general habitat requirements of each particular fish species and lifestage for the Lemhi River sub-basin streams.

4.1.5 Hydraulic Model Selection and Calibration

Reclamation used the USGS Windows version of PHABSIM (USGS 2001) and coordinated hydraulic modeling procedures with the USGS flow study conducted in the upper Salmon River for quality control. PHABSIM has several submodels available for hydraulic simulations. These include STGQ, WSP, and MANSQ (USGS 2001), with STGQ being the most rigorous in terms of data requirements. Each hydraulic model requires multiple flow measurements to extend the predictive range. Depending on model performance, the predictive range may be restrictive, or wide ranging (i.e., 0.1 to 10 times the measured discharges) (USGS 2001). Since water is diverted between April 1 and September 30 of each year for irrigation, the range of flows for the hydraulic simulations covered flows that typically occur during these months.

Field sampling was designed to collect data in formats suitable for application in any of the hydraulic models identified above. The following approach was used:

- Enter field data into appropriate format for water surface simulations
- Calibrate STGQ, MANSQ, or WSP (depending on site specific conditions) to measured WSL
- Document calibration procedure
- Simulate a range of flows to predict water surface elevations
- Simulate depths and velocities for range of flows that occur during the irrigation season
- Evaluate simulation range based on velocity adjustment factors (VAF's) and other calibration sub-models
- Document acceptable range of simulations
- Conduct velocity simulation production run for applicable range of flows that may occur during the irrigation season.

4.1.6 Habitat Modeling

Table 7 shows various life stages and variables used to describe microhabitat.

Table 7. Life stages for species of interest and microhabitat variables used to describe habitat.

Life Stage	Depth	Velocity	Substrate	Cover
Adult passage	X			
Adult holding	X	X	X	
Adult spawning	X	X	X	
Juvenile rearing	X	X	X	X

Since velocity HSCs for juvenile and adult bull trout were developed for nose velocities at 0.2 feet off the stream bottom (EA Engineering 1991b), the nose velocity option in the habitat model was used for these life stages of bull trout.

The following example describes how habitat weighting factors (WF) were determined. Study Site 3 had five cross sections: one deep run, three shallow runs, and one moderate gradient riffle. Within this site, based on the habitat mapping percentages (Appendix B), the three shallow runs represented 340 ft (34%), the moderate gradient riffle 540 ft (54%), and the deep run represented 120 ft (12%) of a 1,000 ft idealized reach. The shallow run distance of 340 ft was divided equally by three (113', 113', 114') to represent the three shallow runs at Study Site 3. Both the deep run and moderate gradient riffle distances remained the same. Weighting factors of 0.00-1.0 were calculated for each cross section to accurately represent the entire stream reach (Table 8).

Table 8. Example of setting cross section weighting factors for habitat modeling.

Cross section	Habitat type	Distance from previous cross section (ft)	Weighting factor
1	Riffle	0	1.0
2	Shallow run	540	1.0
3	Shallow run	114	1.0
4	Shallow run	113	0.48
5	Deep run	233	0.0
Total		1,000	

An assigned WF of 1.0 moved upstream, and an assigned WF of 0.0 moved downstream, or backwards from the cross section. Weighting factors greater than 0.0 up to 1.0 moved the habitat upstream in proportion to the value assigned. For instance, the X-sec 1 WF of 1.0 applied continually upstream to X-sec 2, the entire 540 ft. The same applied to X-sec 2 and 3. The final cross section was handled differently. Essentially, it was combined into one unit, and assigned two WFs to complete the study site. The distances of X-sec 4 and 5 were combined (113+120) for a total distance of 233 ft. The formula below was used for attaining a WF:

$$233(x) = 113$$

$$X = 113/233 = 0.48$$

where X represented the unknown WF, 233 ft was the combined distance (X-sec 4 & 5), and 113 ft was the distance of X-sec 4.

The WF of 0.48 applied the habitat weighting 48% upstream to represent the final run. A weighting factor of 0.0 applied the habitat weighting of the remaining area, or 52% downstream from cross section 5. Figure 7 illustrates this procedure.

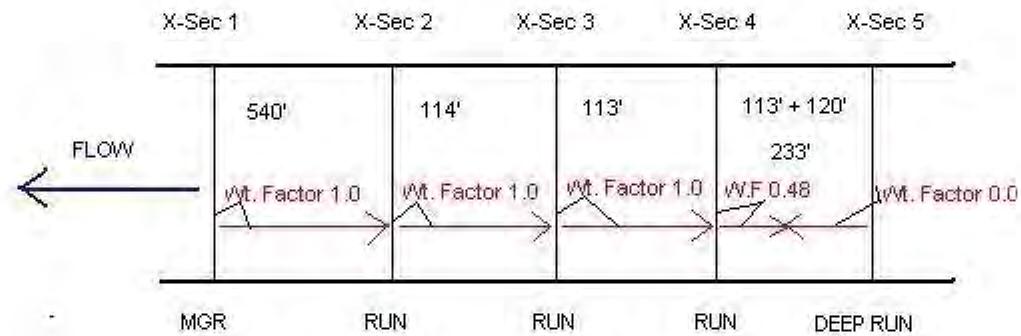

Figure 7. Example of weighting factor assignments at a PHABSIM study site.

If there was a hydraulic control (HC) cross section anywhere in the site it would not affect the habitat weighting. As for the distances (from previous cross section), the cross section immediately upstream from the HC would have a distance of '0 ft'; canceling out the HC in the model. For example, the distances and WF for the cross sections at Study Site 1 are listed in Table 9.

Table 9. Example of setting cross section weighting factors for habitat modeling with hydraulic controls.

Cross section	Habitat type	Distance from previous cross section (ft)	Weighting factor (WF)
1	Run	0	1.0
2	Hydraulic Control (HC)	55	1.0
3	Pool	0	1.0
4	Pool	170	1.0
5	HC	170	1.0
6	Pool	0	1.0
7	Riffle	170	0.87
8	Run	435	0.0
Total		1,000	

Weighted usable area (WUA) within each representative stream reach was calculated for each discharge of interest for each species. Weighted usable area is an index of habitat availability or quantity for the selected species/life stage at each simulated flow. The WUA for each species was computed by multiplying the depth, velocity, substrate, and cover HSC values for a life stage at predicted hydraulic conditions, and cell surface area in the HABTAE submodel of PHABSIM. The output from the HABTAE simulation was habitat area, expressed as WUA (ft^2/1,000 ft of stream). Weighted Usable Area was predicted for a range of discharges at the six study sites. For presentation purposes, WUAs were normalized as a percentage of maximum habitat. It should be noted that there is a level of uncertainty associated with the WUAs. Sources of uncertainty include errors in HSCs, hydraulic simulations, or selection of options to simulate microhabitat (e.g., geometric versus multiplicative means). Recognition that there is uncertainty in these sources is important in the interpretation and use of PHABSIM model results (Bovee et al. 1998).

Habitat for juveniles of each species was modeled separately using substrate and cover because of the known association of this life stage with cover. Since all substrates and cover were considered most suitable (SI=1.0) for juveniles, habitat modeled for substrate included the discrete cover component because cells containing cover were already accounted for by the continuous substrate variable.

4.2 Passage

Suggested passage criteria for adult Chinook salmon, steelhead trout, and bull trout follow guidelines adopted by Oregon Department of Fish and Wildlife and taken from Thompson (1972) and Scott et al. (1981) (Table 10). To determine the recommended flow for passage, shallow bars most critical to passage of adult fish were located, and a linear transect was measured which followed the shallowest course from bank to bank. For each transect, a flow was computed for conditions which met the minimum depth criteria in Table 10 where at least 25% of the total transect width and a continuous portion equaling at least 10% of its total width, equal to or greater than the minimum depth, was maintained (Thompson 1972). Both width criteria must be met to insure passage.

Table 10. Suggested Big Timber River salmonid passage criteria (Thompson 1972; Scott et al. 1981).

Species	Minimum Depth (ft)	Maximum Water Velocity (ft/sec)
Steelhead Trout	0.6	8.0
Chinook Salmon	0.8	8.0
Bull Trout	0.4	4.0

4.3 Flow Recommendations using PHABSIM

The NOAA Fisheries draft protocol estimates idealized annual flow schedules for Pacific and interior northwest streams (Arthaud et al. 2002). The protocol identifies objectives for deriving minimum flow conditions necessary to protect sensitive salmonid life stages that can be quantified using PHABSIM methodologies. Results from this study can be used to help determine target flow objectives to improve passage, spawning, and rearing conditions for salmon, steelhead, and bull trout. Table 11 provides suggested critical life stage assignments for each month in the Lemhi River Drainage which could be used to determine target flows from the PHABSIM analysis.

Table 11. Suggested critical life-stage assignments for applying flow recommendations in the Lemhi River Drainage.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Steelhead											
J	J	A	P/S	S	S	J	J	J	J	J	J
Chinook salmon											
J	J	J	J	A	A	P/S	P/S	S	S	J	J
Bull trout											
J	J	A	A	A	A	A	A	P/S	S	J	J

J=juvenile; A=adult; S=spawning; P=passage

5.0 RESULTS AND DISCUSSION

Measured discharges and dates of field surveys are summarized in Table 12. Attempts to measure low, medium, and high flows at most sites were confounded by diversions downstream from Study Site 7. In most cases, only medium and low flows were measured. However, these conditions typically occur during the summer irrigation season with diversions. At Study Site 1, only low flow from groundwater seepage was present each time it was visited during the summer. Reclamation was able to measure one additional higher flow in late March, 2004 to improve model calibration and habitat simulations.

Written descriptions and photos of each selected study site are provided in Appendix A. Habitat mapping proportions are presented in Appendix B. Cross sectional profiles and measured WSLs are illustrated in Appendix C. Hydraulic model calibration results are summarized in Appendix D. Habitat suitability criteria (HSCs) are presented in Appendix E.

Complete habitat modeling output results (i.e., WUA vs discharge) are summarized in Appendix F for each stream reach. Graphical representations of final normalized WUA versus discharge relationships are presented in Figures 8 to 28 for each site. Juvenile habitat using the cover component independent of substrate did not model well because of the binary HSC criteria (i.e., present (SI=1.0) or absent (SI=0.0)). If a method could be developed to provide some quality ranking of cover types, the modeling could be improved. Separate cover habitat modeling results are included in Appendix F tables for juveniles. Appendix G contains site-specific IFG4 files for input into the PHABSIM program.

Passage flow results for contiguous widths at depths greater than the passage criteria (Table 10) are illustrated in Figures 29-35.

Summary results, including flows required for optimal WUAs and to flows needed to meet the 0.6 feet deep passage criteria are presented in Tables 13 to 19. Summary results reflected differences in stream channel hydraulics among study sites.

Table 12. Discharges measured from highest to lowest at Big Timber Creek study sites during field surveys in 2003.

Stream Site	Discharge (cfs)	Survey Dates
Study Site 1	2.0	June 24
	1.2	July 15
	1.3	September 18
	6.5	March 31, 2004
Study Site 2	8.2	September 18
	6.0	June 29
	4.9	July 17
Study Site 3	15.8	June 25
	8.9	September 18
	8.0	July 15
Study Site 4	11.0	June 29
	9.0	September 17
	8.0	July 17
Study Site 5	28.0	June 28
	25.0	July 16
	15.0	September 17
Study Site 6	29.0	July 16
	16.0	June 27
	13.0	September 16
Study Site 7 (Reference)	47.0 (gage)	June 26
	27.0 (gage)	July 17
	17.0 (gage)	September 15

Examination of cross-sectional profiles of study site transects (Appendix C) showed a narrower stream channel in the lower reaches (e.g., Study Site 1) of Big Timber Creek than the upstream reaches (e.g., Study Site 7). At any given flow, more wetted area occurred at Study Site 7 than Study Site 1. For example, at 10 cfs, 13,106 ft^2 of wetted area per 1,000 ft of stream occurred at Study Site 1. This compared with 21,993 ft^2 of wetted area per 1,000 ft of stream at Study Site 7 (Appendix F). Thus, with a smaller channel, less flow was needed to optimize habitat in the lower reaches than the upper reaches (Tables 13 to 19). For example, at Study Site 1, 5 cfs provided optimal habitat for juvenile bull trout, 9 cfs for adult bull trout, 10 cfs for spawning, and 13 cfs was required for passage of adults. These flows were less than Study Site 7 where 20 cfs provided optimal habitat for adult and juvenile bull trout, 60 cfs for spawning, and 17 cfs was required for passage.

Weighted Usable Area (WUA) estimates from a previous unpublished study conducted by EA Engineering on Big Timber Creek (Dudley Reiser, personal communication, July 21, 2003) were compared to our results at Study Site 7 (Appendix F). The objective of the EA Engineering study was to determine flows for fish recovery based on undisturbed stream segments and unimpaired flows for the Bureau of Indian Affairs adjudication process. This differed from our study objectives to determine target flows to improve passage, spawning, and rearing conditions for salmon, steelhead, and bull trout in stream segments impacted by irrigation diversions. Thus, the value of this comparison was a relative check on our ability to replicate the habitat modeling results from a previous study and was only appropriate at Study Site 7 because this was the only stream segment located upstream from the major diversions where the stream channel hydraulics were similar between studies. Appendix F includes graphical comparisons of the habitat modeling results between this study and the less intensive EA Engineering study in the vicinity of Study Site 7. Although study results show similarities for the spawning life stage, reasons for differences between WUA estimates for other life stages are unknown since the EA Engineering study was never published. The results of this study are not easily transferrable to other drainages unless hydrology, hydraulics, and limiting factors (e.g., temperature, passage) are similar among streams.

6.1 Guidelines for Using Study Results

The results presented in this report summarize the hydrology, habitat, and temperature characteristics of Big Timber Creek during summer, 2003. PHABSIM analysis of the data collected and compiled for this study resulted in a series of graphs that illustrate relations between a dimensionless value called weighted usable area (WUA) and discharge (Figures 8-28). The highest point on each curve represents the discharge at which habitat is optimized for adult, spawning, or juvenile life stages for the fish species analyzed in this study (salmon, steelhead, and bull trout). These optimized values, summarized in Tables 13-19, rarely coincide among life stages for any one species. Furthermore, adult, spawning, and juvenile life stages for salmon, steelhead, and bull trout occur at different times of the year (Table 11). These results imply that the optimum amount of water needed for adult, spawning, and juvenile life stages is not constant, but varies during the year. It is suggested to consider these implications during development of flow targets. Also, WUAs do not address water availability in any way and even the unregulated flow may commonly exceed or be less than the discharge at which the maximum WUA is available. The amount of WUA available, in terms of lost or gained, can be determined by comparing to a reference or unregulated streamflow condition. Typically, the maximum, percentiles, or inflections are chosen from these curves at the level of protection desired or at points above which greater amounts of flow only provide minor gains in usable habitat. In streams with more than one species of interest, the results should be reviewed to insure the recommended flows are beneficial to all species and harmful to none.

The mechanisms by which the various components are integrated and the relative importance they are assigned within the water management decision process is a matter of professional judgment and beyond the scope of this study. However, it would seem reasonable that providing connectivity to the Lemhi River by providing enough water for adult fish passage would be foremost in management priorities. Water depths are an additional consideration for the adult life stage (Figures 29-35). Choice of target flows should not be reduced below the optimum flow to the point that stream depth is reduced below the level needed for fish passage (Tables 13-19), depending on available water supply.

Discharge estimates providing optimal WUA for juvenile salmonid lifestages are usually less than summer base flows, suggesting a disconnect between the models used and actual juvenile salmonid needs. Reasons for this may include: inability to accurately measure and/or quantify habitat parameters such as, flow velocity, cover, and substrate, at a scale that is meaningful for small fishes; inability to accurately quantify side channels, bank indentations, riparian wetlands, or other lateral habitats that are important for rearing juvenile salmonids; and inability to adequately incorporate temperature, or other water quality parameters, into the model. Thus, until juvenile habitat modeling can be improved, the existing juvenile WUA results should be used with caution in developing flow recommendations.

The selection of a target flow should be based on a hierarchical system of highest priority life stage and species present for the month or period of concern, using the assumption that the priority life stage and species would require higher streamflows than other life stages and species. Table 11 provides some general guidelines. For small tributary streams of the Lemhi River sub-basin, suggested priority life stage ranking would be (from high to low): passage > spawning > adult > juvenile. Once the priority life stage and species are ranked, then each study site should be examined to determine streamflow and passage conditions for the time period of concern.

Once an adequate number of sites have been characterized using PHABSIM, it may be feasible to develop habitat-discharge relations for streams with similar basin characteristics within specific geographic locations. This could possibly provide a regional planning tool that could eliminate intensive site-specific studies.

The natural hydrograph also needs to be considered when developing flow targets. In drought years, summer flows that provide maximum possible habitat may not be attainable because of the hydrologic limits on the stream. Also, PHABSIM does not estimate flow or habitat needs of downstream migrants or spring runoff conditions necessary for maintenance of channel morphology or riparian zone functions. Arthaud and others (2002) have shown that downstream migrant survival can significantly increase with discharge. Thus, high spring flows that mimic the natural hydrograph should be a consideration in managing streamflows outside PHABSIM analysis.

Finally, it should be noted that PHABSIM was designed as a tool to provide science-based linkage between biology and river hydraulics with results to be used in negotiations or mediated settlements (Arthaud et al. 2002).

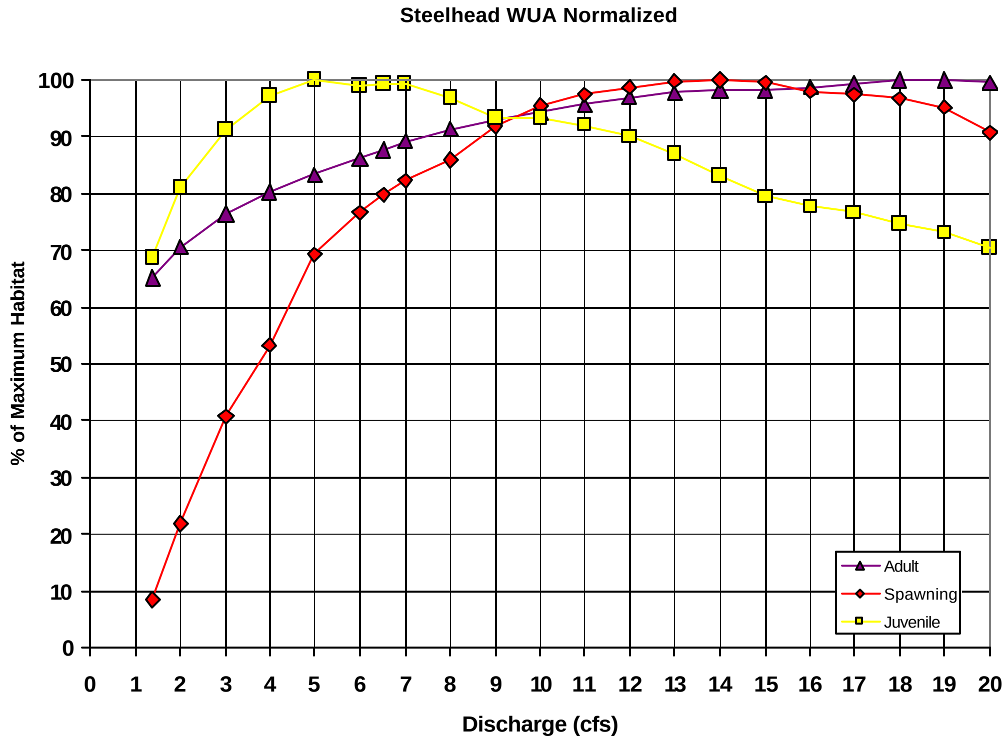

Figure 8. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Big Timber Creek, Study Site 1.

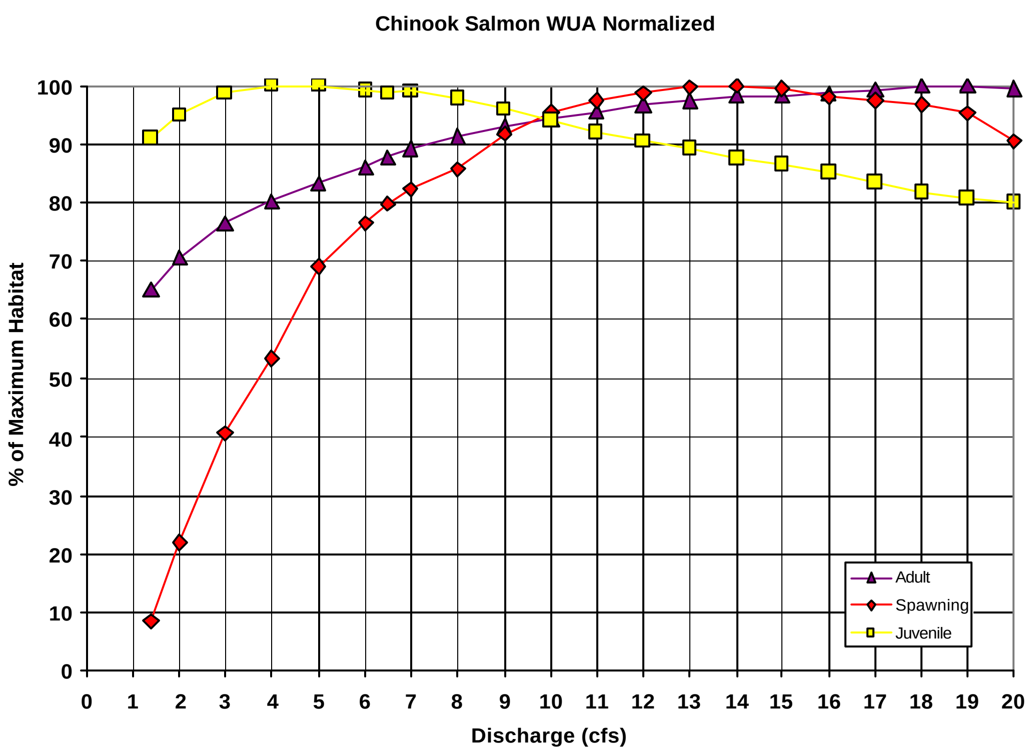

Figure 9. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Big Timber Creek, Study Site 1.

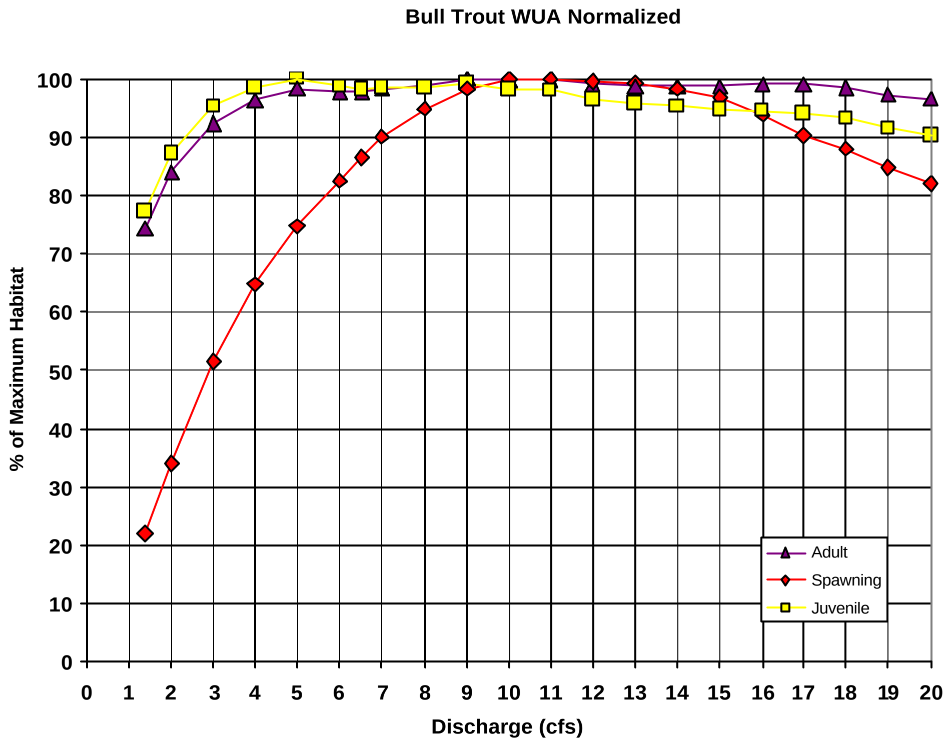

Figure 10. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Big Timber Creek, Study Site 1.

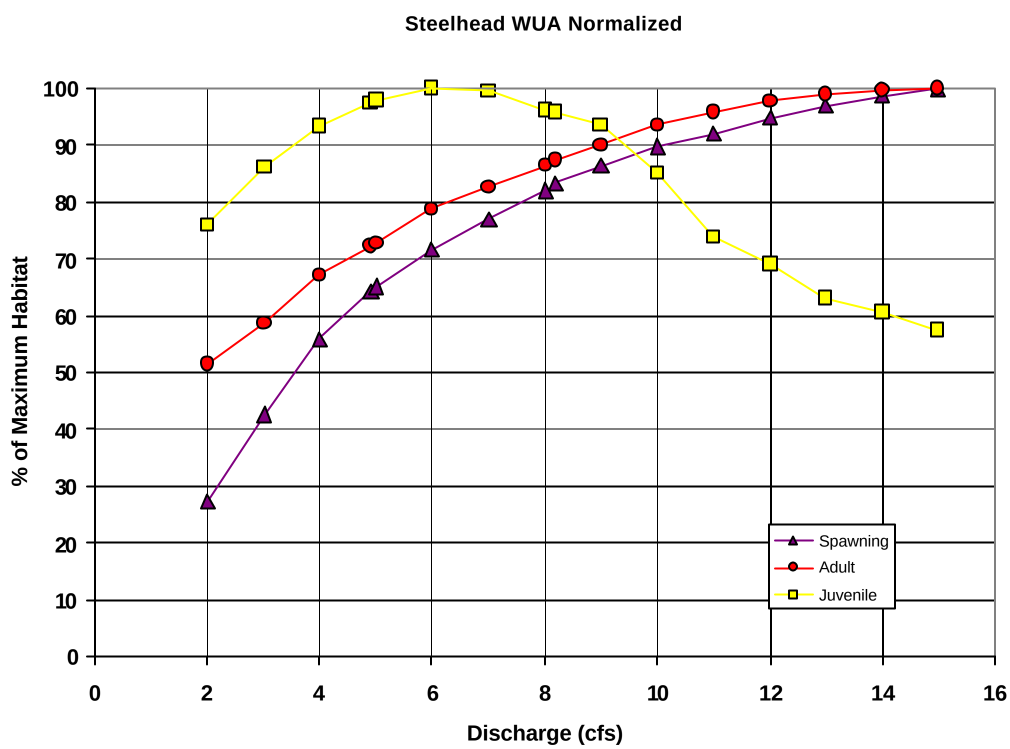

Figure 11. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Big Timber Creek, Study Site 2.

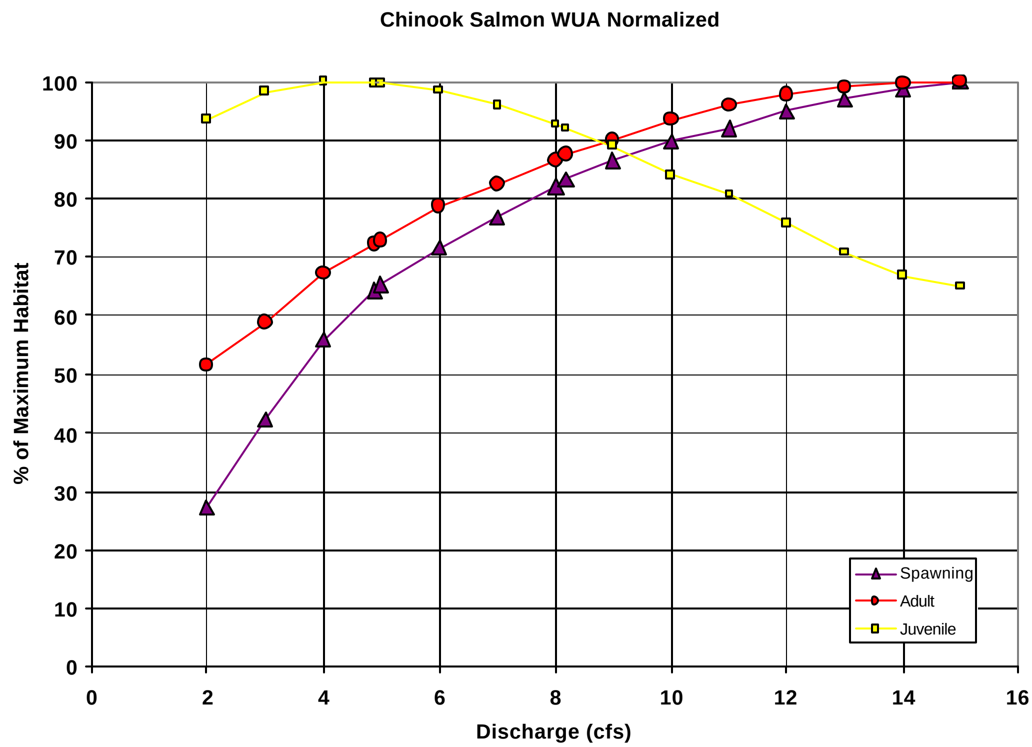

Figure 12. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Big Timber Creek, Study Site 2.

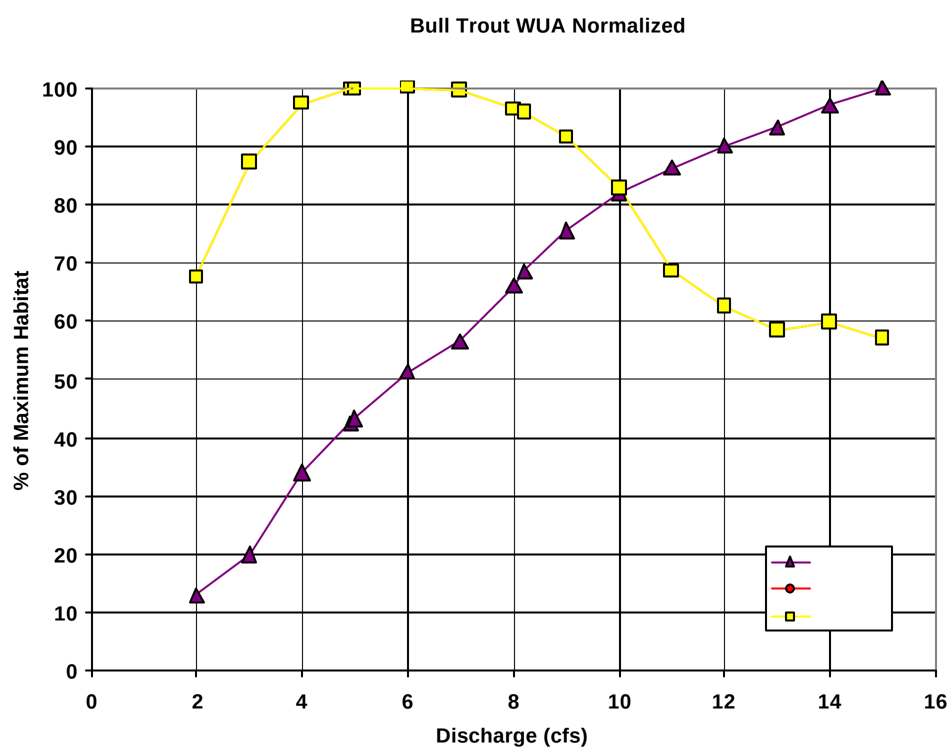

Figure 13. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Big Timber Creek, Study Site 2 (adults same as juveniles).

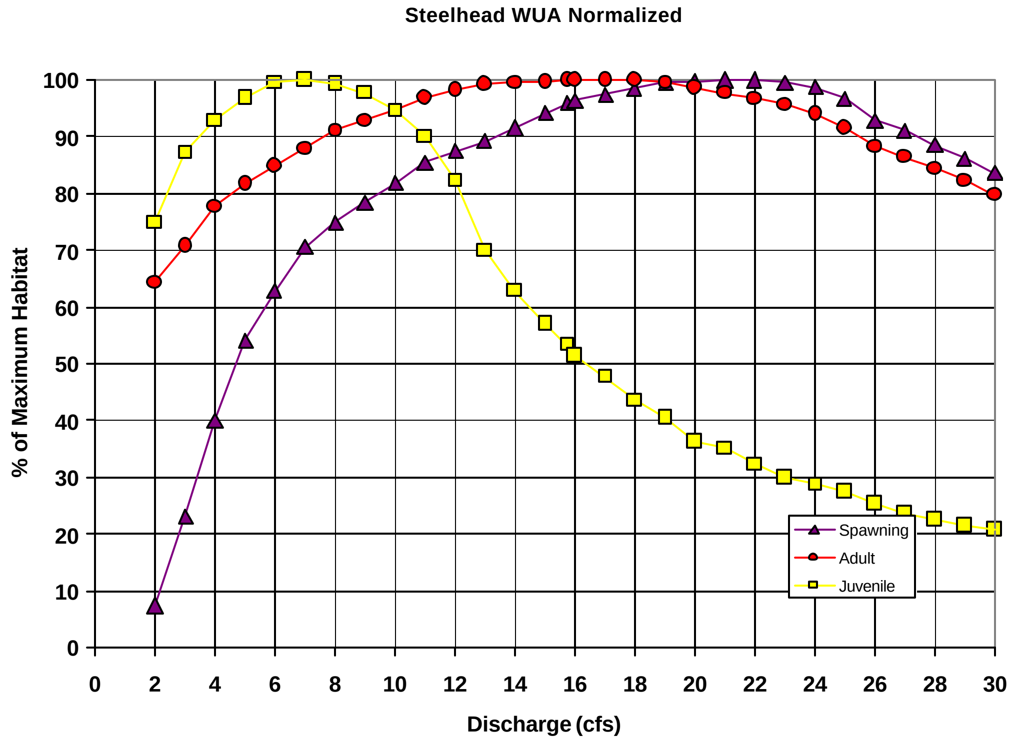

Figure 14. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Big Timber Creek, Study Site 3.

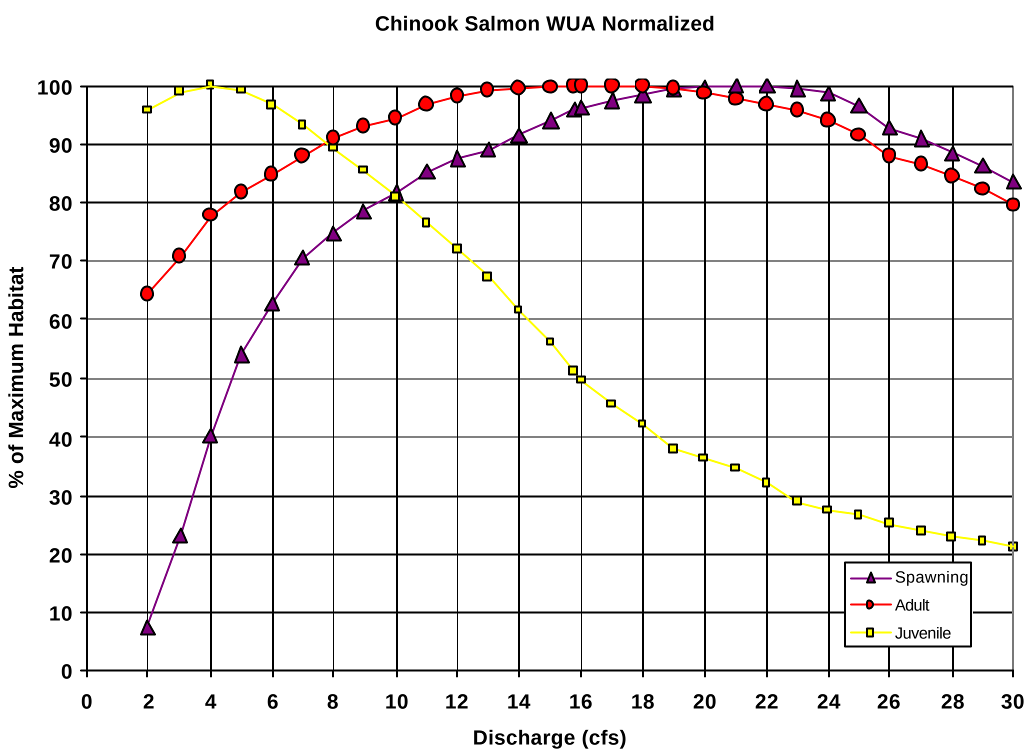

Figure 15. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Big Timber Creek, Study Site 3.

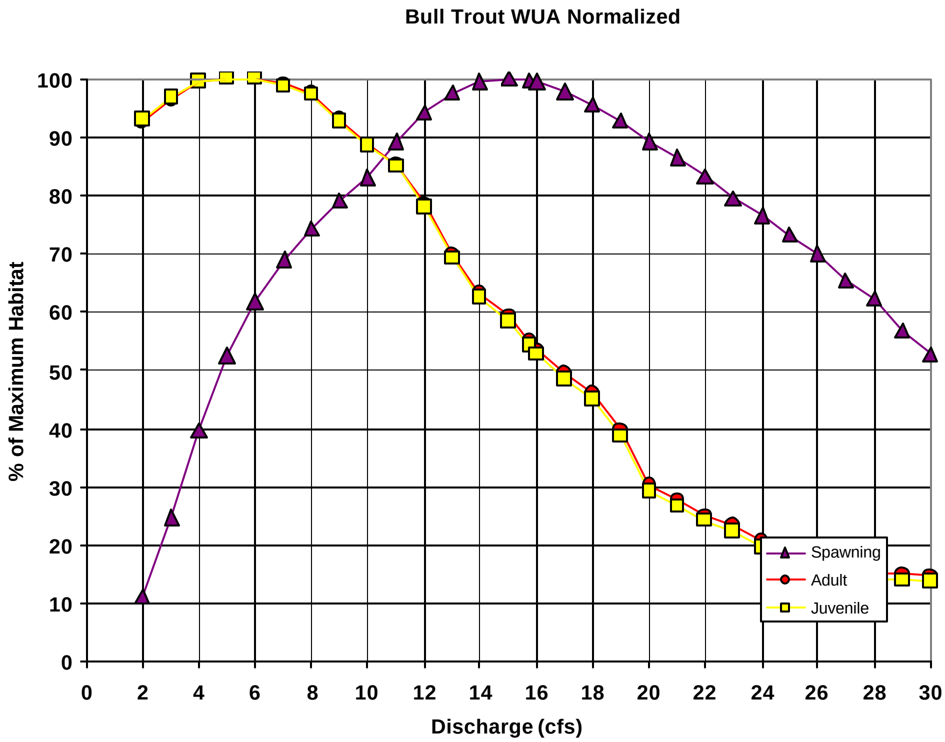

Figure 16. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Big Timber Creek, Study Site 3.

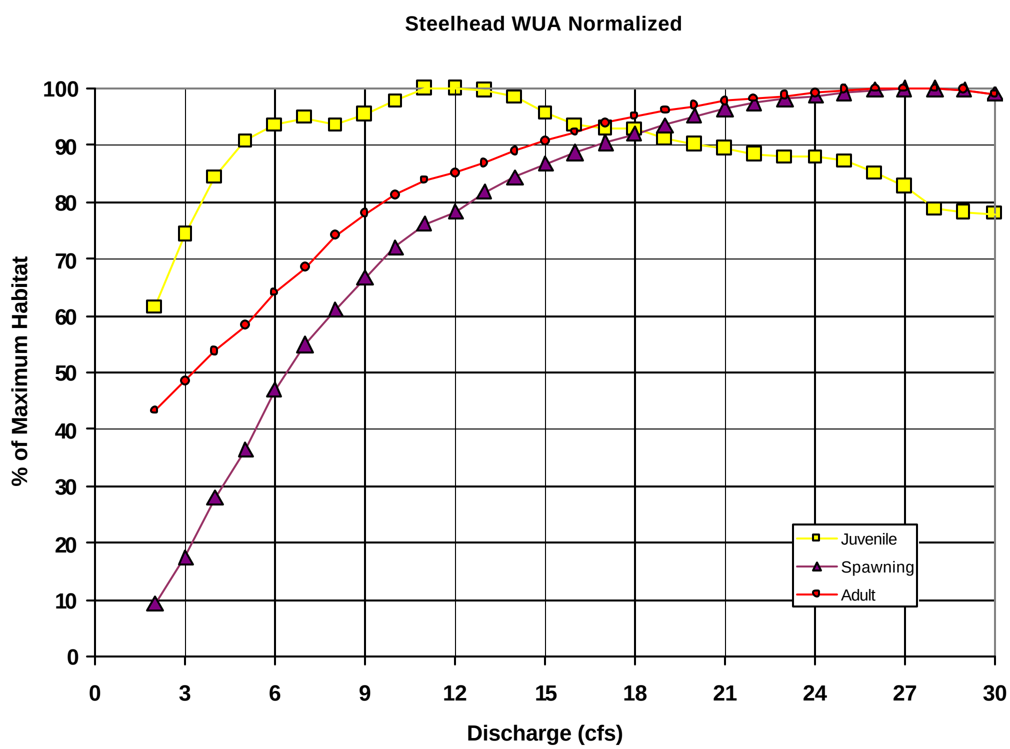

Figure 17. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Big Timber Creek, Study Site 4.

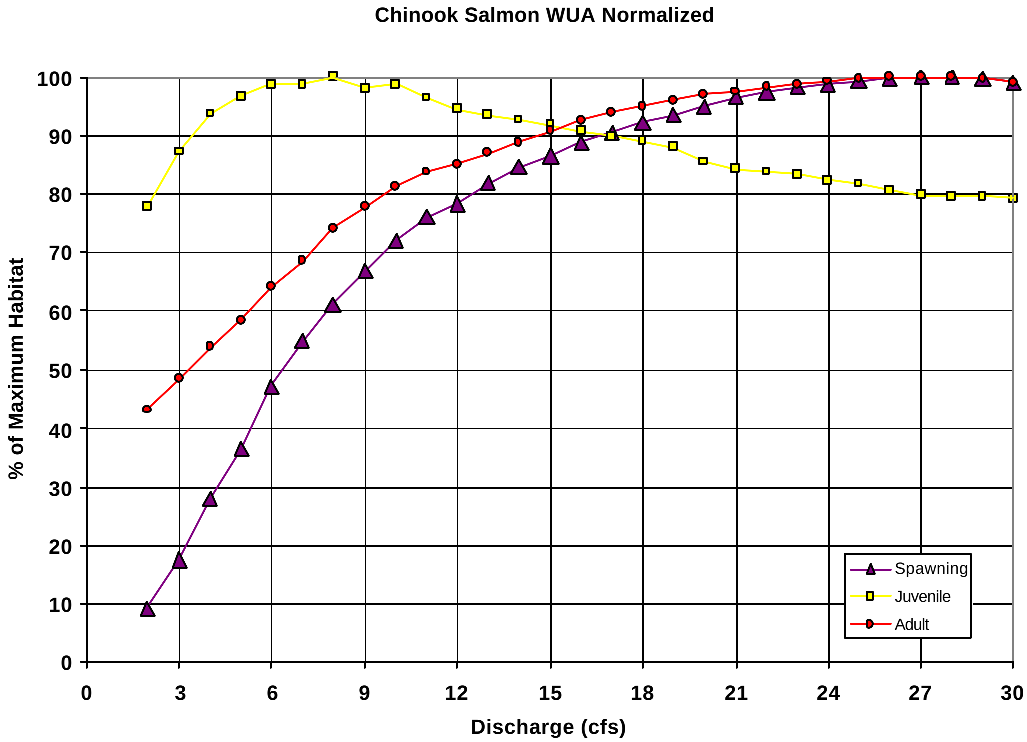

Figure 18. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Big Timber Creek, Study Site 4.

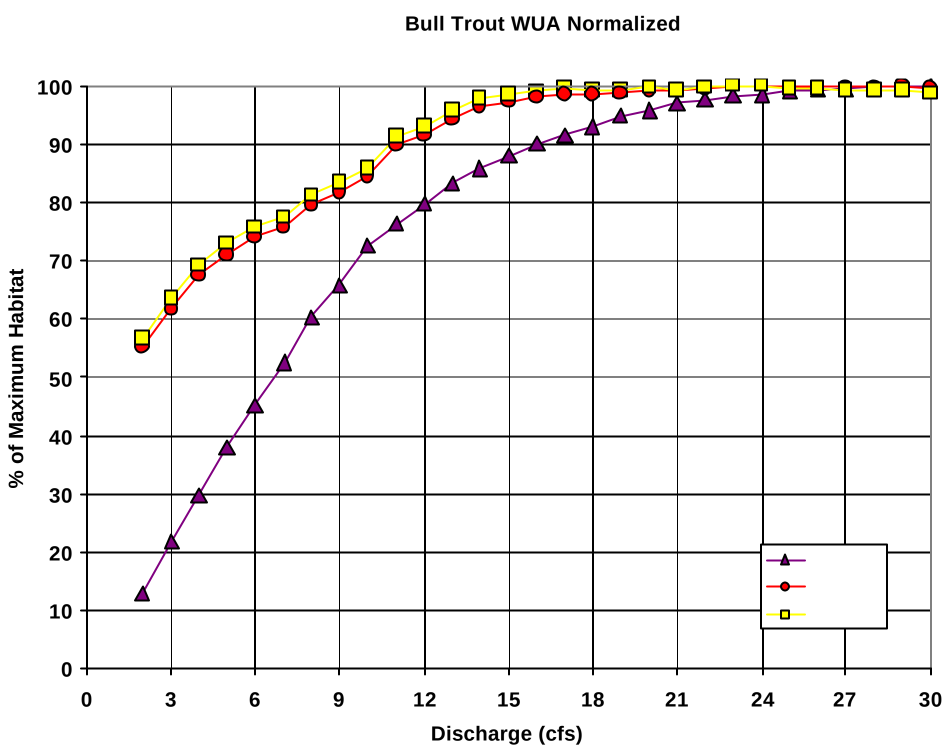

Figure 19. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Big Timber Creek, Study Site 4.

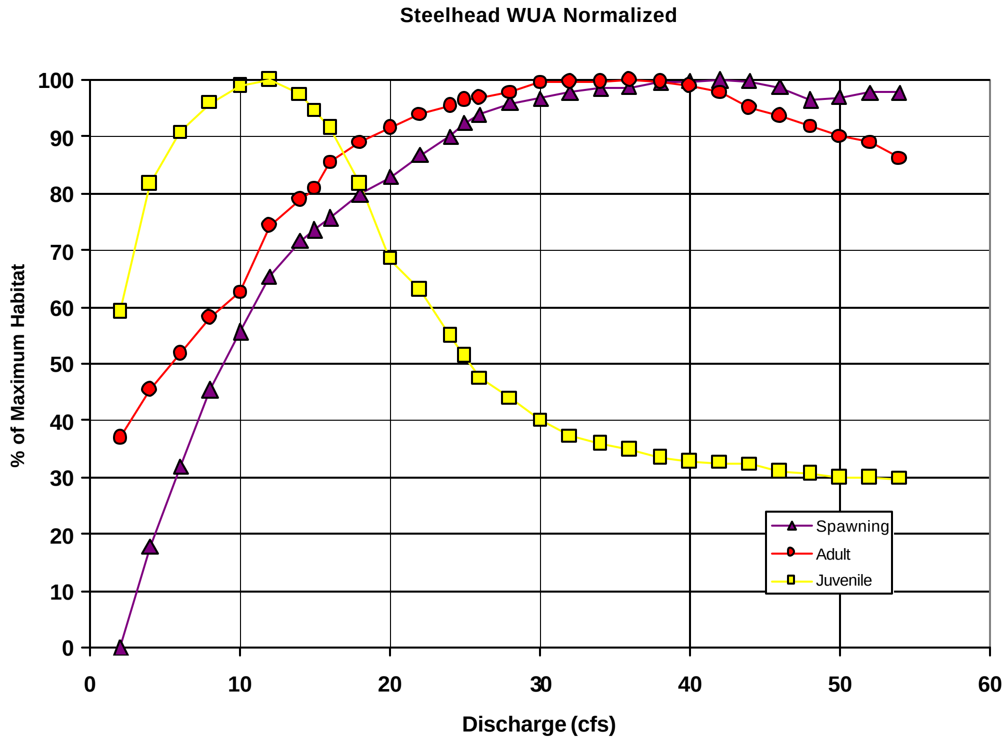

Figure 20. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Big Timber Creek, Study Site 5.

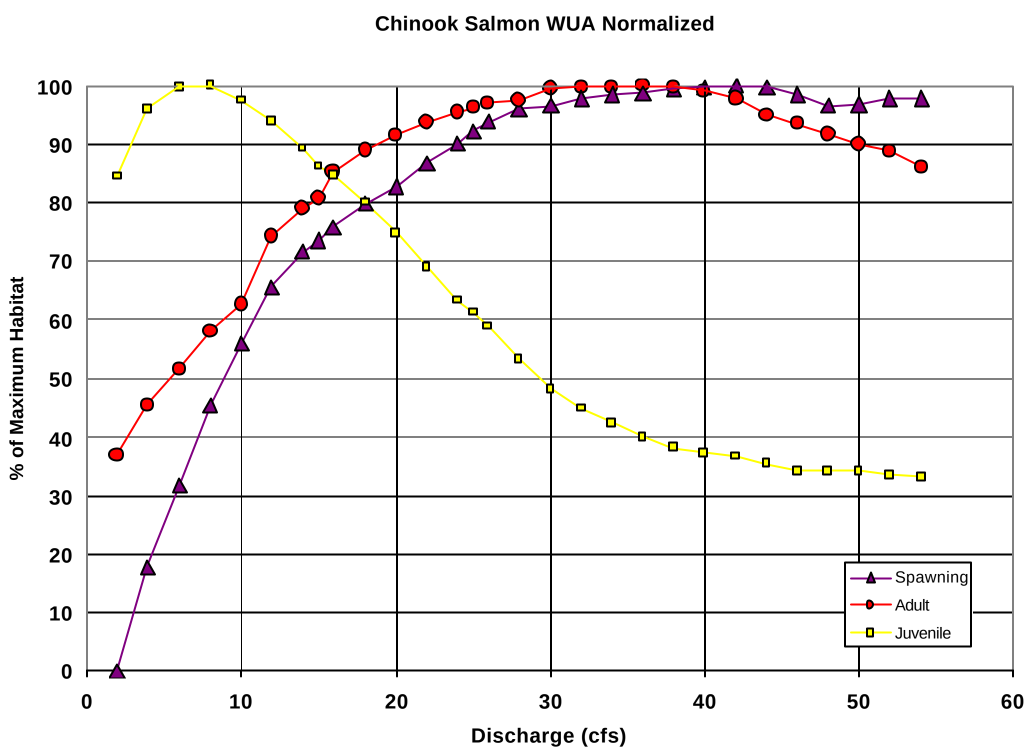

Figure 21. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Big Timber Creek, Study Site 5.

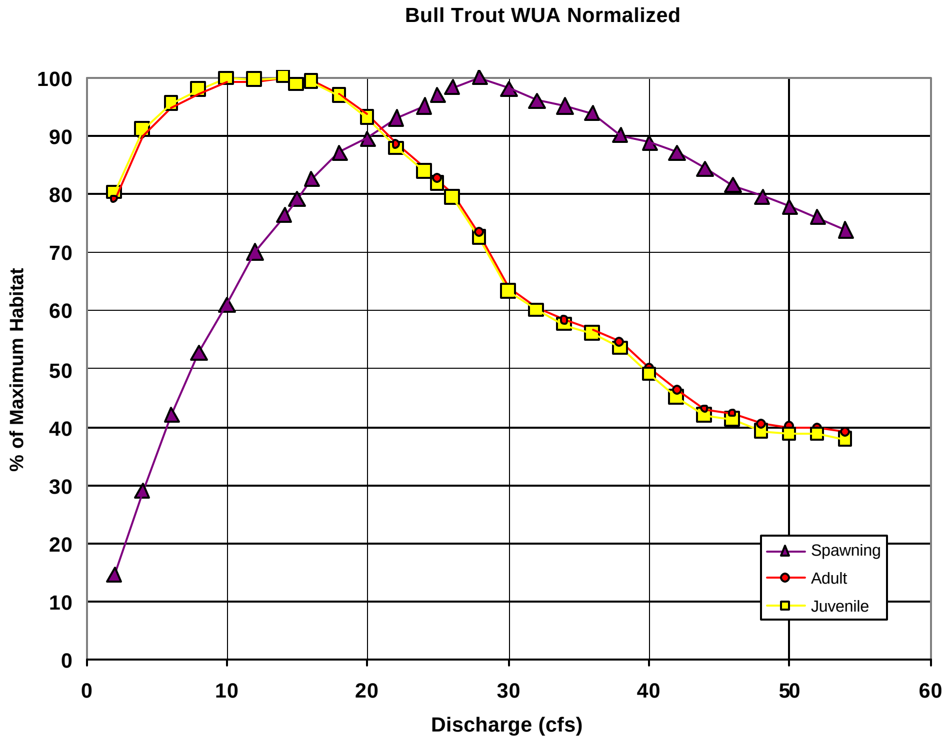

Figure 22. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Big Timber Creek, Study Site 5.

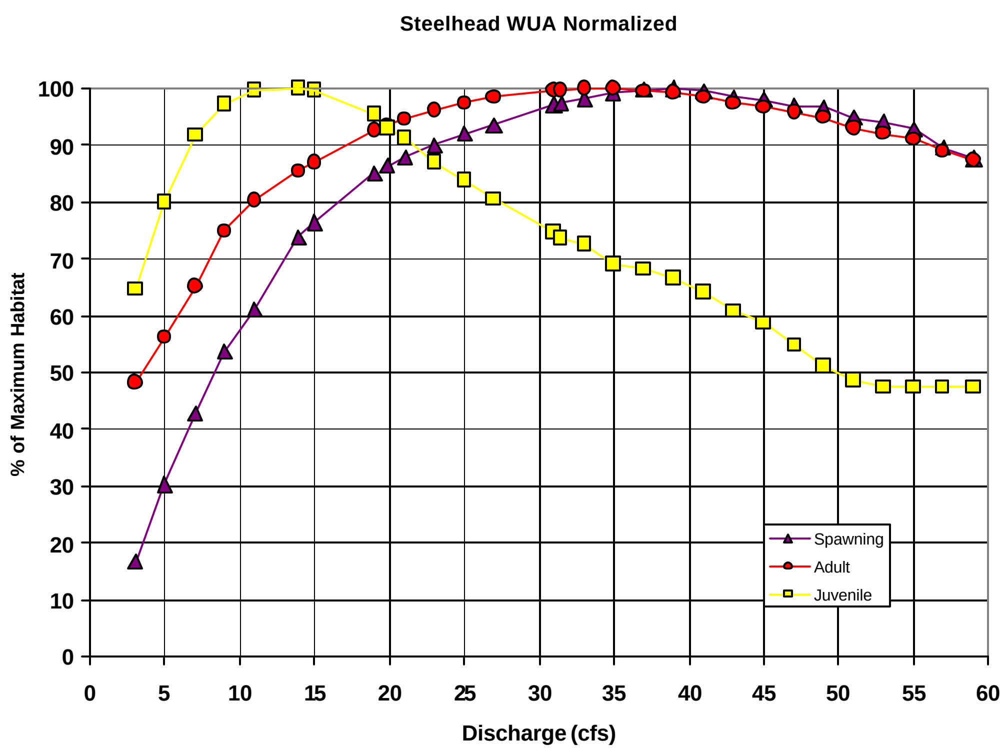

Figure 23. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Big Timber Creek, Study Site 6.

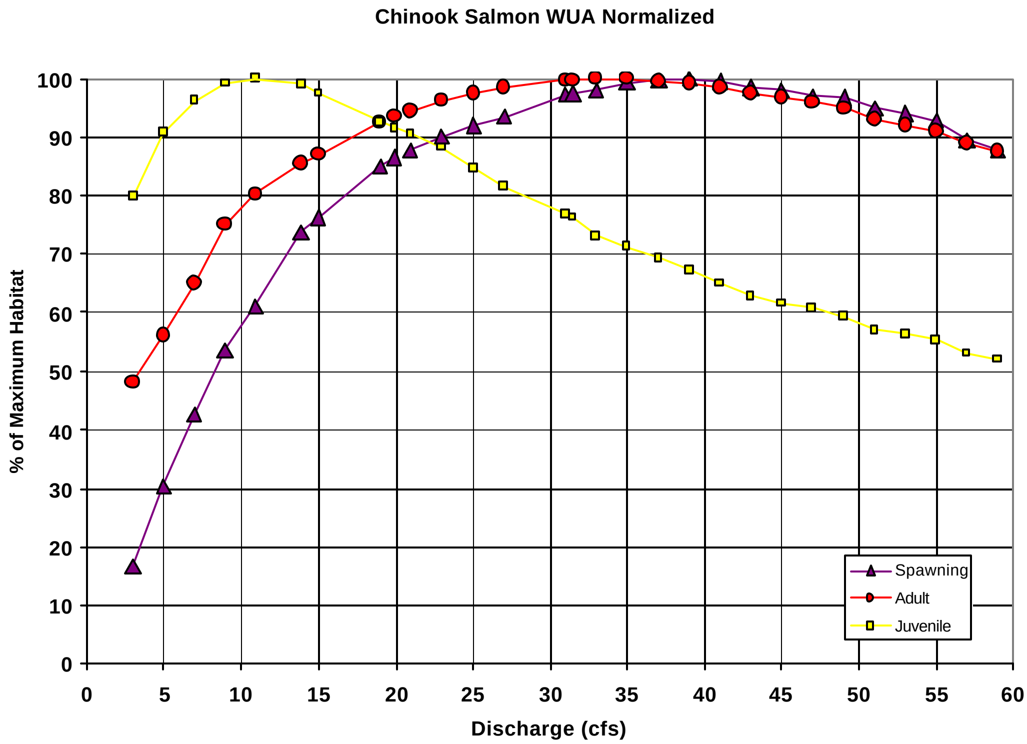

Figure 24. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Big Timber Creek, Study Site 6.

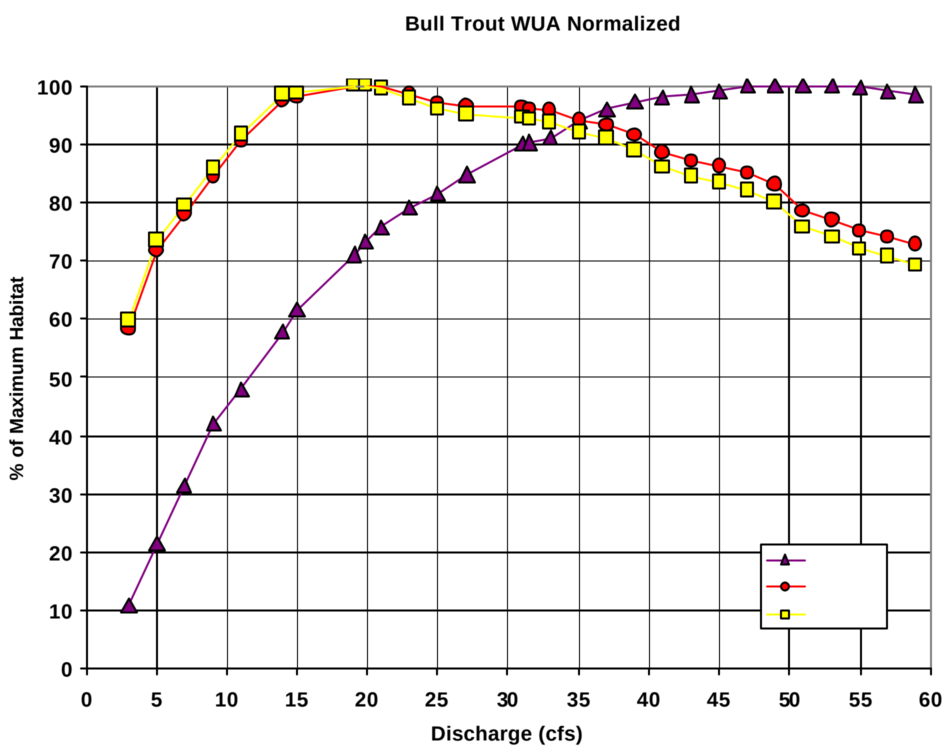

Figure 25. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Big Timber Creek, Study Site 6.

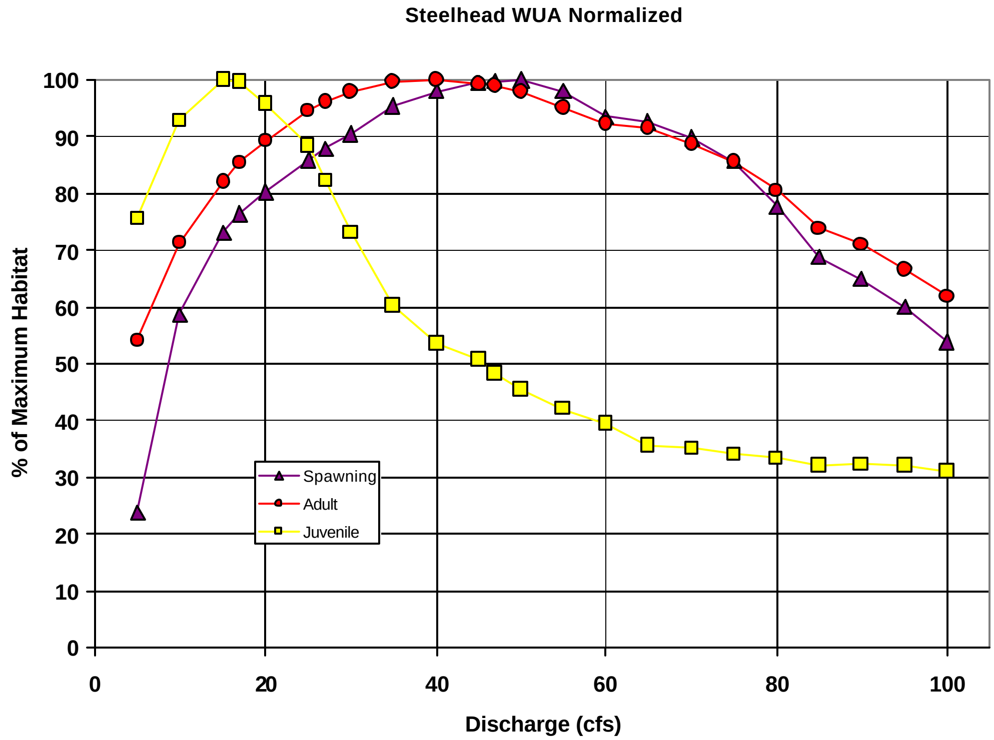

Figure 26. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Big Timber Creek, Reference Site.

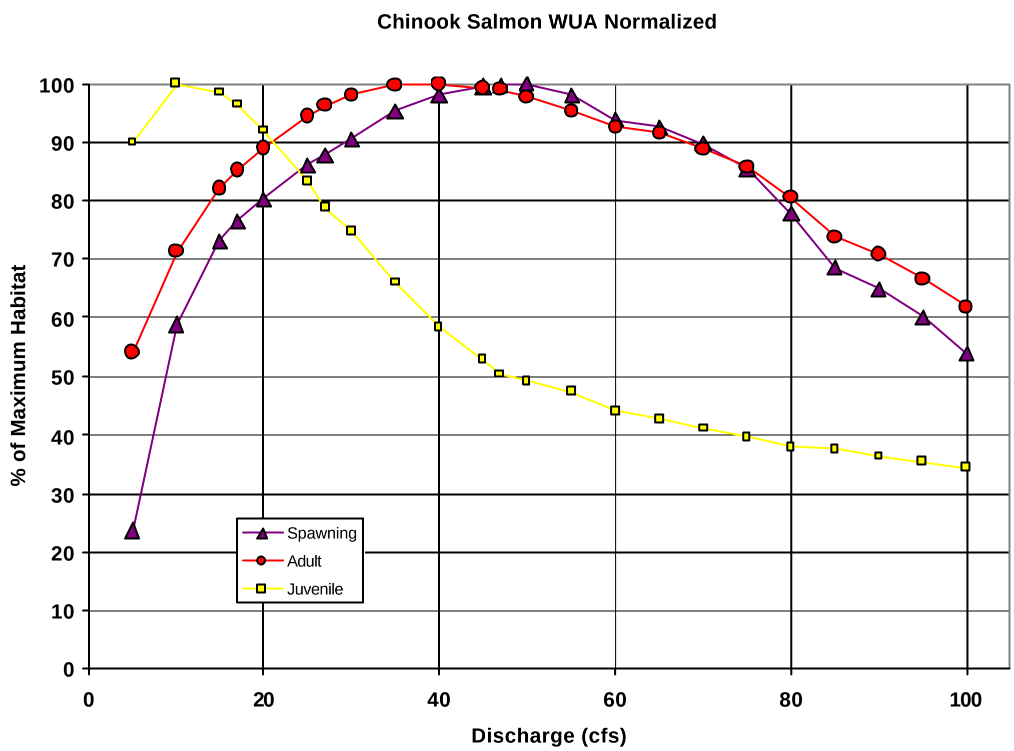

Figure 27. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Big Timber Creek, Reference Site.

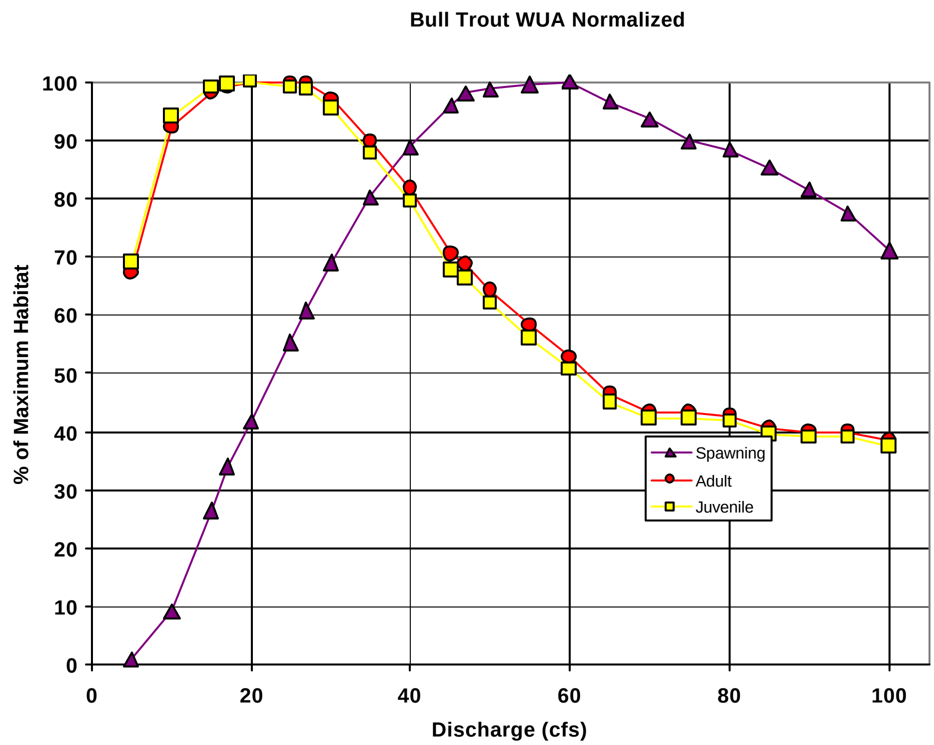

Figure 28. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Big Timber Creek, Reference Site.

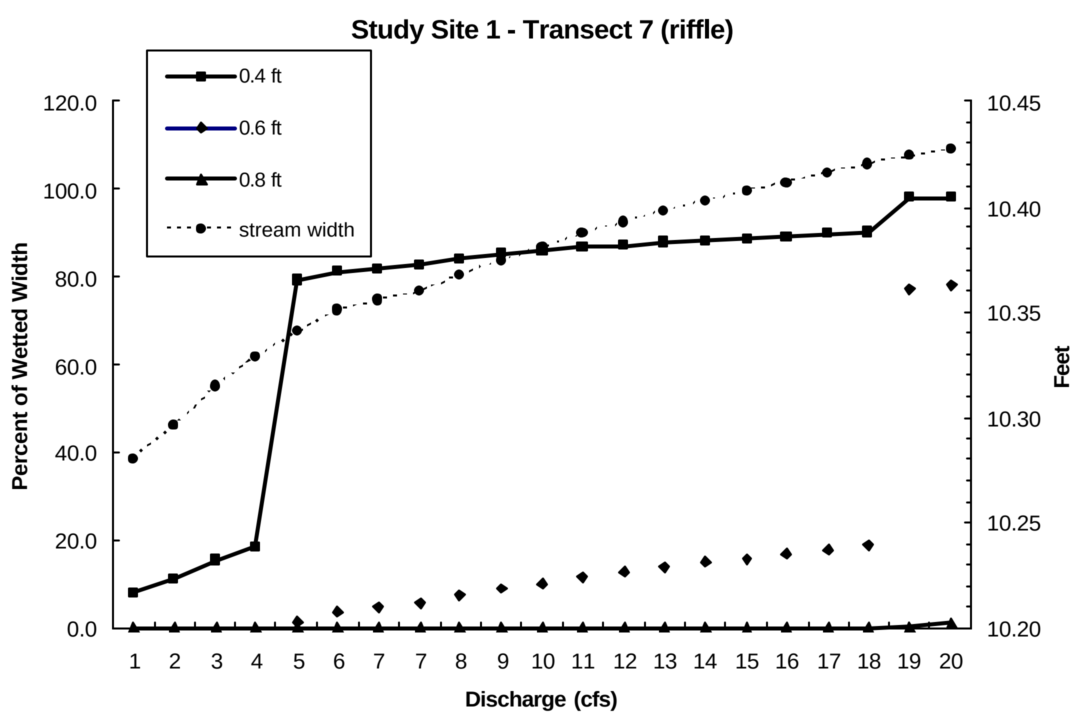

Figure 29. Contiguous widths at depths greater than passage criteria at a riffle transect (56 feet longitudinal distance) on Big Timber Creek, Study Site 1.

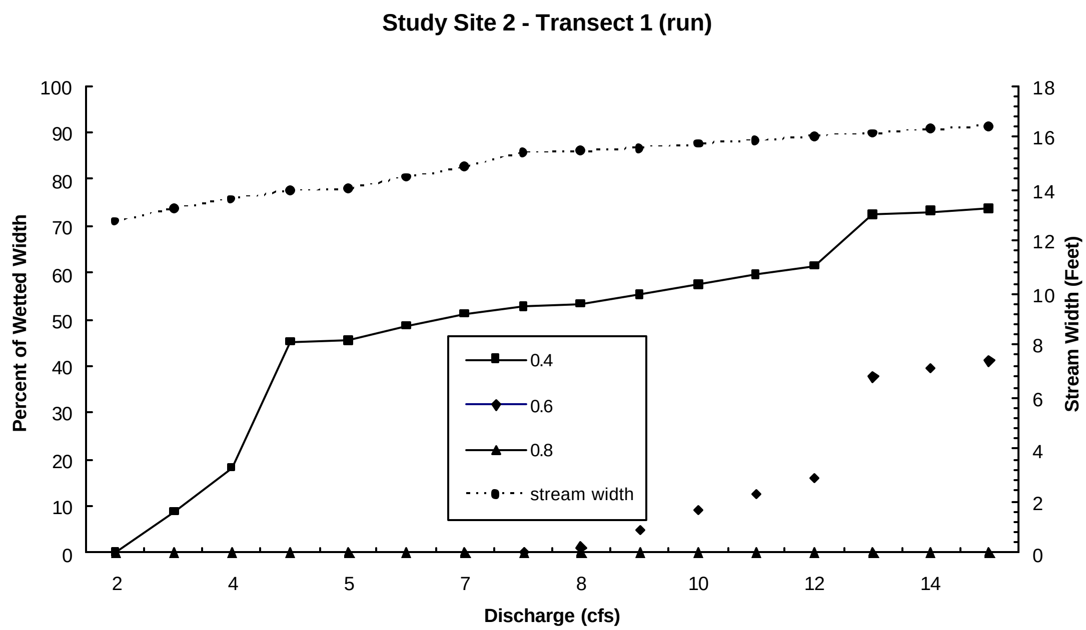

Figure 30. Contiguous widths at depths greater than passage criteria at a run transect (17 feet longitudinal distance) on Big Timber Creek, Study Site 2.

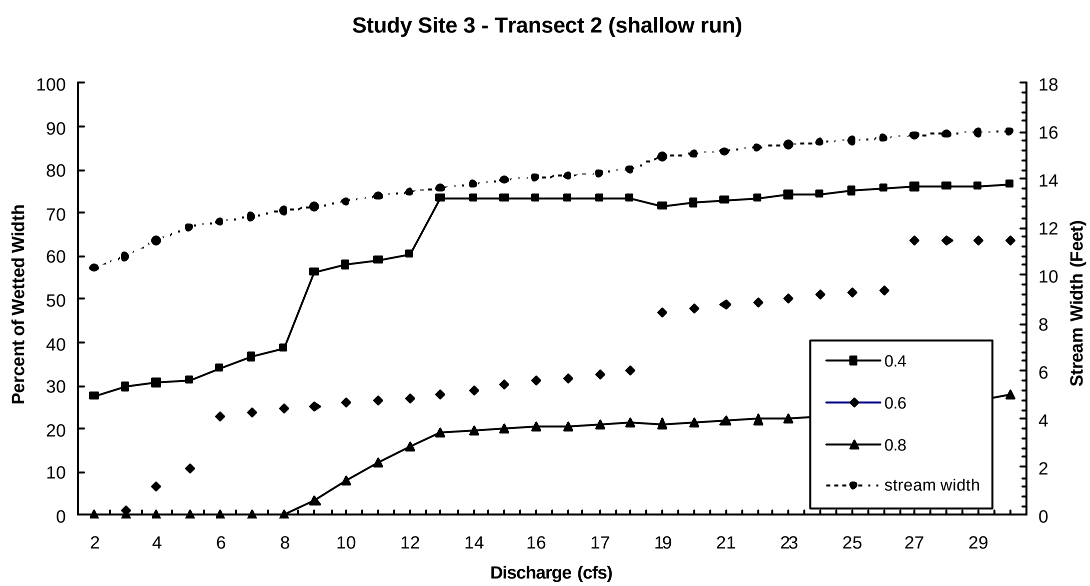

Figure 31. Contiguous widths at depths greater than passage criteria at a run transect (75 feet longitudinal distance) on Big Timber Creek, Study Site 3.

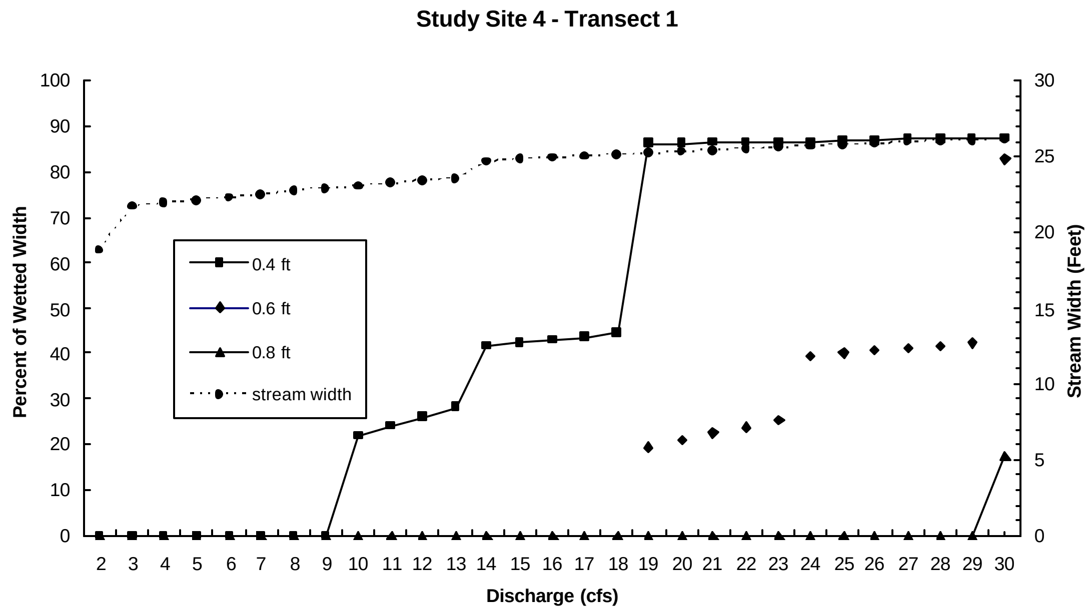

Figure 32. Contiguous widths at depths greater than passage criteria at a riffle transect (17 feet longitudinal distance) on Big Timber Creek, Study Site 4.

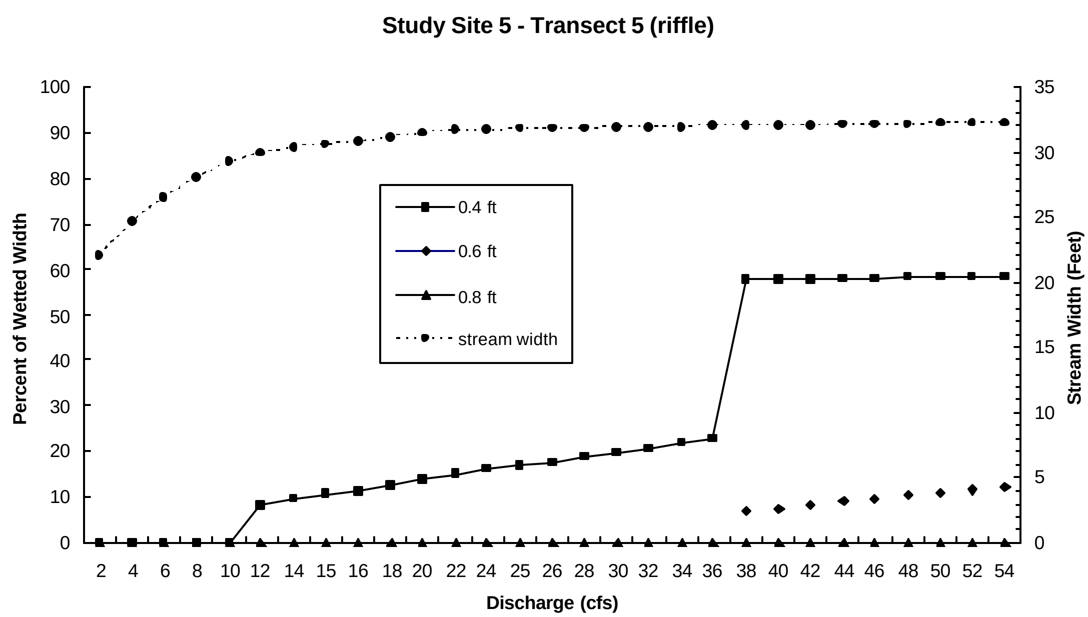

Figure 33. Contiguous widths at depths greater than passage criteria at a riffle transect (30 feet longitudinal distance) on Big Timber Creek, Study Site 5.

Study Site 6 - Transect 7

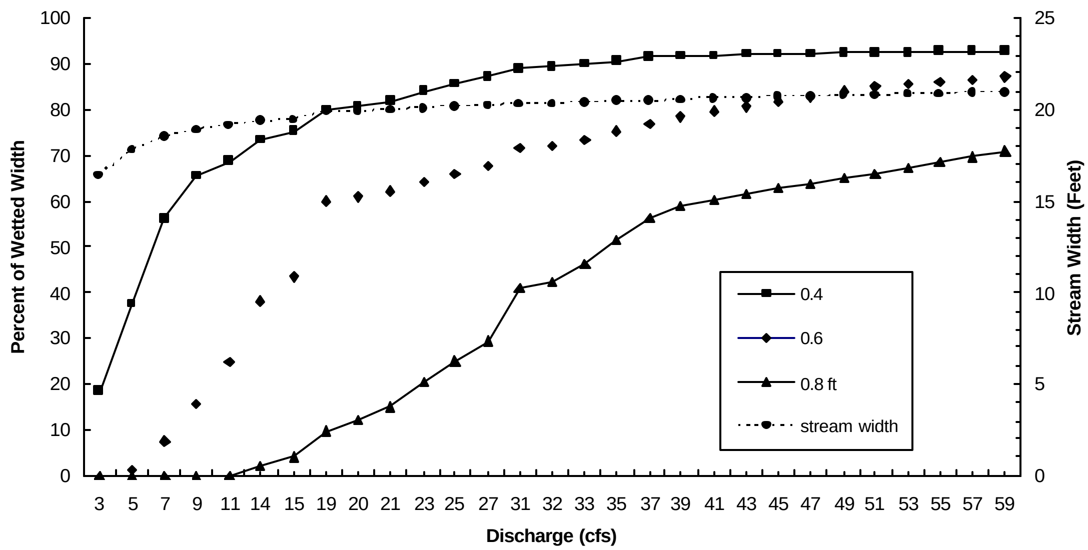

Figure 34. Contiguous widths at depths greater than passage criteria at a shallow run transect (23 feet longitudinal distance) on Big Timber Creek, Study Site 6.

Study Site 7 - Transect 3

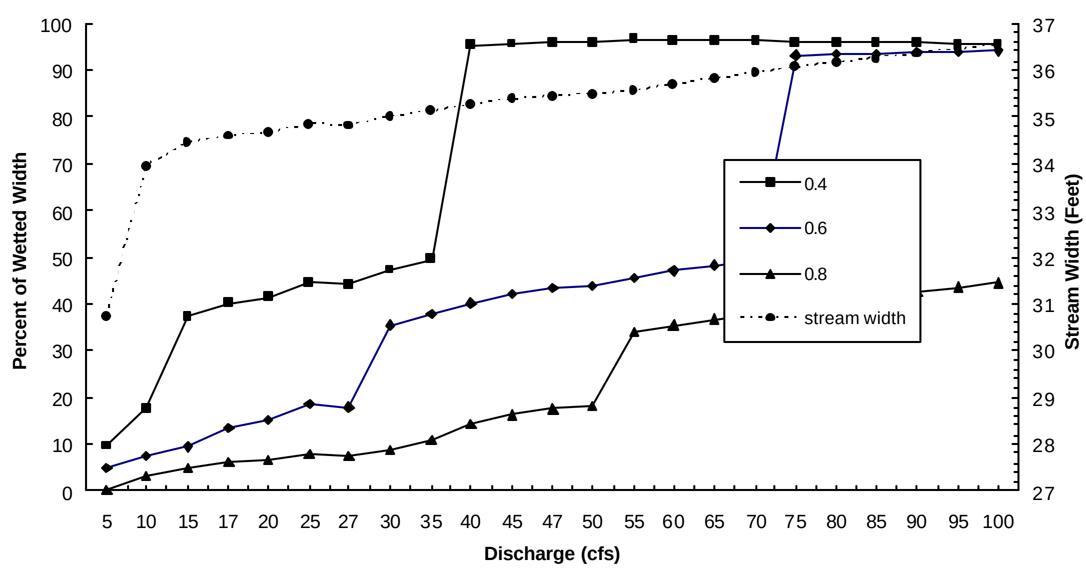

Figure 35. Contiguous widths at depths greater than passage criteria at a riffle transect (22 feet longitudinal distance) on Big Timber Creek, Study Site 7.

Table 13. Habitat modeling summary at Study Site 1 on Big Timber Creek.

Life Stage	Discharge (cfs) required for optimum weighted usable area (WUA)			Discharge (cfs) required for adult salmonid passage using 0.6 foot depth criterion[1]	
	Steelhead	Chinook salmon	Bull trout	>25% of total channel width	>10% of contiguous channel width
Spawning	14	14	10	NA[2]	NA
Adult	18	18	9	13	10
Juvenile	5	4	5	NA	NA

[1] Passage criteria taken from Thompson (1972) and Scott et al. (1981); both width criteria must be met to insure passage.
[2] NA – Not applicable

Table 14. Habitat modeling summary at Study Site 2 on Big Timber Creek.

Life Stage	Discharge (cfs) required for optimum weighted usable area (WUA)			Discharge (cfs) required for adult salmonid passage using 0.6 foot depth criterion[1]	
	Steelhead	Chinook salmon	Bull trout	>25% of total channel width	>10% of contiguous channel width
Spawning	>15	>15	>15	NA[2]	NA
Adult	>15	>15	6	13	11
Juvenile	6	4	6	NA	NA

[1] Passage criteria taken from Thompson (1972) and Scott et al. (1981); both width criteria must be met to insure passage.
[2] NA – Not applicable

Table 15. Habitat modeling summary at Study Site 3 on Big Timber Creek.

Life Stage	Discharge (cfs) required for optimum weighted usable area (WUA)			Discharge (cfs) required for adult salmonid passage using 0.6 foot depth criterion[1]	
	Steelhead	Chinook salmon	Bull trout	>25% of total channel width	>10% of contiguous channel width
Spawning	21	21	15	NA[2]	NA
Adult	16	16	6	9	5
Juvenile	7	4	6	NA	NA

[1] Passage criteria taken from Thompson (1972) and Scott et al. (1981); both width criteria must be met to insure passage.
[2] NA – Not applicable

Table 16. Habitat modeling summary at Study Site 4 on Big Timber Creek.

Life Stage	Discharge (cfs) required for optimum weighted usable area (WUA)			Discharge (cfs) required for adult salmonid passage using 0.6 foot depth criterion[1]	
	Steelhead	Chinook salmon	Bull trout	>25% of total channel width	>10% of contiguous channel width
Spawning	28	28	29	NA[2]	NA
Adult	27	27	24	19	19
Juvenile	11	8	23	NA	NA

[1] Passage criteria taken from Thompson (1972) and Scott et al. (1981); both width criteria must be met to insure passage.
[2] NA – Not applicable

Table 17. Habitat modeling summary at Study Site 5 on Big Timber Creek.

Life Stage	Discharge (cfs) required for optimum weighted usable area (WUA)			Discharge (cfs) required for adult salmonid passage using 0.6 foot depth criterion[1]	
	Steelhead	Chinook salmon	Bull trout	>25% of total channel width	>10% of contiguous channel width
Spawning	42	42	28	NA[2]	NA
Adult	36	36	14	>54	48
Juvenile	12	8	14	NA	NA

[1] Passage criteria taken from Thompson (1972) and Scott et al. (1981); both width criteria must be met to insure passage.
[2] NA – Not applicable

Table 18. Habitat modeling summary at Study Site 6 on Big Timber Creek.

Life Stage	Discharge (cfs) required for optimum weighted usable area (WUA)			Discharge (cfs) required for adult salmonid passage using 0.6 foot depth criterion[1]	
	Steelhead	Chinook salmon	Bull trout	>25% of total channel width	>10% of contiguous channel width
Spawning	39	39	49	NA[2]	NA
Adult	35	35	20	11	9
Juvenile	14	11	19	NA	NA

[1] Passage criteria taken from Thompson (1972) and Scott et al. (1981); both width criteria must be met to insure passage.
[2] NA – Not applicable

Table 19. Habitat modeling summary at Study Site 7 (Reference Site) on Big Timber Creek.

Life Stage	Discharge (cfs) required for optimum weighted usable area (WUA)			Discharge (cfs) required for adult salmonid passage using 0.6 foot depth criterion[1]	
	Steelhead	Chinook salmon	Bull trout	>25% of total channel width	>10% of contiguous channel width
Spawning	50	50	60	NA[2]	NA
Adult	40	40	20	15	17
Juvenile	15	10	20	NA	NA

[1] Passage criteria taken from Thompson (1972) and Scott et al. (1981); both width criteria must be met to insure passage.
[2] NA – Not applicable

6.0 ACKNOWLEDGEMENTS

We thank the numerous representatives from various organizations who contributed to the success of this project. Al Simpson of Reclamation and Greg Lowell of IDFG provided valuable assistance in obtaining landowner permission on private land. Joe Spinazola of Reclamation contributed to the planning and funding of the study. Jim Henriksen of USGS provided quality control of the PHABSIM modeling. Terry Maret, John Hortness, Joseph Bunt, and Alvin Sablan assisted with obtaining valuable hydrology data. Patrick Murphy of IDFG provided recently collected fishery data for Big Timber Creek. Dudley Reiser of R2 Resource Consultants provided useful information on previous PHABSIM work completed for BIA. Representatives on the Interagency Technical Workgroup organized by Reclamation also provided guidance, including Cynthia Robertson (IDFG), Jim Morrow and Donald Anderson (NOAA Fisheries), Jana Brimmer (FWS), and Jude Trapani (BLM).

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Appendix A – Reach and Study Site Descriptions and Photos

Reach 1: This reach extended from the confluence with the Lemhi River upstream to the first major diversion (N44.67760186 W113.3700417) that dewaters the stream channel during the irrigation season. The study site for this reach was located downstream from the dewatered channel where the stream was fed only by groundwater seeps on private property. The stream channel was narrower in this reach than the other reaches.

Study Site 1 - Most downstream study site (N44.69674 W113.37238)

Transect 1 – run (most downstream transect)
Transect 2 – hydraulic control
Transect 3 – pool
Transect 4 – pool
Transect 5 – hydraulic control
Transect 6 – pool
Transect 7 – riffle/passage
Transect 8 – run (most upstream transect)

Reach 2: This reach extended from the upstream diversion boundary for reach 1 upstream to another major diversion (N44.66095604 W113) on and BLM property. The study site for this reach was represented by low gradient riffles and runs.

<u>Study Site 2 (N44.670527 W113.371053)</u>

Transect 1 – low gradient run/passage (most downstream transect)
Transect 2 – run
Transect 3 – run
Transect 4 – low gradient riffle (most upstream transect)

Reach 3: This reach was located between two major diversions that defined the upstream and downstream boundaries of reaches 2 and 4, respectively. The study site for this reach was located on BLM property just downstream from a bridge crossing.

<u>Study Site 3 (N44.66358 W113.37464)</u>

Transect 1 – riffle (most downstream transect)
Transect 2 – run/passage
Transect 3 – narrow run
Transect 4 – riffle
Transect 5 – deep run (most upstream transect)

Reach 4: This reach extended from a relatively new major diversion (N44.660844 W113.377399) located upstream from the bridge crossing upstream to the confluence with Little Timber Creek (N44.64249705 W113.3831149). The study site for this reach was located on private property and represented a mixture of riffle, run, and pool habitat types.

Study Site 4 (N44.653344 W113.381240)

Transect 1 – hydraulic control/passage (most downstream transect)
Transect 2 – run/shallow pool
Transect 3 – run
Transect 4 – run
Transect 5 – high gradient riffle
Transect 6 – moderate gradient riffle
Transect 7 – hydraulic control
Transect 8 – pool (most upstream transect)

Reach 5: This reach was located between the confluence with Little Timber Creek and the next major upstream diversion (N44.620541 W113). This reach was characterized by beaver dams mixed with riffle, run, and pool habitats. Riparian vegetation was dominated by willows. The study site represented the riffles, runs, and pools within this reach.

<u>Study Site 5 (N44.624548 W113.394656)</u>

Transect 1 – hydraulic control/ riffle (most downstream transect)
Transect 2 – run/shallow pool
Transect 3 – pool
Transect 4 – high gradient riffle
Transect 5 – moderate gradient riffle/passage (most upstream transect)

Reach 6: This reach was located between the upstream diversion boundary for reach 5 upstream to the Cary Act Diversion (N44.61482736 W113.3967245) and Pipe Diversion (N44.613771 W113.397011). This reach had similar habitat characteristics as reach 5, including blown-out beaver dams and excellent riparian vegetation. The study site in this reach represented a mixture of riffles, runs, and pools.

Study Site 6 (N44.620337 W113.396056)

Transect 1 – hydraulic control (most downstream transect)
Transect 2 – run/shallow pool
Transect 3 – moderate gradient riffle
Transect 4 – hydraulic control
Transect 5 – pool
Transect 6 – high gradient riffle
Transect 7 – run/passage (most upstream transect)

Reach 7: The reach was located between the Pipe Diversion upstream to Basin Creek (N44.608750 W113.393787) and represented Big Timber Creek undisturbed by diversion structures. The study site represented natural flow conditions immediately upstream from the major diversions on Big Timber Creek.

<u>Study Site 7 (Reference) (N44.610365 W113.398288) (undisturbed) – most upstream study site</u>

Transect 1 – run (most downstream transect)
Transect 2 – high gradient riffle
Transect 3 – hydraulic control/passage
Transect 4 – pool
Transect 5 – plunge/chute (most upstream transect)

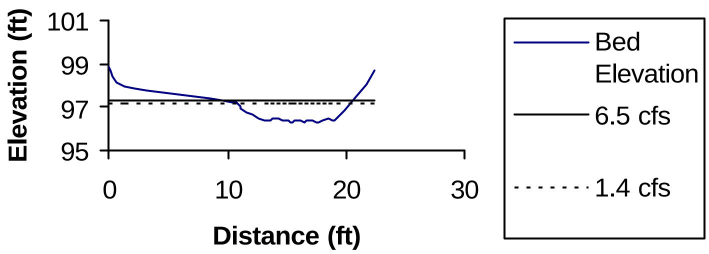
Appendix B – Habitat Mapping Proportions

	DISTANCE MAPPED	PROPORTIONS
Study site 1	(FEET)	(%)
LOW GRADIENT RIFFLE	479	38
POOL	638	51
RUN	133	11
TOTAL	1250	100
Study sites 2 and 3		
MOD GRADIENT RIFFLE	961	54
DEEP RUN	209	12
RUN	607	34
TOTAL	1777	100
Study site 4		
HIGH GRADIENT RIFFLE	308	13
MOD GRADIENT RIFFLE	698	31
POOL	167	7
RUN	1106	49
TOTAL	2279	100
Study site 5		
HIGH GRADIENT RI FFLE	419	21
MOD GRADIENT RIFFLE	798	40
POOL	206	10
RUN	580	29
TOTAL	2003	100
Study site 6		
HIGH GRADIENT RIFFLE	463	7
MOD GRADIENT RIFFLE	2477	37
POOL	639	10
RUN	3065	46
TOTAL	6644	100
Study site 7 REFERENCE		
HIGH GRADIENT RIFFLE	1211	56
POOL	1657	7
RUN	671	31
PLUNGE	129	6
TOTAL	2176	100

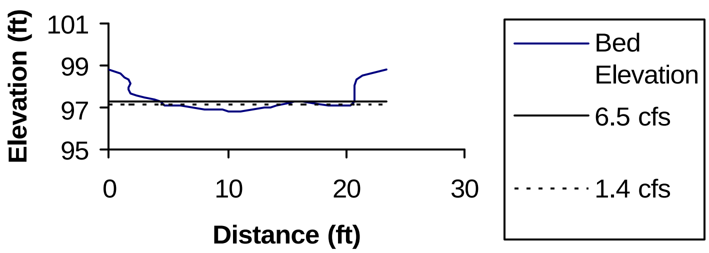
Appendix C – Cross-sectional Profiles and Measured Water Surface Elevations

Site 1

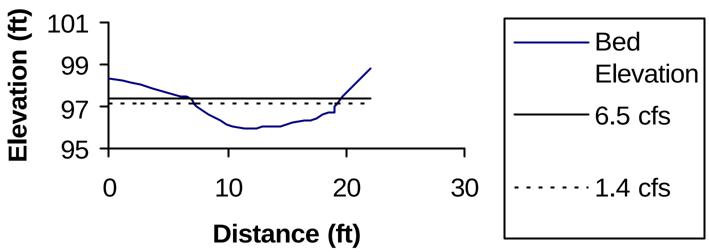
Transect 1



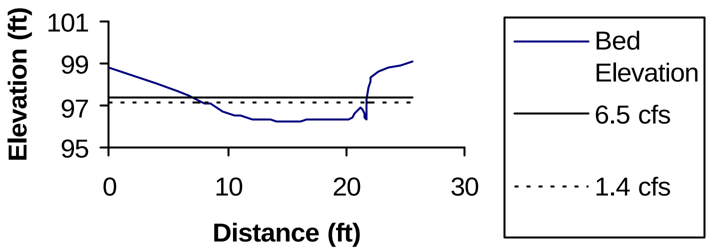
Transect 2

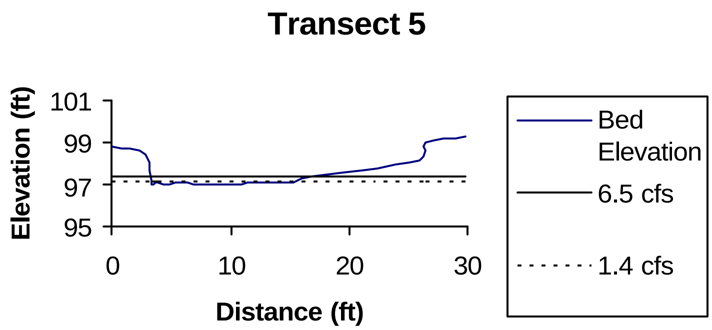


Transect 3

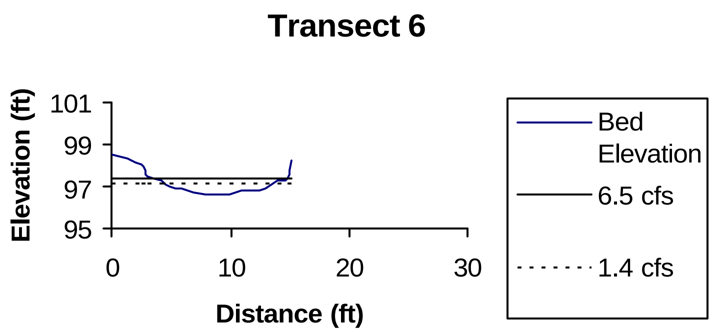


Transect 4

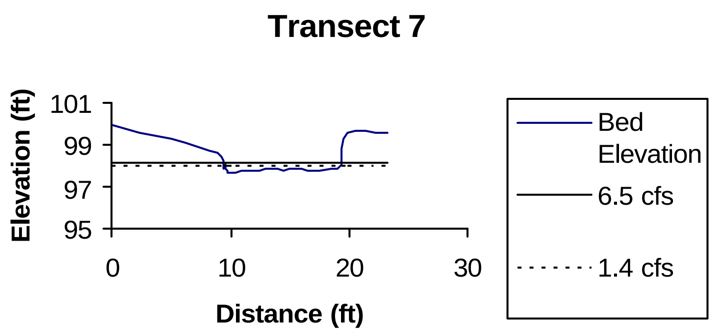




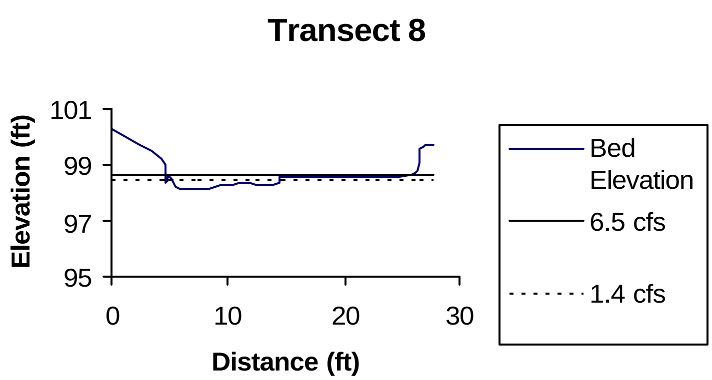
Transect 5
Elevation (ft)
101
99
97
95
0
10
20
30
Distance (ft)
Bed Elevation
6.5 cfs
1.4 cfs



Transect 6
Elevation (ft)
101
99
97
95
0
10
20
30
Distance (ft)
Bed Elevation
6.5 cfs
1.4 cfs



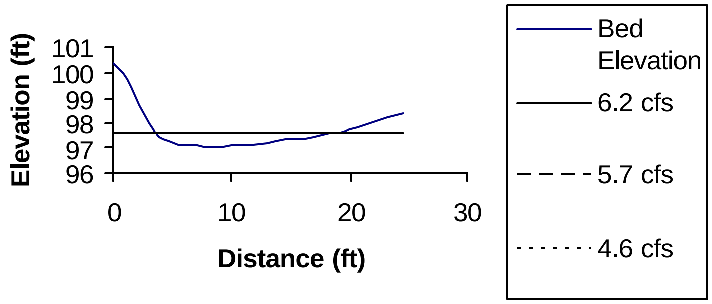
Transect 7
Elevation (ft)
101
99
97
95
0
10
20
30
Distance (ft)
Bed Elevation
6.5 cfs
1.4 cfs



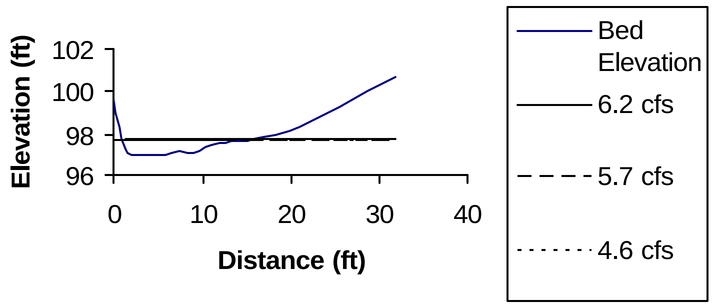
Transect 8
Elevation (ft)
101
99
97
95
0
10
20
30
Distance (ft)
Bed Elevation
6.5 cfs
1.4 cfs

Site 2

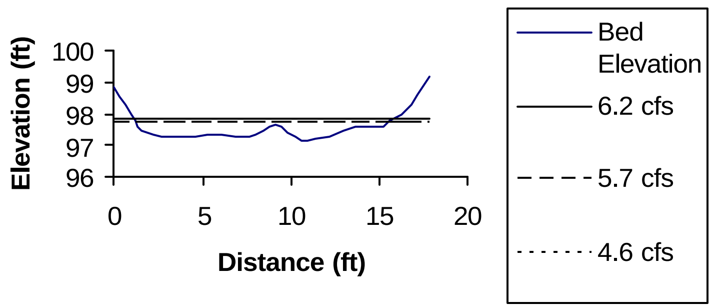
Transect 1



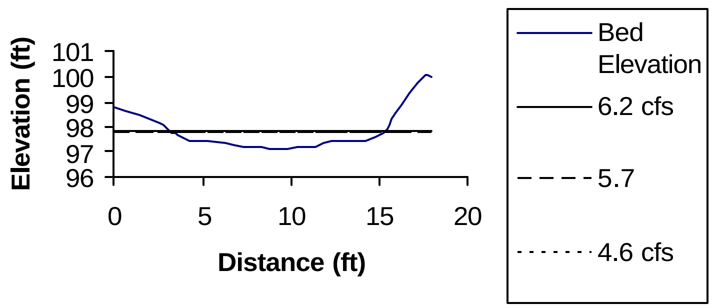
Transect 2



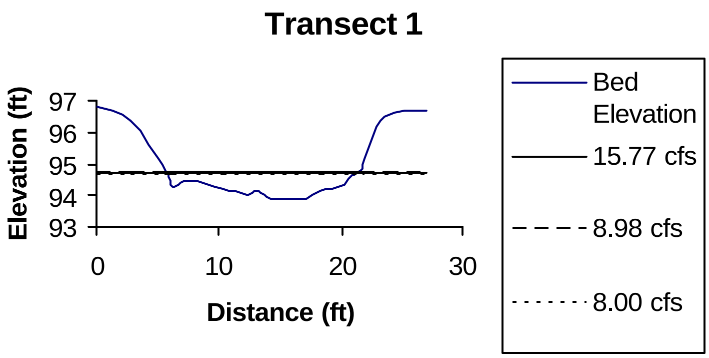
Transect 3

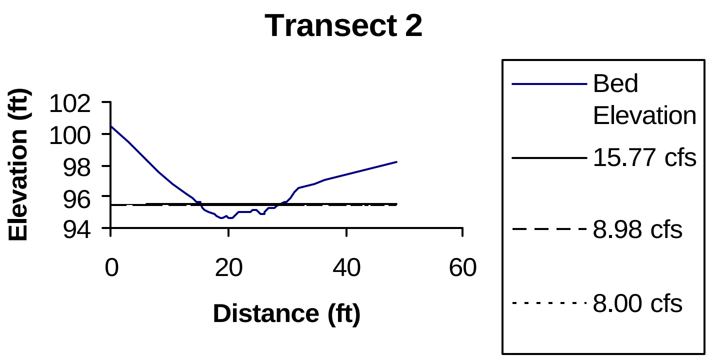


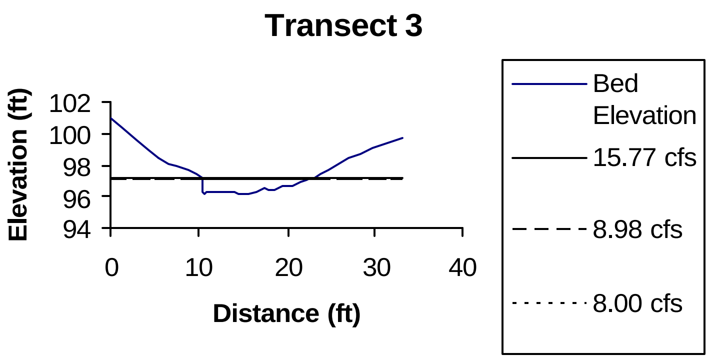
Transect 4



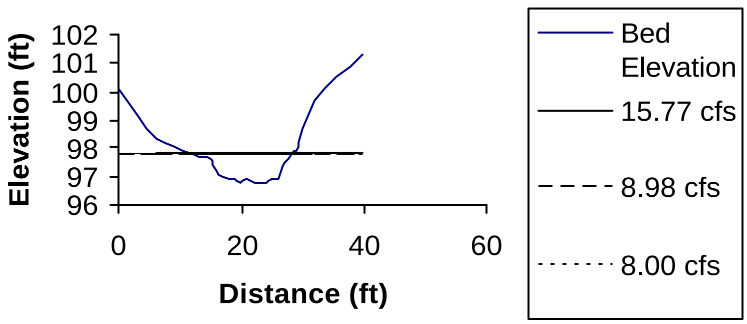
Site 3


Transect 1
Elevation (ft)
97
96
95
94
93
0
10
20
30
Distance (ft)
Bed Elevation
15.77 cfs
8.98 cfs
8.00 cfs

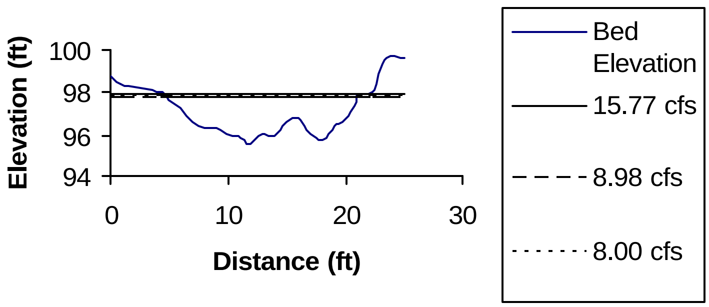

Transect 2
Elevation (ft)
102
100
98
96
94
0
20
40
60
Distance (ft)
Bed Elevation
15.77 cfs
8.98 cfs
8.00 cfs


Transect 3
Elevation (ft)
102
100
98
96
94
0
10
20
30
40
Distance (ft)
Bed Elevation
15.77 cfs
8.98 cfs
8.00 cfs

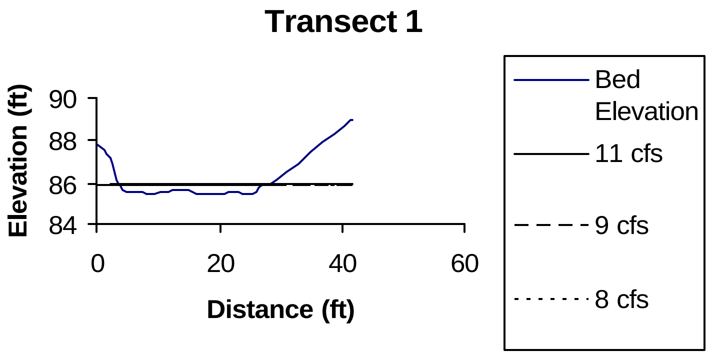
Transect 4



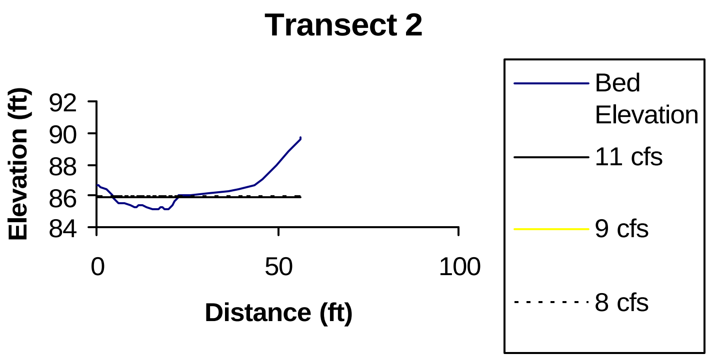
Transect 5



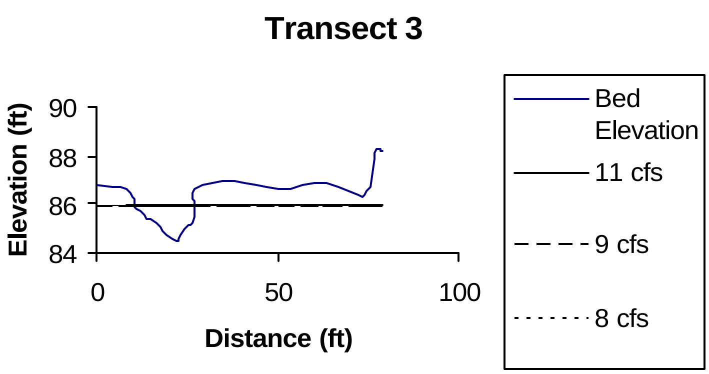
Site 4



Transect 1
Elevation (ft)
90
88
86
84
0
20
40
60
Distance (ft)
Bed Elevation
11 cfs
9 cfs
8 cfs

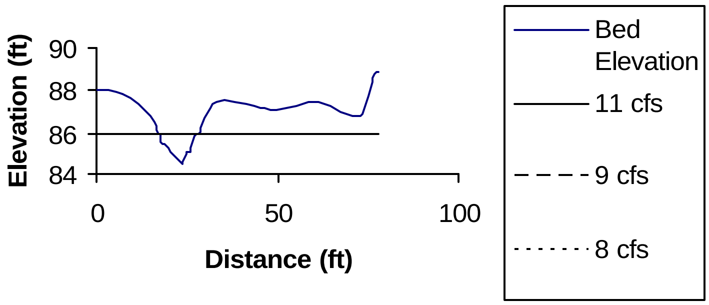


Transect 2
Elevation (ft)
92
90
88
86
84
0
50
100
Distance (ft)
Bed Elevation
11 cfs
9 cfs
8 cfs

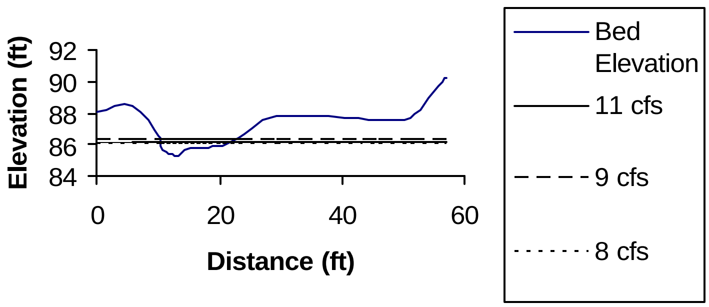


Transect 3
Elevation (ft)
90
88
86
84
0
50
100
Distance (ft)
Bed Elevation
11 cfs
9 cfs
8 cfs

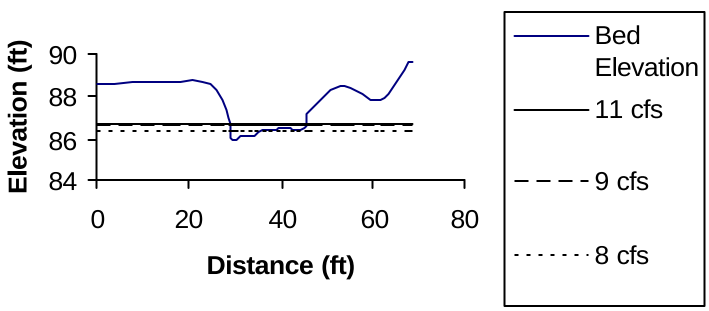
Transect 4



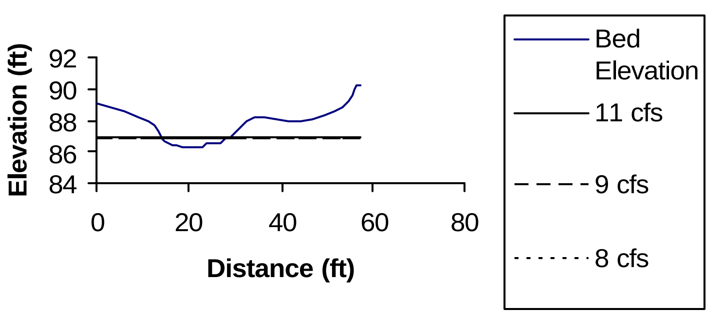
Transect 5

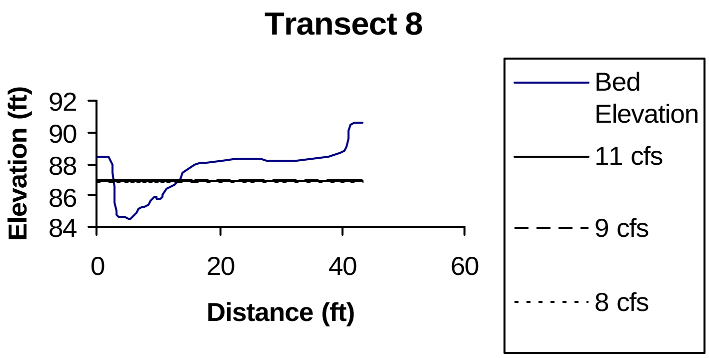


Transect 6

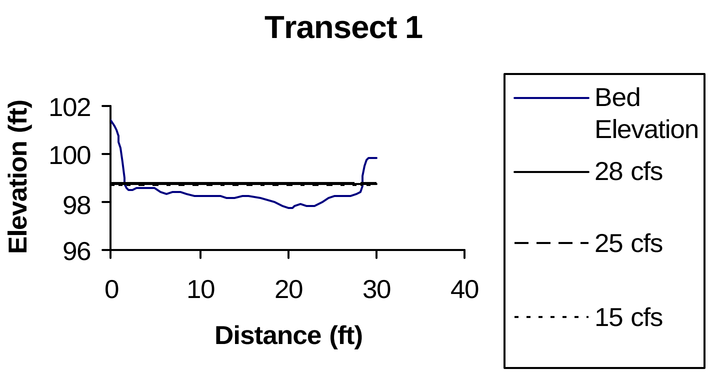


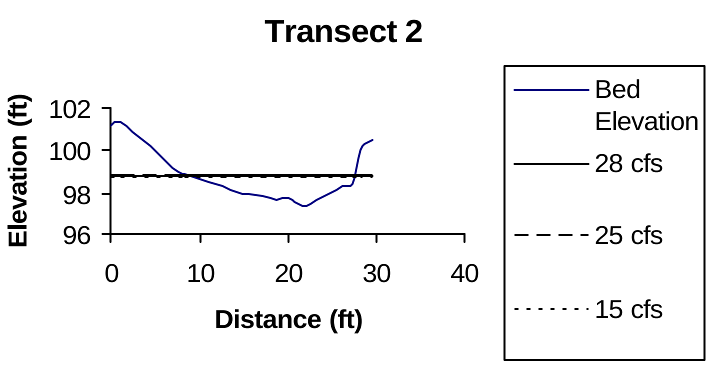
Transect 7

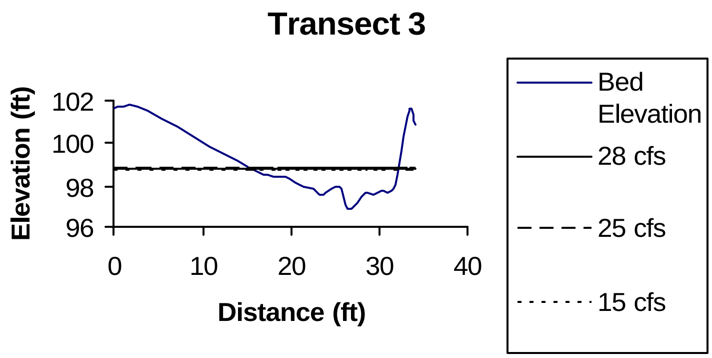


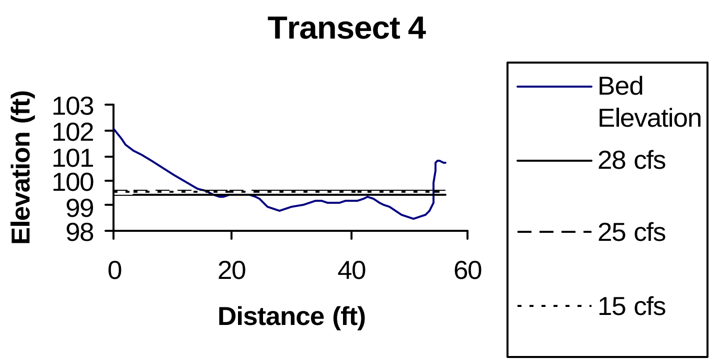

Transect 8
Elevation (ft)
92
90
88
86
84
0
20
40
60
Distance (ft)
Bed Elevation
11 cfs
9 cfs
8 cfs

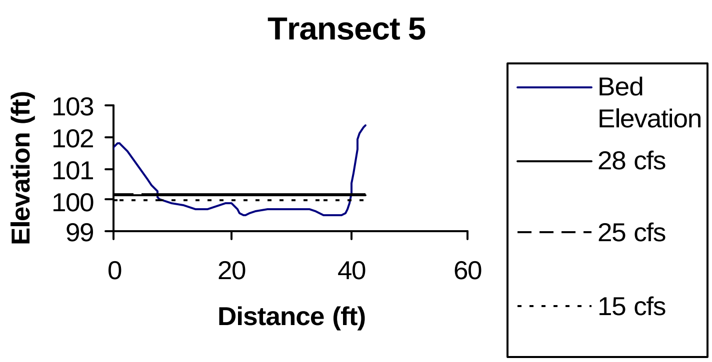
Site 5


Transect 1
Elevation (ft)
102
100
98
96
0
10
20
30
40
Distance (ft)
Bed Elevation
28 cfs
25 cfs
15 cfs

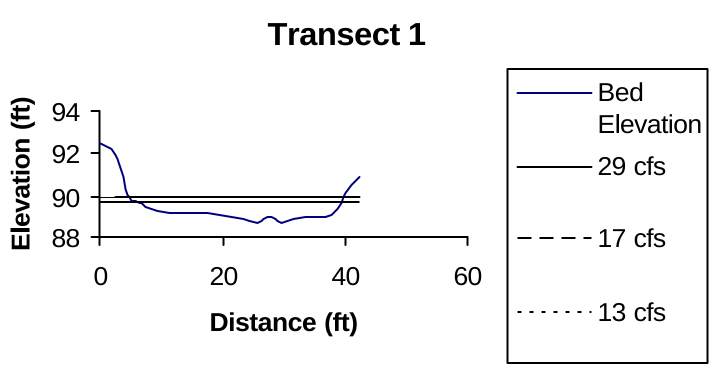

Transect 2
Elevation (ft)
102
100
98
96
0
10
20
30
40
Distance (ft)
Bed Elevation
28 cfs
25 cfs
15 cfs

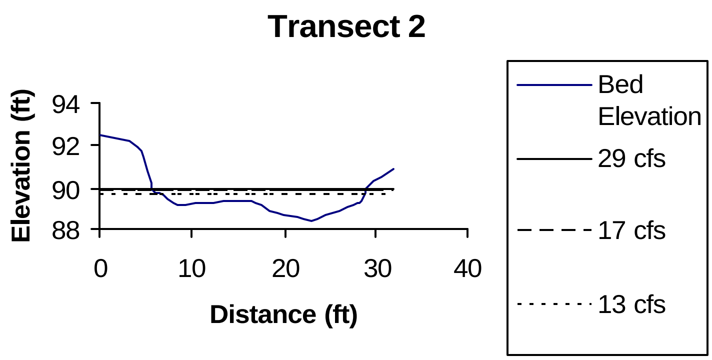

Transect 3
Elevation (ft)
102
100
98
96
0
10
20
30
40
Distance (ft)
Bed Elevation
28 cfs
25 cfs
15 cfs

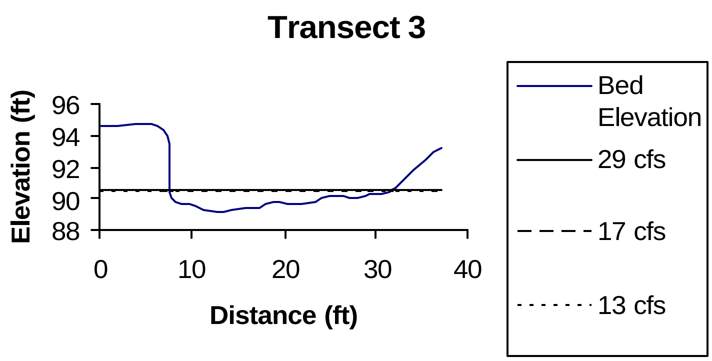

Transect 4
Elevation (ft)
103
102
101
100
99
98
0
20
40
60
Distance (ft)
Bed Elevation
28 cfs
25 cfs
15 cfs

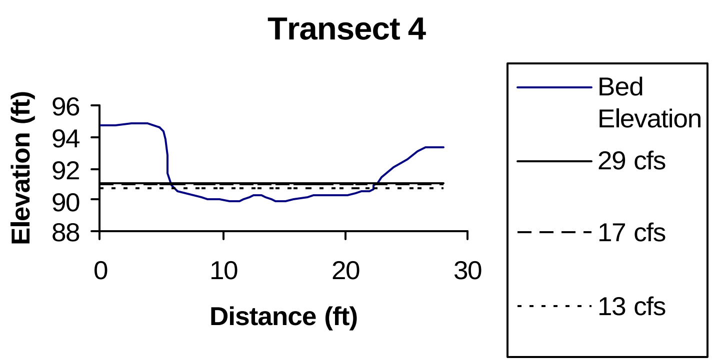

Transect 5
Elevation (ft)
103
102
101
100
99
0
20
40
60
Distance (ft)
Bed Elevation
28 cfs
25 cfs
15 cfs

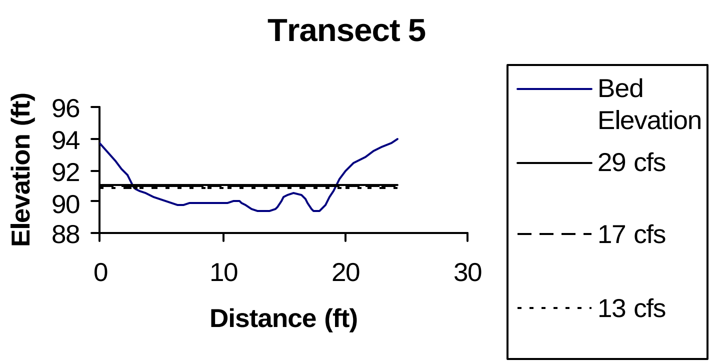
Site 6


Transect 1
Elevation (ft)
94
92
90
88
0
20
40
60
Distance (ft)
Bed Elevation
29 cfs
17 cfs
13 cfs

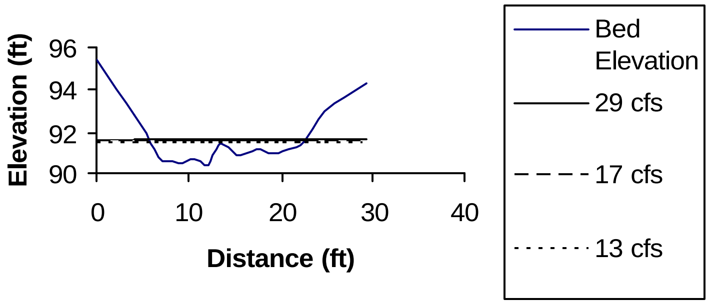

Transect 2
Elevation (ft)
94
92
90
88
0
10
20
30
40
Distance (ft)
Bed Elevation
29 cfs
17 cfs
13 cfs


Transect 3
Elevation (ft)
96
94
92
90
88
0
10
20
30
40
Distance (ft)
Bed Elevation
29 cfs
17 cfs
13 cfs

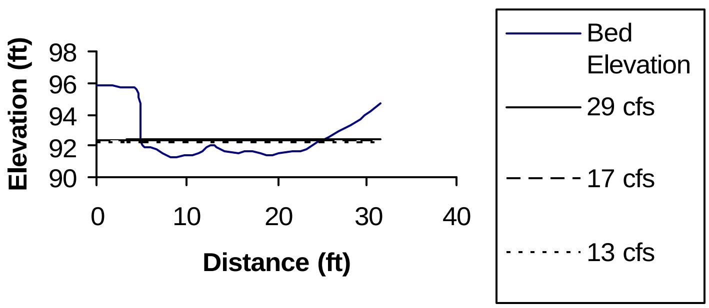

Transect 4
Elevation (ft)
96
94
92
90
88
0
10
20
30
Distance (ft)
Bed Elevation
29 cfs
17 cfs
13 cfs


Transect 5
Elevation (ft)
96
94
92
90
88
0
10
20
30
Distance (ft)
Bed Elevation
29 cfs
17 cfs
13 cfs

Transect 6

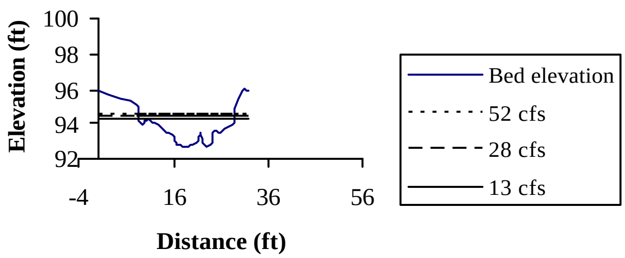


Transect 7

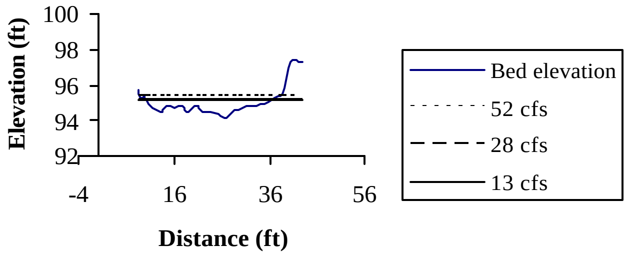


Reference Site

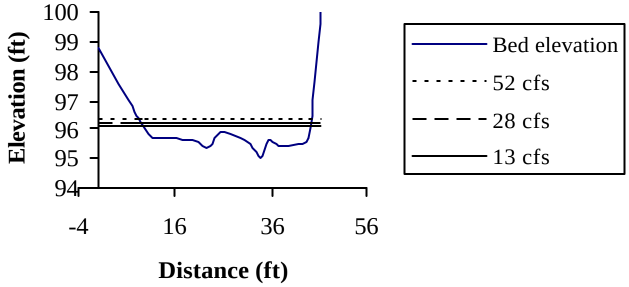
Transect 1



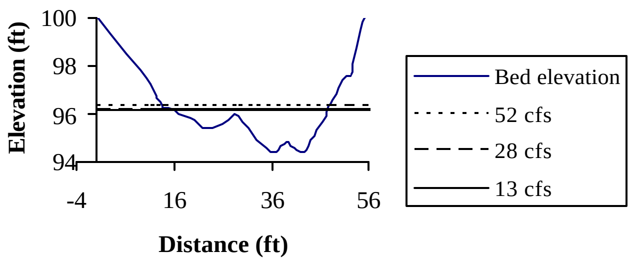
Transect 2



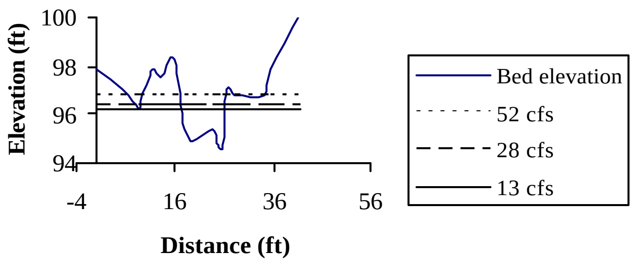
Transect 3



Transect 4



Transect 5



Appendix D – Hydraulic Calibration Results

Table D-1 Water surface elevation calibration results (ft) for Big Timber Cr. Site 1 using the WSP (transects 2-6) and STGQ (transects 1,7,8) models.

Transect	Distance from next downstream transect (ft)	1.4 cfs			6.5 cfs		
		Water surface elevations (ft)					
		Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	97.13	97.13	0.000	97.35	97.35	0.000
2	12	97.14	97.14	0.000	97.36	97.36	0.000
3	25	97.15	97.145	-0.005	97.42	97.419	-0.001
4	43	97.16	97.147	-0.013	97.44	97.431	-0.009
5	21	97.17	97.17	0.000	97.45	97.45	0.000
6	9	97.18	97.177	-0.003	97.46	97.459	-0.001
7	69	97.98	97.98	0.000	98.15	98.15	0.000
8	43	98.45	98.45	0.000	98.70	98.70	0.000

Table D-2 Water surface elevation calibration results (ft) for Big Timber Cr. Site 2 using the STGQ model.

Transect	Distance from next downstream transect (ft)	4.9 cfs			6.0 cfs			8.2 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	97.51	97.51	0.00	97.56	97.55	-0.01	97.60	97.61	0.01
2	17	97.58	97.56	-0.02	97.59	97.61	0.02	97.70	97.70	0.00
3	27	97.74	97.74	0.00	97.78	97.77	-0.01	97.80	97.81	0.01
4	9	97.80	97.80	0.00	97.81	97.82	0.01	97.85	97.85	0.00

Table D-3 Water surface elevation calibration results (ft) for Big Timber Cr. Site 3 using the STGQ model.

Transect	Distance from next downstream transect (ft)	8.0 cfs			9.0 cfs			15.8 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	94.70	94.70	0.00	94.72	94.71	-0.01	94.74	94.74	0.00
2	75	95.41	95.39	-0.02	95.40	95.42	0.02	95.55	95.55	0.00
3	75	97.13	97.13	0.01	97.16	97.14	-0.02	97.19	97.20	0.01
4	40	97.71	97.72	0.01	97.75	97.73	-0.01	97.82	97.82	0.00
5	8	97.81	97.81	0.00	97.83	97.83	0.00	97.93	97.93	0.00

Table D-4 Water surface elevation calibration results (ft) for Big Timber Cr. Site 4 using the WSP (transects 1-5, 7- 8) and STGQ (transect 6) models.

Transect	Distance from next downstream transect (ft)	8.0 cfs			9.0 cfs			11.0 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	85.78	85.78	0.00	85.79	85.79	0.00	85.85	85.85	0.00
2	17	85.82	85.83	0.01	85.84	85.84	0.00	85.90	85.90	0.00
3	31	85.84	85.85	0.01	85.84	85.87	0.03	85.91	85.94	0.03
4	34	85.88	85.87	-0.01	85.90	85.89	-0.01	85.96	85.96	0.00
5	50	86.00	86.01	0.01	86.06	86.04	-0.02	86.09	86.10	0.01
6	26	86.69	86.68	-0.01	86.70	86.71	0.01	86.76	86.76	0.00
7	12	86.88	86.88	0.00	86.90	86.90	0.00	86.96	86.96	0.00
8	21	86.89	86.91	0.02	86.90	86.94	0.04	86.98	87.00	0.02

Table D-5 Water surface elevation calibration results (ft) for Big Timber Cr. Site 5 using the WSP (transects 1, 2, 3) and STGQ (transects 4-5) models.

Transect	Distance from next downstream transect (ft)	15.0 cfs			25.0 cfs			28.0 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	98.68	98.68	0.00	98.72	98.72	0.00	98.73	98.73	0.00
2	19	98.77	98.72	-0.05	98.84	98.81	-0.03	98.86	98.84	-0.02
3	13	98.74	98.74	0.00	98.84	98.85	0.01	98.86	98.88	0.02
4	16	99.40	99.40	0.00	99.49	99.49	0.00	99.51	99.51	0.00
5	30	99.95	99.95	0.00	100.03	100.03	0.00	100.05	100.05	0.00

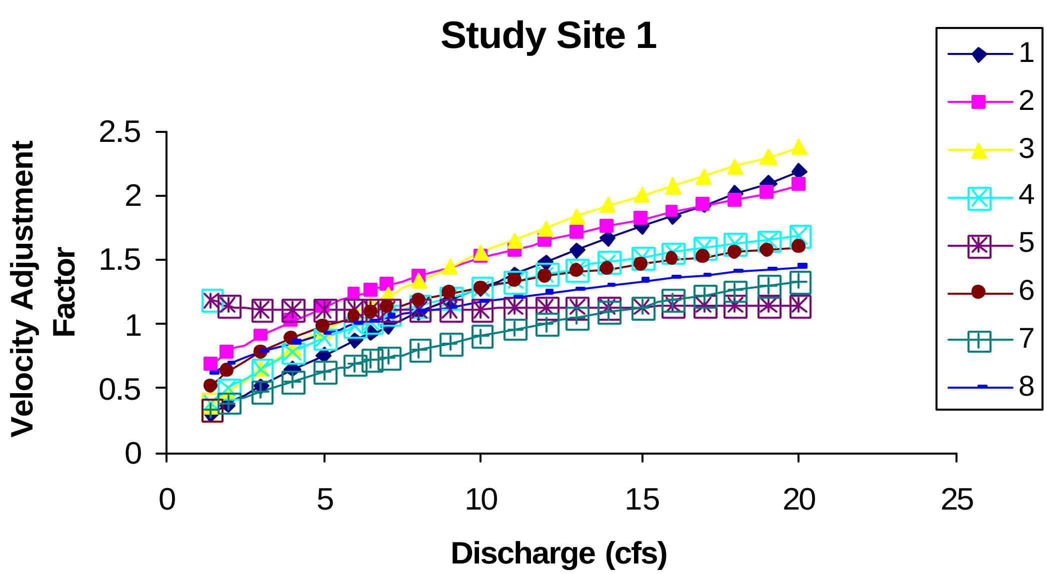
Table D-6 Water surface elevation calibration results (ft) for Big Timber Cr. Site 6 using the WSP (transects 4,5) and STGQ (transects 1,2,3,6,7) models.

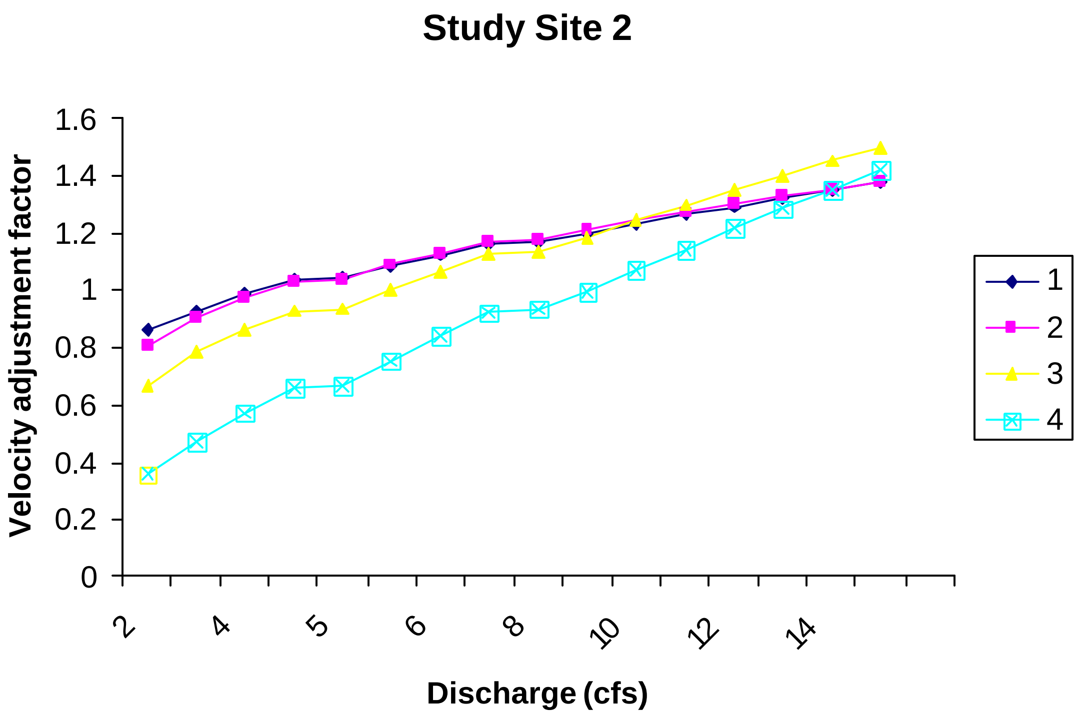
Transect	Distance from next downstream transect (ft)	13.9 cfs			19.9 cfs			31.5 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	89.59	89.59	0.00	89.72	89.72	0.00	89.92	89.92	0.00
2	38	89.66	89.67	0.01	89.82	89.80	-0.02	89.97	89.98	0.01
3	40	90.44	90.42	-0.02	90.46	90.49	0.03	90.59	90.59	0.00
4	27	90.85	90.85	0.00	90.96	90.96	0.00	91.14	91.14	0.00
5	21	90.90	90.87	-0.03	91.03	91.00	-0.03	91.15	91.19	0.04
6	12	91.36	91.36	0.00	91.46	91.47	0.01	91.63	91.63	0.00
7	23	92.12	92.12	0.00	92.22	92.21	-0.01	92.34	92.34	0.00

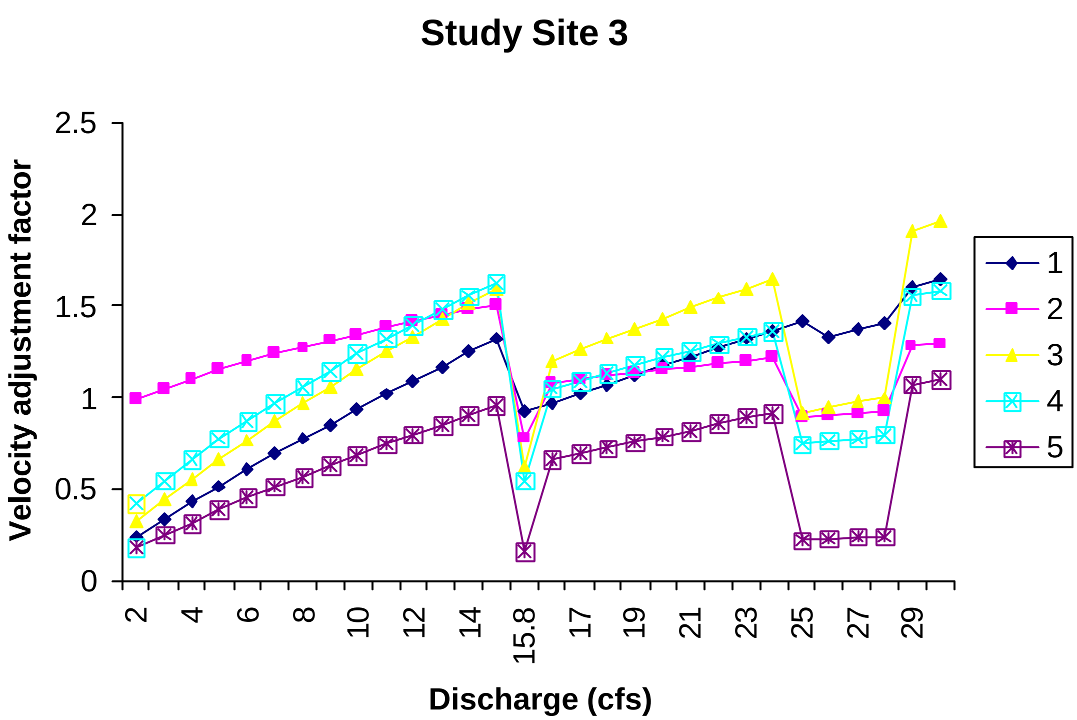
Table D-7 Water surface elevation calibration results (ft) for Big Timber Cr. Reference Site using the WSP (transects 3, 4) and STGQ (transects 1, 2, 5) models.

Transect	Distance from next downstream transect (ft)	17.0 cfs			27.0 cfs			47.0 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	94.21	94.21	0.00	94.35	94.36	0.01	94.56	94.56	0.00
2	58	95.17	95.17	0.00	95.27	95.27	0.00	95.41	95.41	0.00
3	36	96.09	96.09	0.00	96.16	96.16	0.00	96.36	96.36	0.00
4	8	96.14	96.10	-0.04	96.17	96.18	0.01	96.38	96.39	0.01
5	24	96.36	96.35	-0.01	96.55	96.56	0.01	96.86	96.85	-0.01

Velocity adjustment factors for each transect (indicated in legends):




Study Site 2
Velocity adjustment factor
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
4
5
6
8
10
12
14
Discharge (cfs)
1
2
3
4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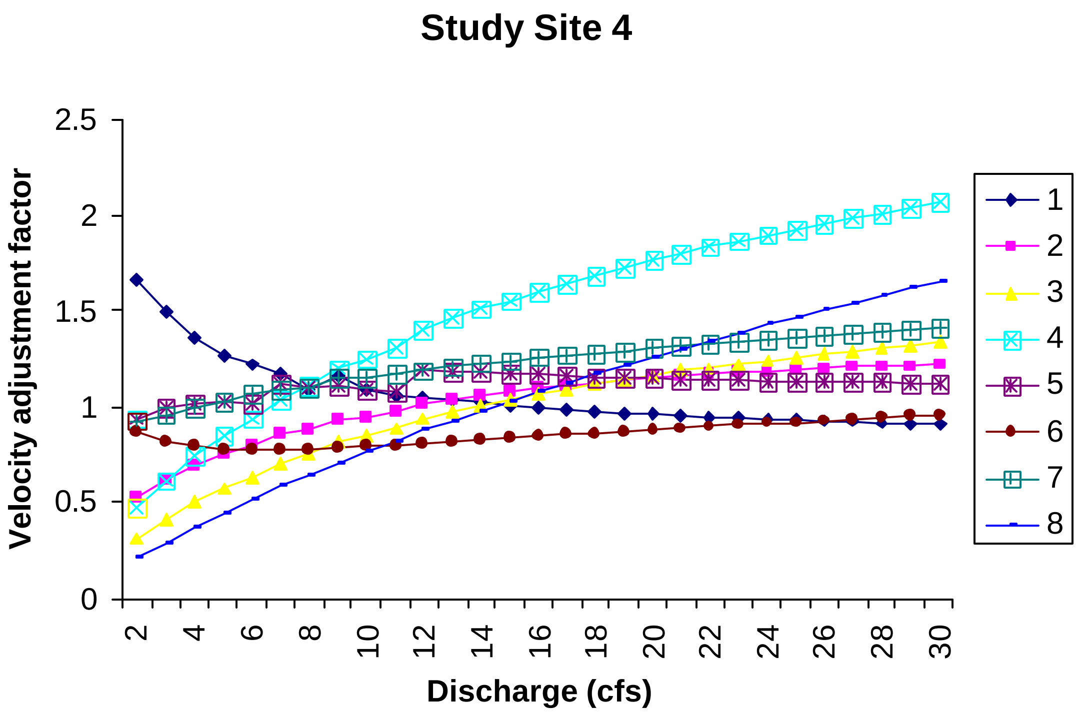
Velocity adjustment factor
2.5
2
1.5
1
0.5
0
2
4
6
8
10
12
14
15.8
17
19
21
23
25
27
29
Discharge (cfs)
1
2
3
4
5


Study Site 4
Velocity adjustment factor
Discharge (cfs)
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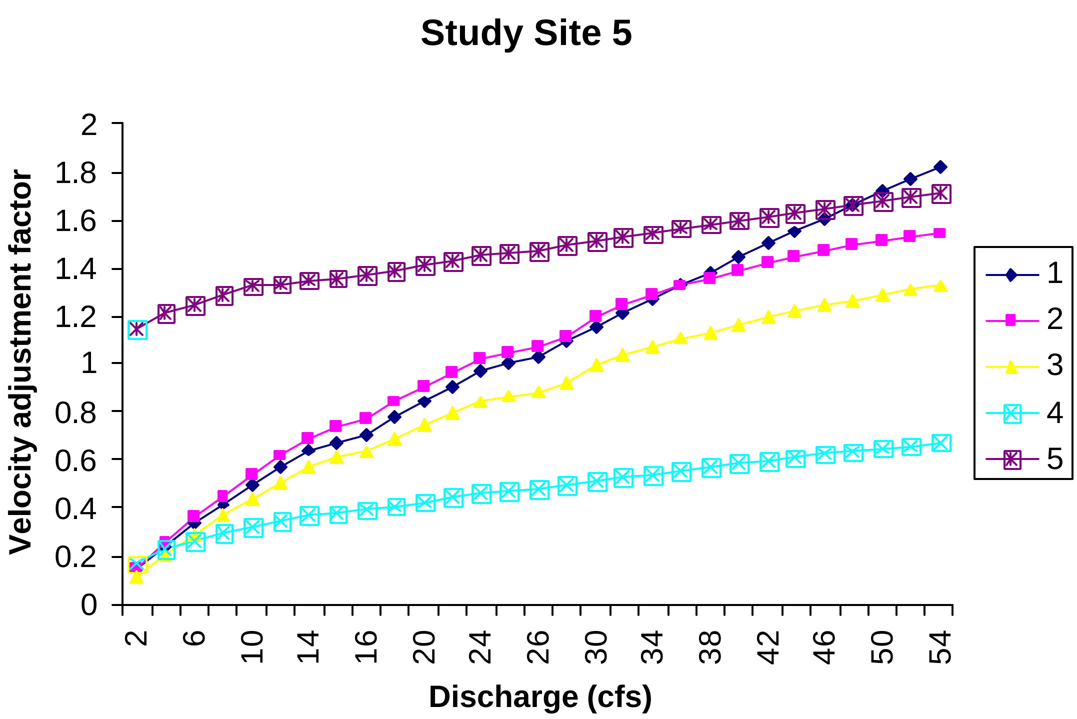
2
1.5
1
0.5
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
1
2
3
4
5
6
7
8


Study Site 5
Velocity adjustment factor
Discharge (cfs)
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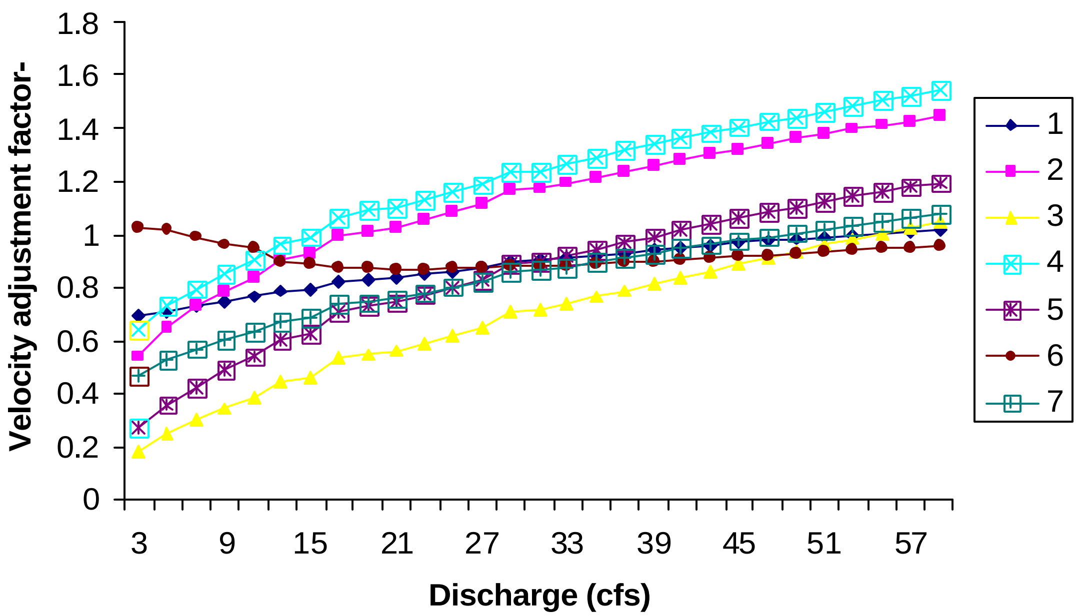
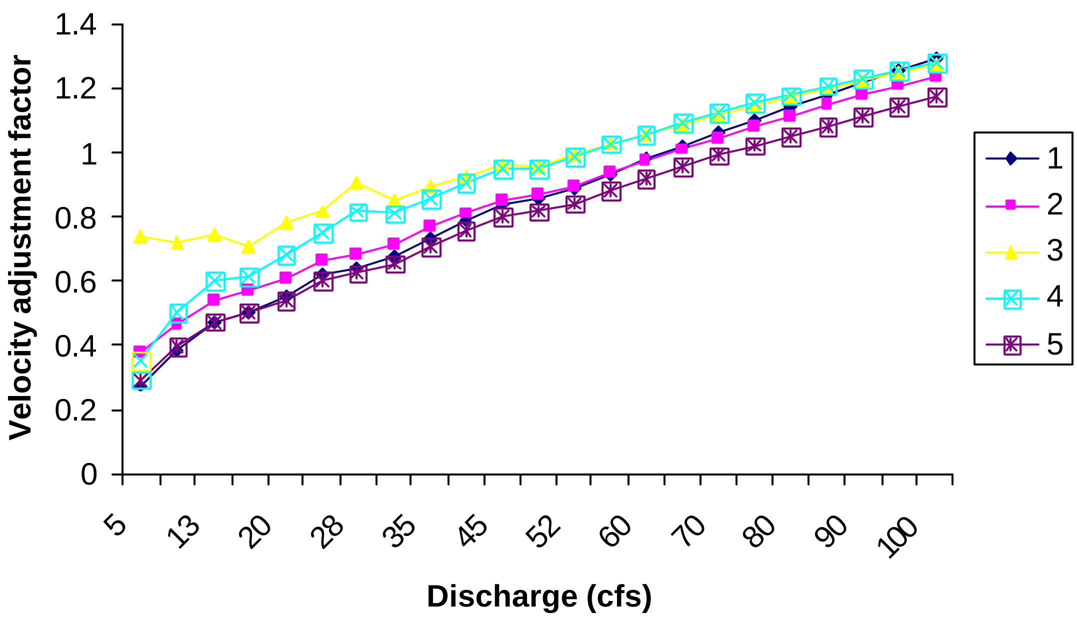
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
6
10
14
16
20
24
26
30
34
38
42
46
50
54
1
2
3
4
5

Study Site 6



Reference Site (Study Site 7)



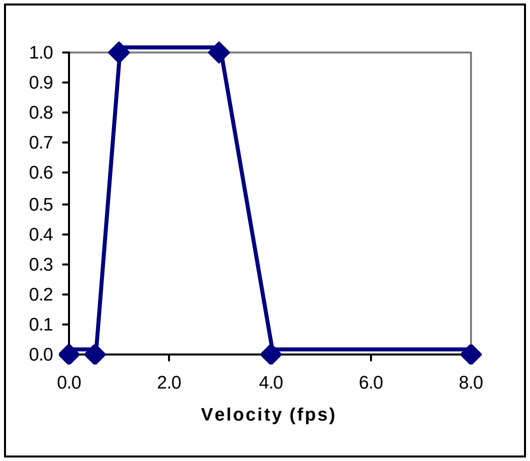
Appendix E - Habitat Suitability Criteria

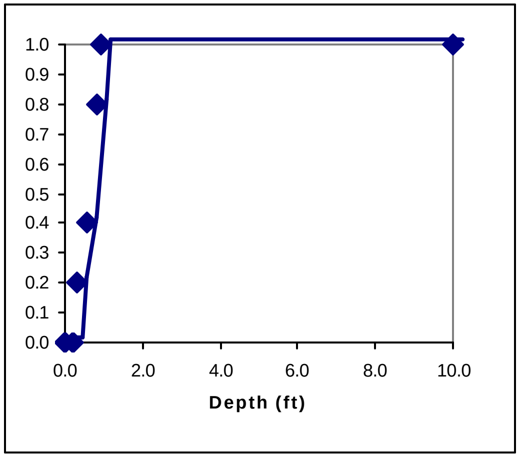
```
Fish Curves
H  10000  8  8 11  0 CHINOOK SALMON*                              SPAWNING
V  10000  0.00  0.00  0.50  0.00  1.00  1.00  3.00  1.00  4.00  0.00  8.00  0.00
V  10000 10.00  0.00100.00  0.00
D  10000  0.00  0.00  0.20  0.00  0.30  0.20  0.58  0.40  0.80  0.80  0.95  1.00
D  10000 10.00  1.00100.00  1.00
S  10000  1.00  0.00  2.00  0.00  3.00  0.00  4.00  0.40  5.00  1.00  6.00  0.20
S  10000  7.00  0.00  8.00  0.00  9.00  0.00 10.00  0.00100.00  0.00
H  10100  6  6  4  0 CHINOOK SALMON*                              ADULT
V  10100  0.00  1.00  2.00  1.00  4.00  0.00  8.00  0.00 10.00  0.00100.00  0.00
D  10100  0.00  0.00  0.20  0.00  1.00  0.30  4.00  1.00 10.00  1.00100.00  1.00
S  10100  1.00  1.00  9.00  1.00 10.00  0.00100.00  0.00
H  10200 25 13  4  0 CHINOOK SALMON*                              JUVENILE
V  10200  0.00  0.88  0.10  0.95  0.20  0.99  0.30  1.00  0.40  0.99  0.50  0.95
V  10200  0.60  0.89  0.70  0.81  0.80  0.72  1.00  0.52  1.10  0.43  1.20  0.34
V  10200  1.30  0.26  1.40  0.20  1.50  0.15  1.60  0.11  1.70  0.07  1.80  0.05
V  10200  1.90  0.03  2.00  0.02  2.10  0.01  2.20  0.01  2.30  0.00  8.00  0.00
V  10200100.00  0.00
D  10200  0.00  0.00  0.20  0.02  0.40  0.07  0.60  0.16  0.80  0.26  1.00  0.37
D  10200  1.20  0.48  1.40  0.59  1.60  0.68  1.80  0.76  2.00  1.00 10.00  1.00
D  10200100.00  1.00
S  10200  1.00  1.00  9.00  1.00 10.00  0.00100.00  0.00
H  10300  7  8 11  0 STEELHEAD*                                   SPAWNING
V  10300  0.00  0.00  0.50  0.00  1.00  1.00  3.00  1.00  4.00  0.00  8.00  0.00
V  10300100.00  0.00
D  10300  0.00  0.00  0.20  0.00  0.30  0.20  0.58  0.40  0.80  0.80  0.95  1.00
D  10300 10.00  1.00100.00  1.00
S  10300  1.00  0.00  2.00  0.00  3.00  0.00  4.00  0.40  5.00  1.00  6.00  0.20
S  10300  7.00  0.00  8.00  0.00  9.00  0.00 10.00  0.00100.00  0.00
H  10400  5  6  4  0 STEELHEAD*                                   ADULT
V  10400  0.00  1.00  2.00  1.00  4.00  0.00  8.00  0.00100.00  0.00
D  10400  0.00  0.00  0.20  0.00  1.00  0.30  4.00  1.00 10.00  1.00100.00  1.00
S  10400  1.00  1.00  9.00  1.00 10.00  0.00100.00  0.00
H  10500  9  7  4  0 STEELHEAD*                                   JUVENILE
V  10500  0.00  0.00  0.20  0.15  0.30  0.90  0.50  0.97  0.70  1.00  1.20  1.00
V  10500  2.00  0.00  8.00  0.00100.00  0.00
D  10500  0.00  0.00  0.30  0.20  0.60  0.65  1.00  0.96  1.20  1.00 10.00  1.00
D  10500100.00  1.00
S  10500  1.00  1.00  9.00  1.00 10.00  0.00100.00  0.00
H  10600 24  9 11  0 BULL TROUT*                                  SPAWNING
V  10600  0.00  0.00  0.20  0.00  0.32  0.03  0.42  0.06  0.48  0.11  0.60  0.18
V  10600  0.70  0.30  0.77  0.50  0.87  0.57  0.92  0.78  1.00  0.90  1.10  1.00
V  10600  1.90  1.00  2.05  0.96  2.14  0.90  2.25  0.72  2.40  0.48  2.52  0.32
V  10600  2.72  0.20  2.95  0.15  3.12  0.05  3.50  0.00  8.00  0.00100.00  0.00
D  10600  0.00  0.00  0.20  0.00  0.25  0.04  0.31  0.11  0.45  0.30  0.50  0.56
D  10600  0.60  1.00 10.00  1.00100.00  1.00
S  10600  1.00  0.00  2.00  0.00  3.00  0.00  4.00  1.00  5.00  1.00  6.00  0.00
S  10600  7.00  0.00  8.00  0.00  9.00  0.00 10.00  0.00100.00  0.00
H  10700  5  5  4  0 BULL TROUT*                                  ADULT
V  10700  0.00  1.00  0.40  1.00  1.50  0.00  8.00  0.00100.00  0.00
D  10700  0.00  0.00  0.30  0.00  2.00  1.00 10.00  1.00100.00  1.00
S  10700  1.00  1.00  9.00  1.00 10.00  0.00100.00  0.00
H  10800  5  5  4  0 BULL TROUT*                                  JUVENILE
V  10800  0.00  1.00  0.40  1.00  1.50  0.00  8.00  0.00100.00  0.00
D  10800  0.00  0.00  0.30  0.00  1.00  1.00 10.00  1.00100.00  1.00
S  10800  1.00  1.00  9.00  1.00 10.00  0.00100.00  0.00
H  10900 25 13 10  0 CHINOOK SALMON-COVER*                        JUVENILE
V  10900  0.00  0.88  0.10  0.95  0.20  0.99  0.30  1.00  0.40  0.99  0.50  0.95
V  10900  0.60  0.89  0.70  0.81  0.80  0.72  1.00  0.52  1.10  0.43  1.20  0.34
V  10900  1.30  0.26  1.40  0.20  1.50  0.15  1.60  0.11  1.70  0.07  1.80  0.05
V  10900  1.90  0.03  2.00  0.02  2.10  0.01  2.20  0.01  2.30  0.00  8.00  0.00
V  10900100.00  0.00
D  10900  0.00  0.00  0.20  0.00  0.40  0.10  0.60  0.20  0.80  0.30  1.00  0.40
D  10900  1.20  0.50  1.40  0.60  1.60  0.70  1.80  0.80  2.00  1.00 10.00  1.00
D  10900100.00  1.00
S  10900  1.00  1.00  2.00  1.00  3.00  1.00  4.00  1.00  5.00  1.00  6.00  1.00
S  10900  7.00  1.00  8.00  0.00 10.00  0.00100.00  0.00
H  11000  9  7 10  0 STEELHEAD-COVER*                             JUVENILE
```

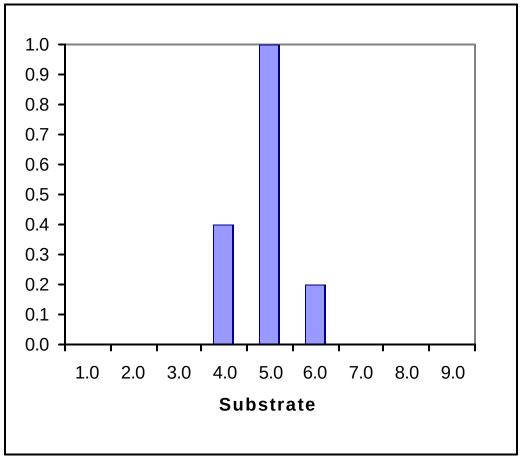
```
V  11000  0.00  0.00  0.20  0.20  0.30  0.90  0.50  1.00  0.70  1.00  1.20  1.00
V  11000  2.00  0.00  8.00  0.00100.00  0.00
D  11000  0.00  0.00  0.30  0.20  0.60  0.65  1.00  0.96  1.20  1.00 10.00  1.00
D  11000100.00  1.00
S  11000  1.00  1.00  2.00  1.00  3.00  1.00  4.00  1.00  5.00  1.00  6.00  1.00
S  11000  7.00  1.00  8.00  0.00 10.00  0.00100.00  0.00
H  11100  5  5 10  0 BULL TROUT-COVER*                  JUVENILE
V  11100  0.00  1.00  0.40  1.00  1.50  0.00  8.00  0.00100.00  0.00
D  11100  0.00  0.00  0.30  0.00  1.00  1.00 10.00  1.00100.00  1.00
S  11100  1.00  1.00  2.00  1.00  3.00  1.00  4.00  1.00  5.00  1.00  6.00  1.00
S  11100  7.00  1.00  8.00  0.00 10.00  0.00100.00  0.00
```

Habitat Suitability Criteria (HSC)

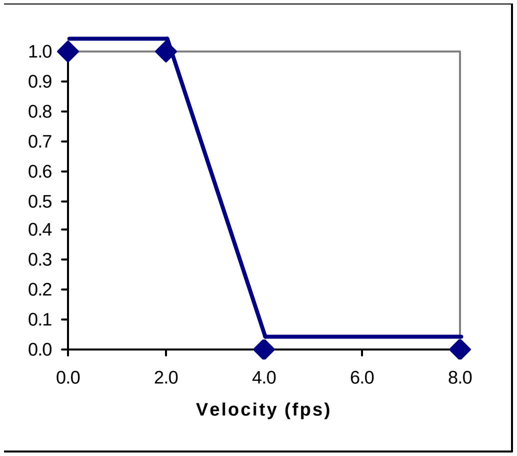
Chinook Salmon – spawning

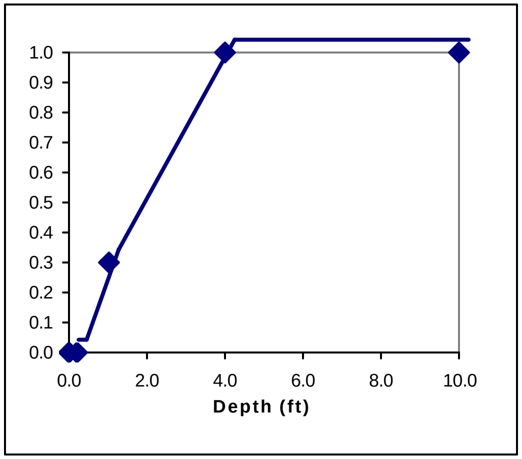


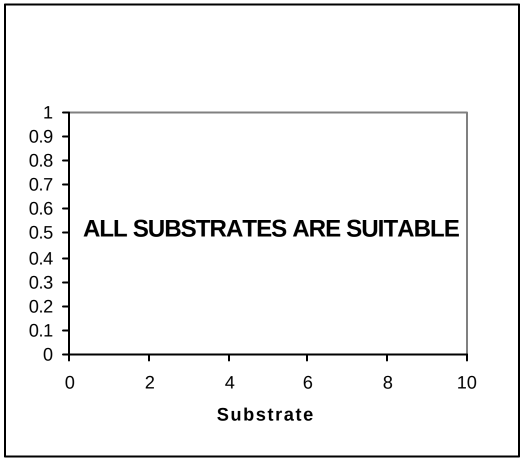




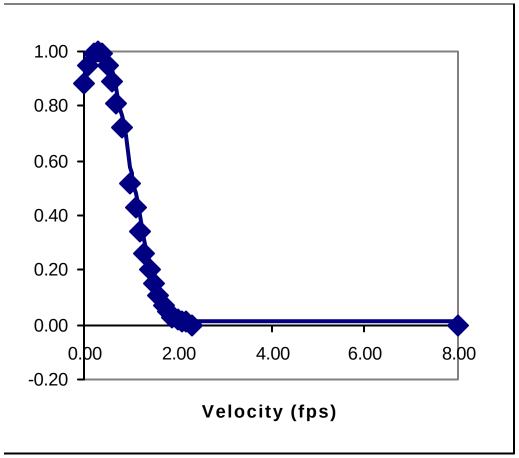
Chinook Salmon – adult holding

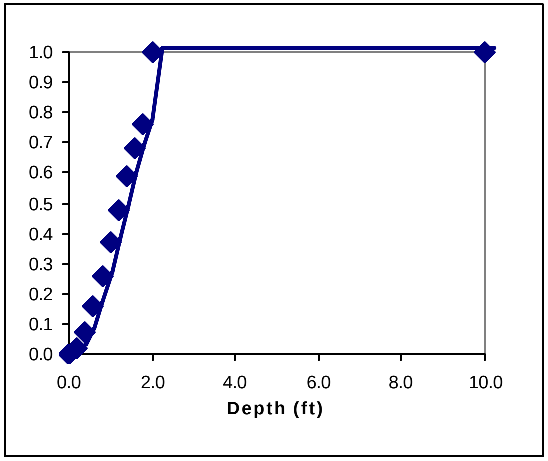


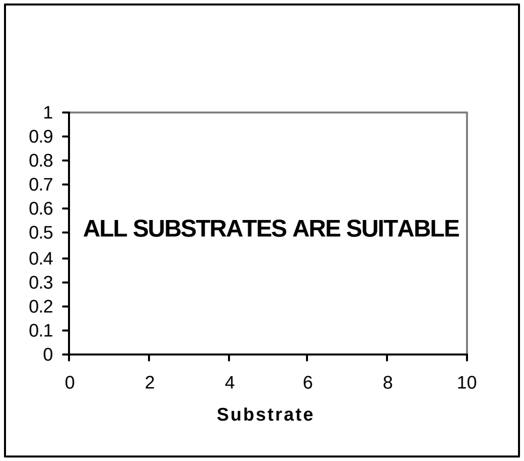


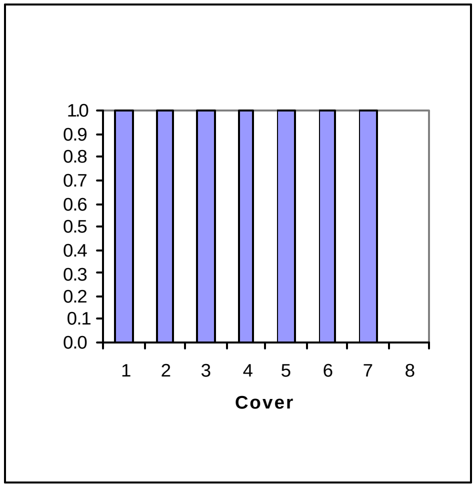


Chinook Salmon - juvenile

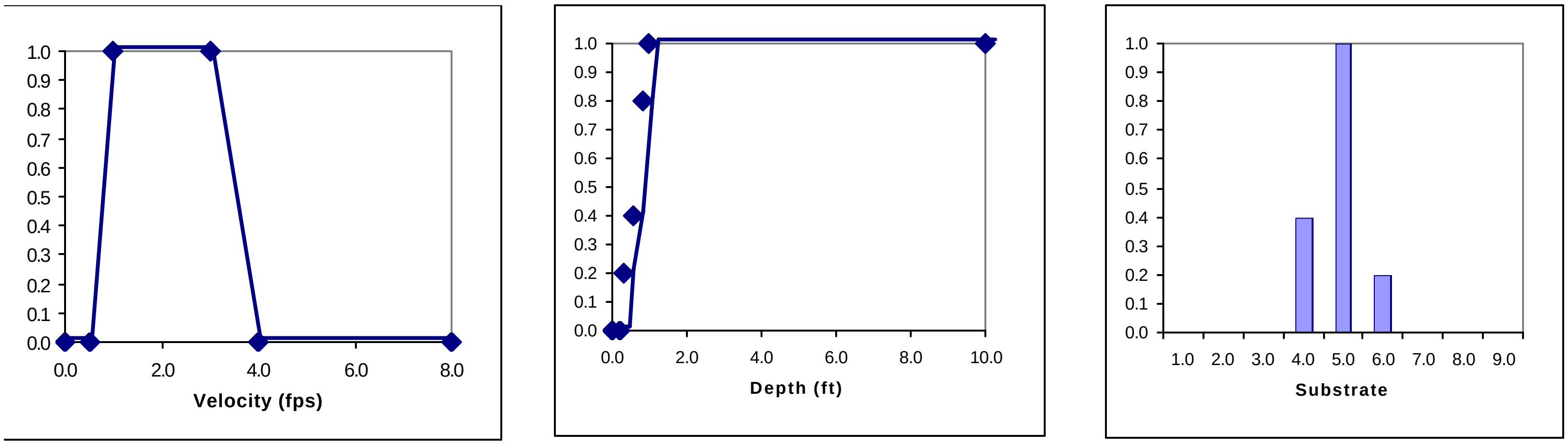




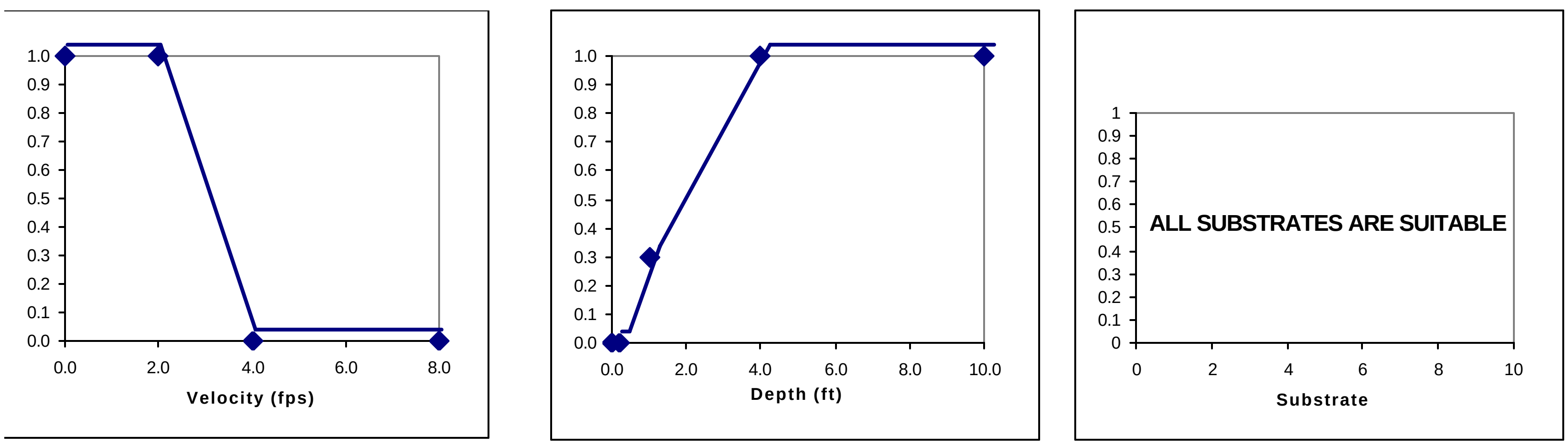




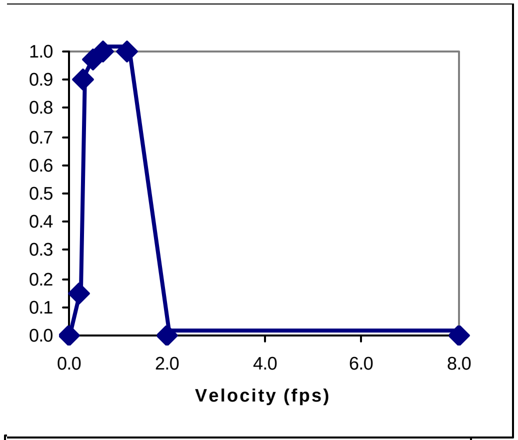
Steelhead – spawning

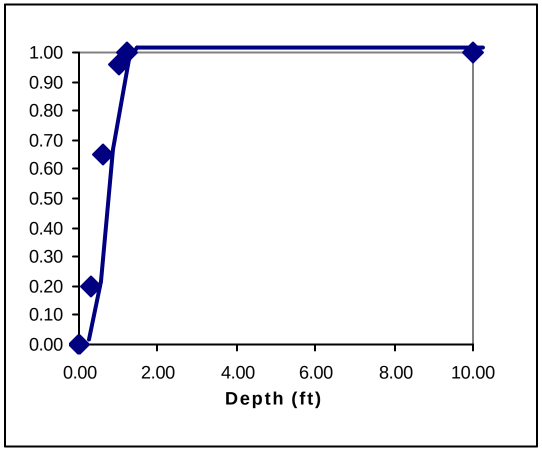


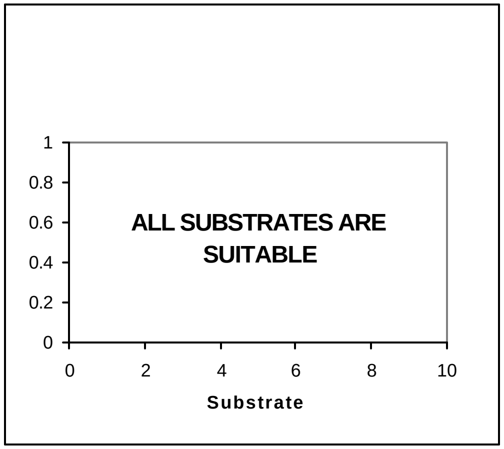
Steelhead – adult holding

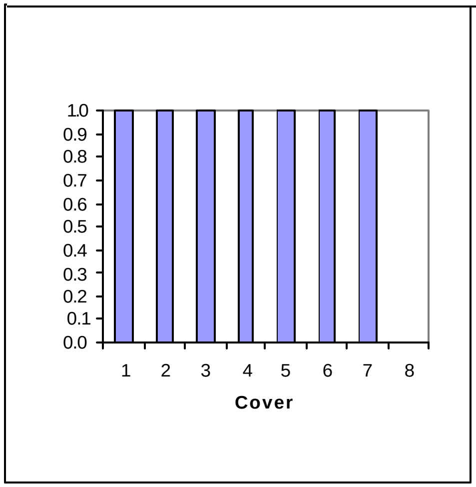


Steelhead - juvenile

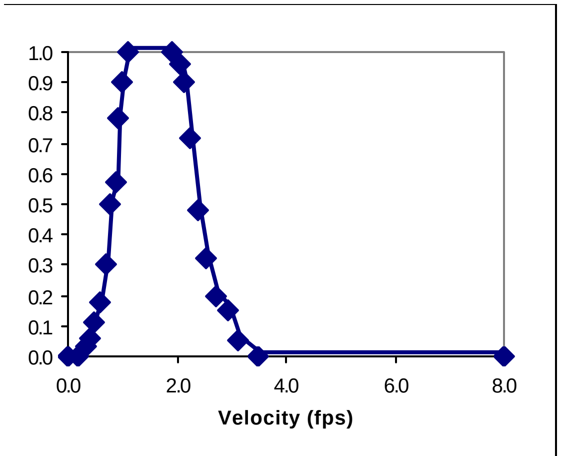


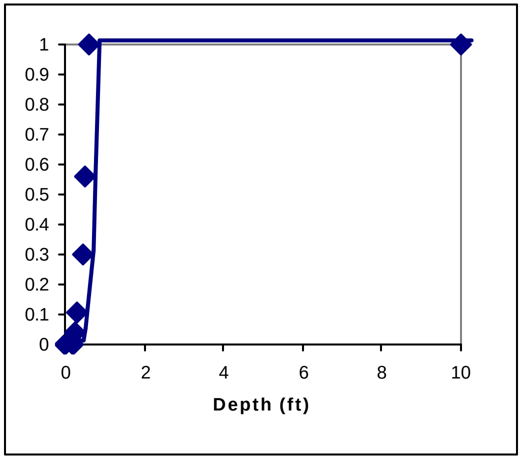


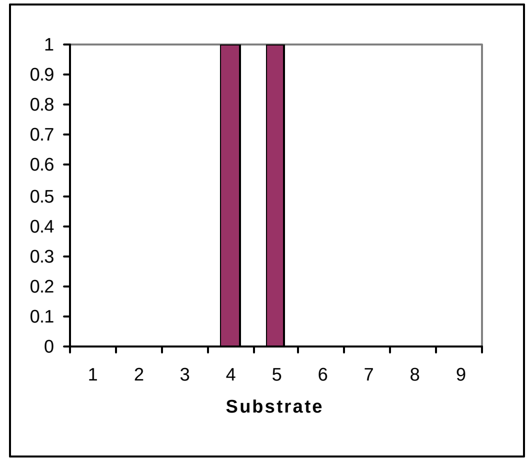




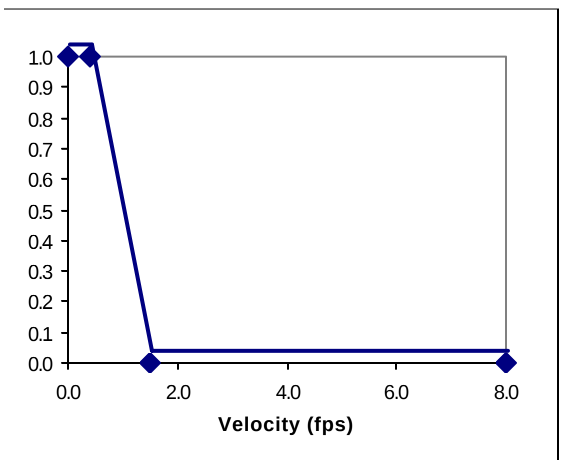
Bull trout - spawning

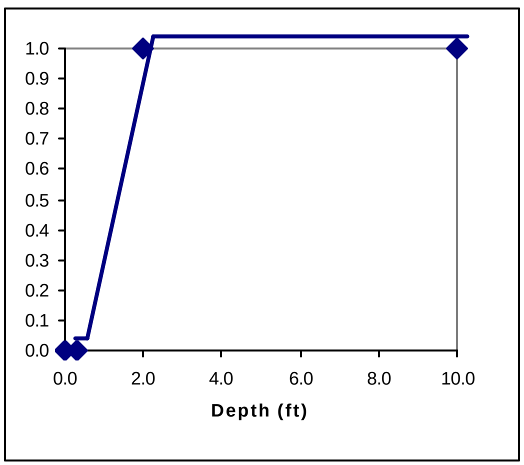


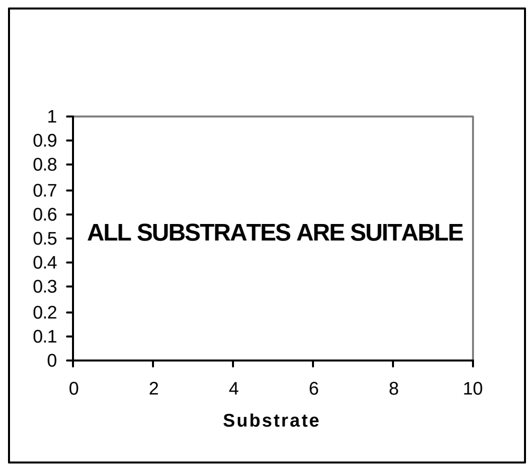




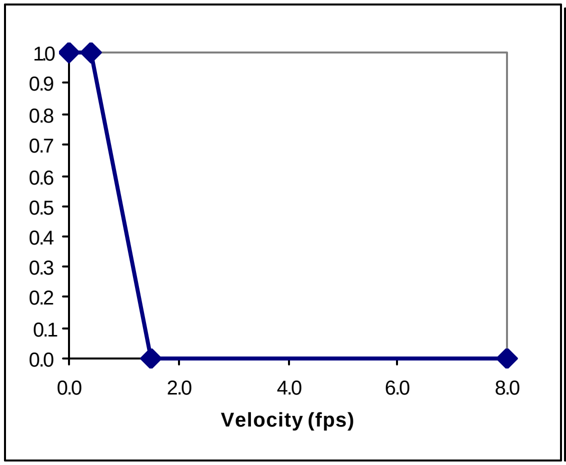
Bull trout – adult

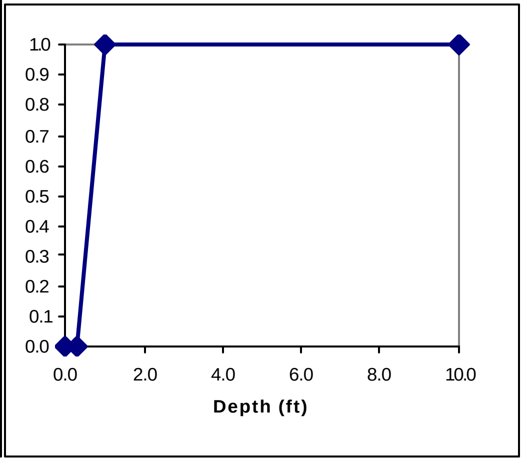


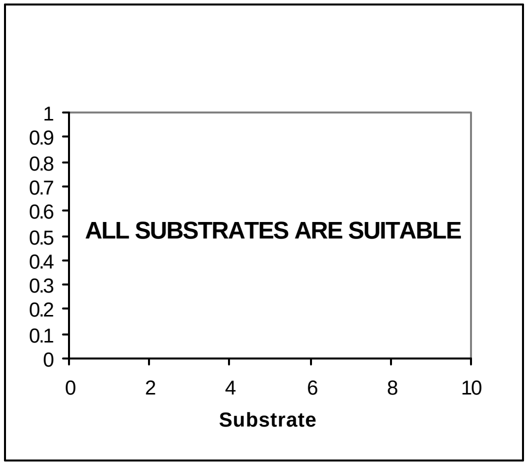


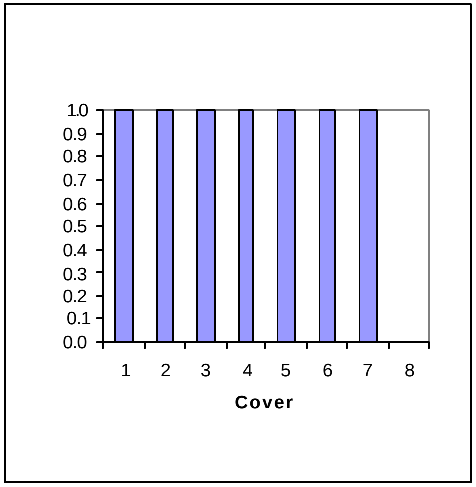


Bull trout – juvenile

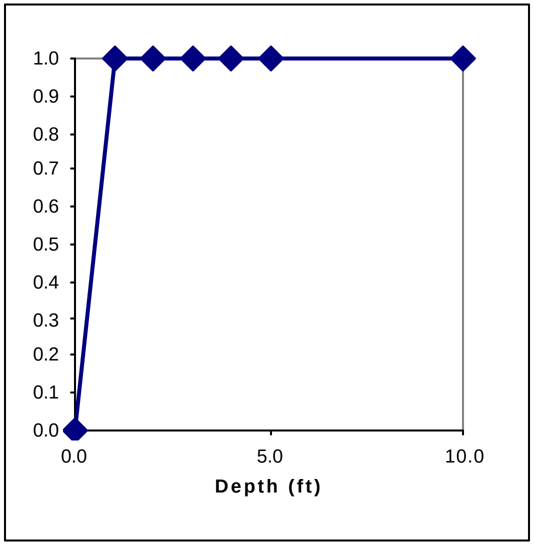




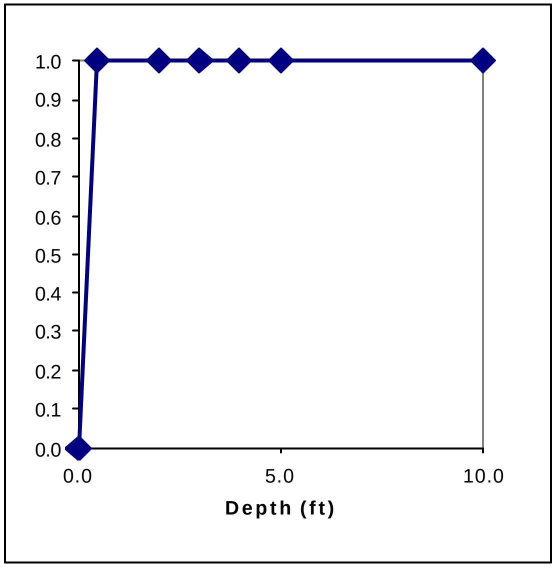




Upstream anadromous passage



Upstream resident passage



Appendix F – Weighted usable area (WUA) versus discharge relationships

Reach 1 (Study Site 1):

Table F-1. Weighted usable area (WUA) versus discharge relationships for steelhead at Big Timber Creek, Study Site 1.

Discharge (cfs)	Total (ft^2)/ 1,000 ft	WUA (ft^2)/1,000 ft Spawning	Adult	Juvenile	Juvenile cover	Percent of optimal habitat Spawning	Adult	Juvenile	Juvenile cover
1.4	11253	375	4725	5488	1985	8.4	65.1	68.7	58.0
2	11370	970	5114	6474	2381	21.8	70.5	81.0	69.5
3	11528	1812	5548	7304	2742	40.8	76.5	91.4	80.1
4	11657	2370	5825	7762	2994	53.3	80.3	97.1	87.4
5	11768	3076	6052	7991	3131	69.2	83.4	100.0	91.4
6	12040	3407	6252	7916	3214	76.6	86.2	99.1	93.8
6.5	12109	3550	6365	7924	3248	79.8	87.7	99.2	94.8
7	12639	3656	6470	7927	3279	82.2	89.2	99.2	95.7
8	12895	3818	6626	7738	3336	85.9	91.3	96.8	97.4
9	13003	4078	6750	7459	3380	91.7	93.0	93.3	98.7
10	13106	4243	6846	7453	3418	95.4	94.3	93.3	99.8
11	13202	4334	6932	7348	3425	97.5	95.5	92.0	100.0
12	13296	4388	7030	7187	3407	98.7	96.9	89.9	99.5
13	13387	4430	7082	6949	3289	99.6	97.6	87.0	96.0
14	13473	4446	7131	6645	3182	100.0	98.3	83.2	92.9
15	13558	4418	7134	6343	3188	99.4	98.3	79.4	93.1
16	13640	4356	7165	6203	3181	98.0	98.7	77.6	92.9
17	13720	4335	7205	6126	3166	97.5	99.3	76.7	92.4
18	13798	4299	7256	5972	3111	96.7	100.0	74.7	90.8
19	13875	4231	7256	5832	3107	95.2	100.0	73.0	90.7
20	13950	4030	7227	5639	3096	90.6	99.6	70.6	90.4

Table F-2. Weighted usable area (WUA) versus discharge relationships for Chinook salmon at Big Timber Creek, Study Site 1.

Discharge (cfs)	Total (ft^2)/ 1,000 ft	WUA (ft^2)/1,000 ft				Percent of optimal habitat			
		Spawning	Adult	Juvenile	Juvenile cover	Spawning	Adult	Juvenile	Juvenile cover
1.4	11253	375	4725	5308	1985	8.4	65.1	91.1	58.0
2	11370	970	5114	5539	2381	21.8	70.5	95.0	69.5
3	11528	1812	5548	5751	2742	40.8	76.5	98.7	80.1
4	11657	2370	5825	5828	2994	53.3	80.3	100.0	87.4
5	11768	3076	6052	5825	3131	69.2	83.4	100.0	91.4
6	12040	3407	6252	5785	3214	76.6	86.2	99.3	93.8
6.5	12109	3550	6365	5757	3248	79.8	87.7	98.8	94.8
7	12639	3656	6470	5765	3279	82.2	89.2	98.9	95.7
8	12895	3818	6626	5691	3336	85.9	91.3	97.7	97.4
9	13003	4078	6750	5590	3380	91.7	93.0	95.9	98.7
10	13106	4243	6846	5476	3418	95.4	94.3	94.0	99.8
11	13202	4334	6932	5359	3425	97.5	95.5	92.0	100.0
12	13296	4388	7030	5275	3407	98.7	96.9	90.5	99.5
13	13387	4430	7082	5204	3289	99.6	97.6	89.3	96.0
14	13473	4446	7131	5101	3182	100.0	98.3	87.5	92.9
15	13558	4418	7134	5040	3188	99.4	98.3	86.5	93.1
16	13640	4356	7165	4975	3181	98.0	98.7	85.4	92.9
17	13720	4335	7205	4863	3166	97.5	99.3	83.4	92.4
18	13798	4299	7256	4761	3111	96.7	100.0	81.7	90.8
19	13875	4231	7256	4705	3107	95.2	100.0	80.7	90.7
20	13950	4030	7227	4670	3096	90.6	99.6	80.1	90.4

Table F-3. Weighted usable area (WUA) versus discharge relationships for bull trout at Big Timber Creek, Study Site 1.

Discharge (cfs)	Total (ft^2)/ 1,000 ft	WUA (ft^2)/1,000 ft Spawning	Adult	Juvenile	Juvenile cover	Percent of optimal habitat Spawning	Adult	Juvenile	Juvenile cover
1.4	11253	1026	4208	5515	3229	21.9	74.2	77.4	76.3
2	11370	1595	4768	6225	3377	34.1	84.1	87.3	79.8
3	11528	2404	5236	6789	3513	51.4	92.3	95.2	83.0
4	11657	3028	5462	7029	3709	64.8	96.3	98.6	87.6
5	11768	3500	5576	7129	3804	74.8	98.3	100.0	89.9
6	12040	3861	5543	7034	3864	82.5	97.8	98.7	91.3
6.5	12109	4049	5538	7004	3914	86.6	97.7	98.2	92.5
7	12639	4213	5572	7027	3947	90.1	98.3	98.6	93.2
8	12895	4434	5601	7023	3987	94.8	98.8	98.5	94.2
9	13003	4593	5671	7077	4009	98.2	100.0	99.3	94.7
10	13106	4677	5652	7011	4070	100.0	99.7	98.4	96.2
11	13202	4676	5658	6982	4099	100.0	99.8	97.9	96.8
12	13296	4658	5616	6887	4163	99.6	99.0	96.6	98.3
13	13387	4644	5596	6821	4187	99.3	98.7	95.7	98.9
14	13473	4591	5594	6782	4216	98.2	98.6	95.1	99.6
15	13558	4530	5606	6763	4230	96.9	98.9	94.9	99.9
16	13640	4387	5618	6744	4233	93.8	99.1	94.6	100.0
17	13720	4224	5608	6698	4231	90.3	98.9	94.0	100.0
18	13798	4117	5591	6645	4221	88.0	98.6	93.2	99.7
19	13875	3963	5517	6519	4201	84.7	97.3	91.4	99.2
20	13950	3834	5475	6440	4161	82.0	96.6	90.3	98.3

Reach 2 (Study Site 2):

Table F-4. Weighted usable area (WUA) versus discharge relationships for steelhead at Big Timber Creek, Study Site 2.

Discharge (cfs)	Total (ft^2)/ 1,000 ft	WUA (ft^2)/1,000 ft Spawning	Adult	Juvenile	Juvenile cover	Percent of optimal habitat Spawning	Adult	Juvenile	Juvenile cover
2	11891	1437	3310	6566	1577	27.1	51.6	75.8	85.2
3	12300	2257	3774	7468	1670	42.5	58.8	86.2	90.2
4	12629	2964	4315	8083	1773	55.8	67.3	93.3	95.8
5	13036	3419	4643	8451	1838	64.4	72.4	97.5	99.3
5.9	13082	3462	4671	8478	1842	65.2	72.8	97.9	99.5
6	13593	3797	5054	8664	1851	71.5	78.8	100.0	100.0
7	13812	4083	5292	8621	1778	76.9	82.5	99.5	96.0
8	14067	4358	5549	8331	1657	82.1	86.5	96.2	89.5
8.2	14094	4423	5606	8309	1627	83.3	87.4	95.9	87.9
9	14198	4594	5767	8103	1477	86.5	89.9	93.5	79.8
10	14319	4761	5994	7374	1064	89.7	93.5	85.1	57.5
11	14431	4891	6149	6407	591	92.1	95.9	74.0	31.9
12	14538	5038	6270	5985	518	94.9	97.8	69.1	28.0
13	14639	5152	6344	5469	457	97.0	98.9	63.1	24.7
14	14741	5240	6389	5237	464	98.7	99.6	60.5	25.1
15	14838	5309	6413	4970	471	100.0	100.0	57.4	25.4

Table F-5. Weighted usable area (WUA) versus discharge relationships for Chinook salmon at Big Timber Creek, Study Site 2.

Discharge (cfs)	Total (ft^2)/ 1,000 ft	WUA (ft^2)/1,000 ft Spawning	Adult	Juvenile	Juvenile cover	Percent of optimal habitat Spawning	Adult	Juvenile	Juvenile cover
2	11891	1437	3310	3957	1047	27.1	51.6	93.4	100.0
3	12300	2257	3774	4168	1041	42.5	58.8	98.4	99.4
4	12629	2964	4315	4237	994	55.8	67.3	100.0	94.9
5	13036	3419	4643	4229	933	64.4	72.4	99.8	89.1
5.9	13082	3462	4671	4226	925	65.2	72.8	99.7	88.3
6	13593	3797	5054	4177	899	71.5	78.8	98.6	85.8
7	13812	4083	5292	4072	828	76.9	82.5	96.1	79.1
8	14067	4358	5549	3930	750	82.1	86.5	92.7	71.6
8.2	14094	4423	5606	3899	732	83.3	87.4	92.0	69.9
9	14198	4594	5767	3776	669	86.5	89.9	89.1	63.9
10	14319	4761	5994	3564	592	89.7	93.5	84.1	56.5
11	14431	4891	6149	3422	530	92.1	95.9	80.8	50.6
12	14538	5038	6270	3217	436	94.9	97.8	75.9	41.7
13	14639	5152	6344	3002	312	97.0	98.9	70.9	29.8
14	14741	5240	6389	2832	307	98.7	99.6	66.8	29.3
15	14838	5309	6413	2755	280	100.0	100.0	65.0	26.7

Table F-6. Weighted usable area (WUA) versus discharge relationships for bull trout at Big Timber Creek, Study Site 2.

Discharge (cfs)	Total (ft^2)/ 1,000 ft	WUA (ft^2)/1,000 ft Spawning	Adult	Juvenile	Juvenile cover	Percent of optimal habitat Spawning	Adult	Juvenile	Juvenile cover
2	11891	170	2000	2689	1228	12.9	67.5	67.5	96.1
3	12300	263	2587	3478	1278	19.9	87.3	87.3	100.0
4	12629	447	2881	3873	1272	33.9	97.3	97.3	99.6
5	13036	561	2954	3971	1245	42.5	99.7	99.7	97.4
5.9	13082	571	2956	3973	1241	43.3	99.8	99.8	97.1
6	13593	677	2962	3982	1189	51.3	100.0	100.0	93.0
7	13812	744	2950	3965	1115	56.4	99.6	99.6	87.3
8	14067	870	2848	3828	1009	66.0	96.1	96.1	79.0
8.2	14094	904	2835	3810	982	68.5	95.7	95.7	76.9
9	14198	997	2711	3644	792	75.6	91.5	91.5	62.0
10	14319	1083	2450	3294	549	82.1	82.7	82.7	43.0
11	14431	1138	2031	2730	239	86.3	68.6	68.6	18.7
12	14538	1188	1852	2490	181	90.1	62.5	62.5	14.2
13	14639	1231	1735	2332	182	93.4	58.6	58.6	14.2
14	14741	1278	1769	2378	244	96.9	59.7	59.7	19.1
15	14838	1319	1685	2265	258	100.0	56.9	56.9	20.2

Reach 3 (Study Site 3):

Table F-7. Weighted usable area (WUA) versus discharge relationships for steelhead at Big Timber Creek, Study Site 3.

Discharge (cfs)	Total (ft^2)/ 1,000 ft	WUA (ft^2)/1,000 ft Spawning	Adult	Juvenile	Juvenile cover	Percent of optimal habitat Spawning	Adult	Juvenile	Juvenile cover
2	12326	544	4295	6889	2969	7.4	64.4	74.9	76.1
3	12582	1715	4723	8026	3476	23.2	70.8	87.3	89.1
4	12890	2959	5188	8545	3654	40.0	77.7	92.9	93.7
5	13146	4005	5464	8926	3811	54.2	81.9	97.0	97.7
6	13287	4649	5659	9146	3900	62.9	84.8	99.4	100.0
7	13405	5221	5867	9198	3884	70.6	87.9	100.0	99.6
8	13538	5529	6070	9124	3804	74.8	91.0	99.2	97.5
9	13655	5809	6201	8989	3731	78.6	92.9	97.7	95.7
10	13772	6045	6308	8692	3593	81.8	94.5	94.5	92.1
11	13878	6310	6462	8281	3394	85.4	96.8	90.0	87.0
12	13977	6472	6556	7582	3048	87.5	98.2	82.4	78.1
13	14070	6588	6616	6432	2649	89.1	99.1	69.9	67.9
14	14159	6771	6647	5768	2566	91.6	99.6	62.7	65.8
15	14243	6953	6657	5263	2449	94.1	99.7	57.2	62.8
15.8	14304	7090	6669	4902	2415	95.9	99.9	53.3	61.9
16	14322	7121	6674	4736	2408	96.3	100.0	51.5	61.7
17	14398	7209	6666	4383	2360	97.5	99.9	47.7	60.5
18	14470	7284	6668	4004	2292	98.5	99.9	43.5	58.8
19	14691	7349	6639	3715	2159	99.4	99.5	40.4	55.4
20	14758	7381	6591	3349	2032	99.8	98.8	36.4	52.1
21	14822	7393	6528	3223	1938	100.0	97.8	35.0	49.7
22	14883	7389	6452	2962	1722	100.0	96.7	32.2	44.1
23	14943	7358	6383	2770	1580	99.5	95.6	30.1	40.5
24	14999	7293	6280	2631	1460	98.7	94.1	28.6	37.4
25	15062	7142	6113	2523	1386	96.6	91.6	27.4	35.5
26	15115	6853	5882	2340	1274	92.7	88.1	25.4	32.7
27	15166	6723	5773	2167	1243	90.9	86.5	23.6	31.9
28	15202	6536	5637	2080	1186	88.4	84.5	22.6	30.4
29	15238	6373	5490	1977	1089	86.2	82.3	21.5	27.9
30	15272	6180	5316	1922	1076	83.6	79.6	20.9	27.6

Table F-8. Weighted usable area (WUA) versus discharge relationships for Chinook salmon at Big Timber Creek, Study Site 3.

Discharge (cfs)	Total (ft^2)/ 1,000 ft	WUA (ft^2)/1,000 ft Spawning	Adult	Juvenile	Juvenile cover	Percent of optimal habitat Spawning	Adult	Juvenile	Juvenile cover
2	12326	544	4295	5195	2150	7.4	64.4	95.8	91.5
3	12582	1715	4723	5364	2286	23.2	70.8	98.9	97.3
4	12890	2959	5188	5424	2350	40.0	77.7	100.0	100.0
5	13146	4005	5464	5382	2305	54.2	81.9	99.2	98.1
6	13287	4649	5659	5243	2222	62.9	84.8	96.7	94.5
7	13405	5221	5867	5056	2177	70.6	87.9	93.2	92.6
8	13538	5529	6070	4845	2152	74.8	91.0	89.3	91.6
9	13655	5809	6201	4634	2067	78.6	92.9	85.4	88.0
10	13772	6045	6308	4396	1954	81.8	94.5	81.0	83.2
11	13878	6310	6462	4155	1841	85.4	96.8	76.6	78.3
12	13977	6472	6556	3906	1713	87.5	98.2	72.0	72.9
13	14070	6588	6616	3655	1590	89.1	99.1	67.4	67.7
14	14159	6771	6647	3347	1409	91.6	99.6	61.7	59.9
15	14243	6953	6657	3048	1220	94.1	99.7	56.2	51.9
15.8	14304	7090	6669	2770	1116	95.9	99.9	51.1	47.5
16	14322	7121	6674	2697	1088	96.3	100.0	49.7	46.3
17	14398	7209	6666	2472	1014	97.5	99.9	45.6	43.1
18	14470	7284	6668	2293	964	98.5	99.9	42.3	41.0
19	14691	7349	6639	2059	915	99.4	99.5	38.0	38.9
20	14758	7381	6591	1973	862	99.8	98.8	36.4	36.7
21	14822	7393	6528	1877	817	100.0	97.8	34.6	34.8
22	14883	7389	6452	1741	762	100.0	96.7	32.1	32.4
23	14943	7358	6383	1572	715	99.5	95.6	29.0	30.4
24	14999	7293	6280	1487	695	98.7	94.1	27.4	29.6
25	15062	7142	6113	1442	672	96.6	91.6	26.6	28.6
26	15115	6853	5882	1360	613	92.7	88.1	25.1	26.1
27	15166	6723	5773	1292	578	90.9	86.5	23.8	24.6
28	15202	6536	5637	1242	573	88.4	84.5	22.9	24.4
29	15238	6373	5490	1209	555	86.2	82.3	22.3	23.6
30	15272	6180	5316	1152	514	83.6	79.6	21.2	21.9

Table F-9. Weighted usable area (WUA) versus discharge relationships for bull trout at Big Timber Creek, Study Site 3.

Discharge (cfs)	Total (ft^2)/ 1,000 ft	WUA (ft^2)/1,000 ft Spawning	Adult	Juvenile	Juvenile cover	Percent of optimal habitat Spawning	Adult	Juvenile	Juvenile cover
2	12326	497	4142	5525	2544	11.3	92.8	92.9	94.8
3	12582	1090	4313	5750	2625	24.8	96.6	96.7	97.8
4	12890	1750	4442	5920	2681	39.8	99.5	99.6	99.9
5	13146	2309	4459	5940	2685	52.5	99.9	99.9	100.0
6	13287	2710	4464	5944	2637	61.6	100.0	100.0	98.2
7	13405	3033	4417	5877	2559	69.0	98.9	98.9	95.3
8	13538	3264	4352	5787	2526	74.2	97.5	97.4	94.1
9	13655	3472	4150	5515	2418	79.0	93.0	92.8	90.1
10	13772	3645	3958	5254	2230	82.9	88.7	88.4	83.1
11	13878	3928	3809	5052	2117	89.3	85.3	85.0	78.8
12	13977	4147	3504	4640	1827	94.3	78.5	78.1	68.1
13	14070	4283	3116	4116	1487	97.4	69.8	69.2	55.4
14	14159	4377	2819	3716	1273	99.5	63.1	62.5	47.4
15	14243	4397	2641	3475	1162	100.0	59.2	58.5	43.3
15.8	14304	4383	2452	3221	995	99.7	54.9	54.2	37.1
16	14322	4376	2390	3138	980	99.5	53.5	52.8	36.5
17	14398	4298	2206	2889	854	97.7	49.4	48.6	31.8
18	14470	4197	2051	2680	807	95.4	45.9	45.1	30.1
19	14691	4079	1775	2310	748	92.7	39.8	38.9	27.9
20	14758	3925	1347	1738	589	89.3	30.2	29.2	21.9
21	14822	3805	1238	1593	545	86.5	27.7	26.8	20.3
22	14883	3665	1121	1436	431	83.3	25.1	24.2	16.1
23	14943	3497	1045	1333	384	79.5	23.4	22.4	14.3
24	14999	3368	923	1168	304	76.6	20.7	19.7	11.3
25	15062	3217	806	1011	307	73.2	18.1	17.0	11.4
26	15115	3074	783	979	306	69.9	17.5	16.5	11.4
27	15166	2881	746	928	304	65.5	16.7	15.6	11.3
28	15202	2737	684	847	300	62.2	15.3	14.2	11.2
29	15238	2500	674	833	296	56.8	15.1	14.0	11.0
30	15272	2322	663	817	291	52.8	14.8	13.7	10.8

Reach 4 (Study Site 4):

Table F-10. Weighted usable area (WUA) versus discharge relationships for steelhead at Big Timber Creek, Study Site 4.

Discharge (cfs)	Total (ft^2)/ 1,000 ft	WUA (ft^2)/1,000 ft Spawning	Adult	Juvenile	Juvenile cover	Percent of optimal habitat Spawning	Adult	Juvenile	Juvenile cover
2	11551	628	3633	5662	707	9.1	43.2	61.4	59.3
3	12888	1208	4074	6851	822	17.5	48.5	74.3	68.9
4	13889	1928	4522	7785	896	28.0	53.8	84.5	75.1
5	14144	2517	4898	8371	986	36.5	58.3	90.8	82.7
6	14295	3243	5380	8615	1054	47.0	64.0	93.5	88.4
7	14403	3775	5759	8750	1104	54.7	68.5	94.9	92.6
8	14542	4205	6235	8629	1122	61.0	74.2	93.6	94.1
9	14633	4604	6542	8787	1134	66.8	77.8	95.3	95.2
10	14754	4965	6841	9014	1160	72.0	81.4	97.8	97.4
11	14853	5249	7048	9213	1188	76.1	83.8	100.0	99.7
12	14899	5400	7148	9217	1192	78.3	85.0	100.0	100.0
13	14974	5643	7310	9205	1189	81.9	87.0	99.9	99.8
14	15144	5825	7469	9079	1141	84.5	88.9	98.5	95.8
15	15229	5969	7637	8819	1154	86.6	90.9	95.7	96.8
16	15314	6113	7767	8633	1162	88.7	92.4	93.7	97.5
17	15501	6242	7898	8579	1164	90.5	94.0	93.1	97.7
18	15686	6355	7995	8550	1151	92.2	95.1	92.8	96.6
19	15862	6452	8075	8392	1097	93.6	96.1	91.1	92.1
20	16036	6551	8145	8328	1101	95.0	96.9	90.3	92.4
21	16205	6652	8203	8253	1098	96.5	97.6	89.5	92.1
22	16372	6717	8253	8145	1060	97.4	98.2	88.4	88.9
23	16532	6768	8304	8114	1065	98.2	98.8	88.0	89.4
24	16698	6813	8343	8104	1070	98.8	99.3	87.9	89.8
25	16849	6845	8383	8033	1075	99.3	99.7	87.2	90.2
26	17008	6873	8400	7855	1079	99.7	99.9	85.2	90.5
27	17164	6890	8405	7630	1081	99.9	100.0	82.8	90.7
28	17325	6895	8402	7267	1084	100.0	100.0	78.8	90.9
29	17478	6884	8383	7208	1086	99.8	99.7	78.2	91.1
30	17625	6825	8322	7173	1088	99.0	99.0	77.8	91.3

Table F-11. Weighted usable area (WUA) versus discharge relationships for Chinook salmon at Big Timber Creek, Study Site 4.

Discharge (cfs)	Total (ft^2)/ 1,000 ft	WUA (ft^2)/1,000 ft Spawning	Adult	Juvenile	Juvenile cover	Percent of optimal habitat Spawning	Adult	Juvenile	Juvenile cover
2	11551	628	3633	4265	761	9.1	43.2	77.9	91.5
3	12888	1208	4074	4774	796	17.5	48.5	87.2	95.8
4	13889	1928	4522	5137	815	28.0	53.8	93.8	98.0
5	14144	2517	4898	5303	824	36.5	58.3	96.9	99.1
6	14295	3243	5380	5407	826	47.0	64.0	98.8	99.4
7	14403	3775	5759	5402	819	54.7	68.5	98.7	98.5
8	14542	4205	6235	5475	816	61.0	74.2	100.0	98.2
9	14633	4604	6542	5371	803	66.8	77.8	98.1	96.7
10	14754	4965	6841	5400	830	72.0	81.4	98.6	99.8
11	14853	5249	7048	5288	831	76.1	83.8	96.6	100.0
12	14899	5400	7148	5173	815	78.3	85.0	94.5	98.1
13	14974	5643	7310	5120	811	81.9	87.0	93.5	97.6
14	15144	5825	7469	5073	808	84.5	88.9	92.7	97.2
15	15229	5969	7637	5021	801	86.6	90.9	91.7	96.4
16	15314	6113	7767	4965	799	88.7	92.4	90.7	96.1
17	15501	6242	7898	4914	778	90.5	94.0	89.8	93.6
18	15686	6355	7995	4878	762	92.2	95.1	89.1	91.7
19	15862	6452	8075	4816	758	93.6	96.1	88.0	91.2
20	16036	6551	8145	4685	751	95.0	96.9	85.6	90.3
21	16205	6652	8203	4610	747	96.5	97.6	84.2	89.8
22	16372	6717	8253	4586	744	97.4	98.2	83.8	89.5
23	16532	6768	8304	4554	742	98.2	98.8	83.2	89.3
24	16698	6813	8343	4512	733	98.8	99.3	82.4	88.2
25	16849	6845	8383	4477	740	99.3	99.7	81.8	89.0
26	17008	6873	8400	4405	721	99.7	99.9	80.5	86.7
27	17164	6890	8405	4375	722	99.9	100.0	79.9	86.9
28	17325	6895	8402	4362	723	100.0	100.0	79.7	87.0
29	17478	6884	8383	4350	722	99.8	99.7	79.4	86.9
30	17625	6825	8322	4336	721	99.0	99.0	79.2	86.7

Table F-12. Weighted usable area (WUA) versus discharge relationships for bull trout at Big Timber Creek, Study Site 4.

Discharge (cfs)	Total (ft^2)/ 1,000 ft	WUA (ft^2)/1,000 ft Spawning	Adult	Juvenile	Juvenile cover	Percent of optimal habitat Spawning	Adult	Juvenile	Juvenile cover
2	11551	525	3053	3956	948	13.1	55.2	56.8	79.9
3	12888	872	3415	4420	1002	21.8	61.8	63.5	84.5
4	13889	1188	3732	4825	1035	29.7	67.5	69.3	87.2
5	14144	1522	3933	5076	1059	38.0	71.1	72.9	89.2
6	14295	1811	4099	5278	1075	45.2	74.1	75.9	90.6
7	14403	2105	4192	5387	1094	52.6	75.8	77.4	92.2
8	14542	2417	4401	5645	1113	60.4	79.6	81.1	93.8
9	14633	2635	4525	5802	1116	65.8	81.8	83.4	94.1
10	14754	2903	4670	5975	1129	72.5	84.4	85.9	95.1
11	14853	3056	4965	6351	1133	76.3	89.8	91.3	95.5
12	14899	3194	5066	6480	1124	79.7	91.6	93.1	94.8
13	14974	3333	5207	6654	1124	83.2	94.2	95.6	94.7
14	15144	3433	5332	6808	1122	85.7	96.4	97.8	94.6
15	15229	3524	5380	6860	1119	88.0	97.3	98.6	94.3
16	15314	3600	5414	6892	1166	89.9	97.9	99.0	98.2
17	15501	3669	5444	6919	1179	91.6	98.4	99.4	99.4
18	15686	3726	5450	6913	1185	93.0	98.5	99.4	99.9
19	15862	3791	5456	6910	1187	94.7	98.7	99.3	100.0
20	16036	3838	5494	6948	1185	95.8	99.3	99.9	99.9
21	16205	3880	5469	6905	1182	96.9	98.9	99.2	99.6
22	16372	3908	5509	6947	1174	97.6	99.6	99.8	99.0
23	16532	3931	5524	6958	1162	98.2	99.9	100.0	97.9
24	16698	3948	5530	6958	1141	98.6	100.0	100.0	96.2
25	16849	3962	5511	6925	1108	98.9	99.6	99.5	93.4
26	17008	3976	5523	6928	1104	99.3	99.9	99.6	93.0
27	17164	3988	5522	6914	1098	99.6	99.9	99.4	92.5
28	17325	3997	5522	6902	1091	99.8	99.9	99.2	92.0
29	17478	4003	5529	6900	1103	100.0	100.0	99.2	92.9
30	17625	4005	5509	6865	1094	100.0	99.6	98.7	92.2

Reach 5 (Study Site 5):

Table F-13. Weighted usable area (WUA) versus discharge relationships for steelhead at Big Timber Creek, Study Site 5.

Discharge (cfs)	Total (ft^2)/ 1,000 ft	WUA (ft^2)/1,000 ft Spawning	Adult	Juvenile	Juvenile cover	Percent of optimal habitat Spawning	Adult	Juvenile	Juvenile cover
2	19398	0	3938	7989	409	0.0	36.8	59.3	48.5
4	21895	946	4866	11021	463	17.7	45.5	81.8	54.9
6	23157	1692	5526	12226	499	31.7	51.7	90.7	59.2
8	24144	2428	6213	12922	530	45.5	58.1	95.9	62.9
10	25019	2977	6697	13334	560	55.8	62.6	99.0	66.4
12	25578	3494	7948	13473	584	65.5	74.3	100.0	69.3
14	26020	3821	8455	13126	602	71.6	79.1	97.4	71.5
15	26752	3930	8635	12733	606	73.6	80.7	94.5	71.9
16	26875	4043	9122	12342	642	75.7	85.3	91.6	76.1
18	27107	4259	9522	11022	676	79.8	89.0	81.8	80.2
20	27326	4420	9787	9213	699	82.8	91.5	68.4	83.0
22	27462	4631	10037	8488	716	86.7	93.8	63.0	84.9
24	27545	4805	10211	7403	727	90.0	95.5	54.9	86.3
25	27586	4928	10307	6948	729	92.3	96.4	51.6	86.5
26	27627	5010	10366	6379	735	93.9	96.9	47.3	87.3
28	27706	5125	10438	5912	746	96.0	97.6	43.9	88.5
30	27737	5155	10634	5383	743	96.6	99.4	40.0	88.2
32	27809	5214	10674	5004	721	97.7	99.8	37.1	85.5
34	27881	5259	10673	4842	609	98.5	99.8	35.9	72.3
36	27953	5272	10695	4689	634	98.8	100.0	34.8	75.3
38	28024	5311	10667	4533	658	99.5	99.7	33.6	78.1
40	28103	5330	10583	4419	681	99.9	99.0	32.8	80.8
42	28183	5338	10442	4398	696	100.0	97.6	32.6	82.6
44	28262	5323	10163	4356	713	99.7	95.0	32.3	84.6
46	28341	5264	10006	4183	739	98.6	93.6	31.1	87.7
48	28420	5146	9823	4153	768	96.4	91.9	30.8	91.2
50	28497	5169	9629	4038	795	96.8	90.0	30.0	94.3
52	28548	5214	9505	4026	819	97.7	88.9	29.9	97.2
54	28598	5214	9206	3994	843	97.7	86.1	29.6	100.0

Table F-14. Weighted usable area (WUA) versus discharge relationships for Chinook salmon at Big Timber Creek, Study Site 5.

Discharge (cfs)	Total (ft^2)/ 1,000 ft	WUA (ft^2)/1,000 ft Spawning	Adult	Juvenile	Juvenile cover	Percent of optimal habitat Spawning	Adult	Juvenile	Juvenile cover
2	19398	0	3938	6126	373	0.0	36.8	84.5	57.7
4	21895	946	4866	6960	460	17.7	45.5	96.0	71.2
6	23157	1692	5526	7238	480	31.7	51.7	99.9	74.3
8	24144	2428	6213	7248	487	45.5	58.1	100.0	75.4
10	25019	2977	6697	7065	490	55.8	62.6	97.5	75.8
12	25578	3494	7948	6817	490	65.5	74.3	94.1	75.8
14	26020	3821	8455	6475	487	71.6	79.1	89.3	75.4
15	26752	3930	8635	6258	482	73.6	80.7	86.3	74.7
16	26875	4043	9122	6144	480	75.7	85.3	84.8	74.4
18	27107	4259	9522	5794	477	79.8	89.0	79.9	73.8
20	27326	4420	9787	5431	473	82.8	91.5	74.9	73.2
22	27462	4631	10037	5010	470	86.7	93.8	69.1	72.7
24	27545	4805	10211	4593	467	90.0	95.5	63.4	72.3
25	27586	4928	10307	4441	468	92.3	96.4	61.3	72.5
26	27627	5010	10366	4261	470	93.9	96.9	58.8	72.7
28	27706	5125	10438	3866	470	96.0	97.6	53.3	72.7
30	27737	5155	10634	3483	459	96.6	99.4	48.1	71.0
32	27809	5214	10674	3258	458	97.7	99.8	44.9	70.9
34	27881	5259	10673	3082	457	98.5	99.8	42.5	70.8
36	27953	5272	10695	2888	453	98.8	100.0	39.8	70.2
38	28024	5311	10667	2769	477	99.5	99.7	38.2	73.8
40	28103	5330	10583	2700	484	99.9	99.0	37.2	74.9
42	28183	5338	10442	2654	464	100.0	97.6	36.6	71.7
44	28262	5323	10163	2568	452	99.7	95.0	35.4	70.0
46	28341	5264	10006	2481	548	98.6	93.6	34.2	84.8
48	28420	5146	9823	2471	581	96.4	91.9	34.1	90.0
50	28497	5169	9629	2471	606	96.8	90.0	34.1	93.9
52	28548	5214	9505	2423	628	97.7	88.9	33.4	97.1
54	28598	5214	9206	2408	646	97.7	86.1	33.2	100.0

Table F-15. Weighted usable area (WUA) versus discharge relationships for bull trout at Big Timber Creek, Study Site 5.

Discharge (cfs)	Total (ft^2)/ 1,000 ft	WUA (ft^2)/1,000 ft Spawning	Adult	Juvenile	Juvenile cover	Percent of optimal habitat Spawning	Adult	Juvenile	Juvenile cover
2	19398	503	3610	4790	494	14.7	79.1	80.3	71.0
4	21895	991	4104	5427	519	29.0	89.9	90.9	74.7
6	23157	1436	4323	5702	529	42.0	94.7	95.6	76.2
8	24144	1803	4431	5834	558	52.7	97.1	97.8	80.3
10	25019	2085	4528	5948	633	60.9	99.2	99.7	91.0
12	25578	2395	4530	5937	657	70.0	99.3	99.5	94.5
14	26020	2612	4563	5967	672	76.4	100.0	100.0	96.7
15	26752	2699	4507	5894	672	78.9	98.8	98.8	96.7
16	26875	2823	4534	5926	677	82.5	99.4	99.3	97.4
18	27107	2981	4428	5775	684	87.1	97.1	96.8	98.4
20	27326	3066	4264	5548	689	89.6	93.5	93.0	99.1
22	27462	3179	4035	5238	692	92.9	88.4	87.8	99.5
24	27545	3247	3848	4990	694	94.9	84.3	83.6	99.8
25	27586	3321	3764	4877	695	97.1	82.5	81.7	99.9
26	27627	3365	3656	4734	695	98.3	80.1	79.3	100.0
28	27706	3421	3342	4326	695	100.0	73.3	72.5	100.0
30	27737	3355	2914	3769	686	98.1	63.9	63.2	98.7
32	27809	3286	2765	3577	684	96.0	60.6	59.9	98.3
34	27881	3252	2653	3436	680	95.1	58.2	57.6	97.8
36	27953	3204	2583	3336	674	93.6	56.6	55.9	96.9
38	28024	3083	2483	3196	666	90.1	54.4	53.6	95.8
40	28103	3034	2285	2928	656	88.7	50.1	49.1	94.4
42	28183	2975	2107	2689	644	86.9	46.2	45.1	92.6
44	28262	2881	1965	2507	626	84.2	43.1	42.0	90.0
46	28341	2789	1933	2462	595	81.5	42.4	41.3	85.6
48	28420	2718	1844	2344	502	79.4	40.4	39.3	72.2
50	28497	2661	1821	2316	516	77.8	39.9	38.8	74.2
52	28548	2598	1816	2305	536	75.9	39.8	38.6	77.2
54	28598	2522	1777	2250	548	73.7	39.0	37.7	78.9

Reach 6 (Study Site 6):

Table F-16. Weighted usable area (WUA) versus discharge relationships for steelhead at Big Timber Creek, Study Site 6.

Discharge (cfs)	Total (ft^2)/ 1,000 ft	WUA (ft^2)/1,000 ft				Percent of optimal habitat			
		Spawning	Adult	Juvenile	Juvenile cover	Spawning	Adult	Juvenile	Juvenile cover
3	17400	1222	5849	9188	1801	16.7	48.1	64.6	61.4
5	19218	2216	6836	11359	2142	30.3	56.2	79.9	73.0
7	19912	3122	7925	13038	2534	42.7	65.1	91.7	86.4
9	20346	3910	9124	13805	2705	53.5	75.0	97.1	92.2
11	20659	4466	9766	14198	2843	61.0	80.2	99.8	96.9
13.9	20945	5398	10411	14222	2910	73.8	85.5	100.0	99.2
15	21023	5592	10591	14197	2933	76.4	87.0	99.8	100.0
19	21358	6228	11254	13564	2887	85.1	92.5	95.4	98.4
19.9	21411	6324	11393	13248	2828	86.5	93.6	93.1	96.4
21	21456	6428	11515	12984	2750	87.9	94.6	91.3	93.8
23	21525	6593	11711	12380	2539	90.1	96.2	87.0	86.6
25	21589	6728	11852	11925	2481	92.0	97.4	83.9	84.6
27	21649	6848	11972	11452	2424	93.6	98.4	80.5	82.7
31	21760	7110	12139	10606	2138	97.2	99.7	74.6	72.9
31.5	21773	7129	12142	10488	2106	97.5	99.8	73.7	71.8
33	21812	7177	12165	10326	2060	98.1	99.9	72.6	70.2
35	21861	7255	12172	9818	1930	99.2	100.0	69.0	65.8
37	21909	7295	12125	9686	1910	99.7	99.6	68.1	65.1
39	21955	7315	12077	9479	1879	100.0	99.2	66.6	64.1
41	21998	7278	11986	9131	1828	99.5	98.5	64.2	62.3
43	22041	7196	11870	8626	1693	98.4	97.5	60.7	57.7
45	22082	7164	11775	8353	1646	97.9	96.7	58.7	56.1
47	22121	7090	11676	7790	1482	96.9	95.9	54.8	50.5
49	22160	7074	11566	7244	1411	96.7	95.0	50.9	48.1
51	22206	6946	11327	6919	1406	95.0	93.1	48.6	47.9
53	22252	6884	11214	6752	1316	94.1	92.1	47.5	44.9
55	22295	6783	11083	6756	1350	92.7	91.1	47.5	46.0
57	22337	6552	10829	6760	1388	89.6	89.0	47.5	47.3
59	22378	6415	10653	6750	1423	87.7	87.5	47.5	48.5

Table F-17. Weighted usable area (WUA) versus discharge relationships for Chinook salmon at Big Timber Creek, Study Site 6.

	Total	WUA (ft^2)/1,000 ft				Percent of optimal habitat			
Discharge (cfs)	(ft^2)/ 1,000 ft	Spawning	Adult	Juvenile	Juvenile cover	Spawning	Adult	Juvenile	Juvenile cover
3	17400	1222	5849	6808	1223	16.7	48.1	79.7	72.9
5	19218	2216	6836	7760	1275	30.3	56.2	90.8	76.0
7	19912	3122	7925	8228	1425	42.7	65.1	96.3	84.9
9	20346	3910	9124	8481	1644	53.5	75.0	99.2	98.0
11	20659	4466	9766	8545	1677	61.0	80.2	100.0	100.0
13.9	20945	5398	10411	8448	1649	73.8	85.5	98.9	98.3
15	21023	5592	10591	8336	1624	76.4	87.0	97.6	96.8
19	21358	6228	11254	7916	1615	85.1	92.5	92.6	96.3
19.9	21411	6324	11393	7828	1600	86.5	93.6	91.6	95.4
21	21456	6428	11515	7727	1575	87.9	94.6	90.4	93.9
23	21525	6593	11711	7534	1546	90.1	96.2	88.2	92.2
25	21589	6728	11852	7241	1502	92.0	97.4	84.7	89.6
27	21649	6848	11972	6969	1441	93.6	98.4	81.6	85.9
31	21760	7110	12139	6563	1378	97.2	99.7	76.8	82.1
31.5	21773	7129	12142	6510	1371	97.5	99.8	76.2	81.8
33	21812	7177	12165	6239	1347	98.1	99.9	73.0	80.3
35	21861	7255	12172	6096	1322	99.2	100.0	71.3	78.8
37	21909	7295	12125	5925	1279	99.7	99.6	69.3	76.3
39	21955	7315	12077	5756	1226	100.0	99.2	67.4	73.1
41	21998	7278	11986	5564	1174	99.5	98.5	65.1	70.0
43	22041	7196	11870	5372	1133	98.4	97.5	62.9	67.6
45	22082	7164	11775	5272	1115	97.9	96.7	61.7	66.5
47	22121	7090	11676	5205	1107	96.9	95.9	60.9	66.0
49	22160	7074	11566	5078	1081	96.7	95.0	59.4	64.5
51	22206	6946	11327	4874	1065	95.0	93.1	57.0	63.5
53	22252	6884	11214	4817	1071	94.1	92.1	56.4	63.9
55	22295	6783	11083	4729	1046	92.7	91.1	55.3	62.4
57	22337	6552	10829	4541	993	89.6	89.0	53.1	59.2
59	22378	6415	10653	4462	1010	87.7	87.5	52.2	60.2

Table F-18. Weighted usable area (WUA) versus discharge relationships for bull trout at Big Timber Creek, Study Site 6.

Discharge (cfs)	Total (ft^2)/ 1,000 ft	WUA (ft^2)/1,000 ft Spawning	Adult	Juvenile	Juvenile cover	Percent of optimal habitat Spawning	Adult	Juvenile	Juvenile cover
3	17400	135	5042	6775	1481	10.9	58.3	59.8	69.4
5	19218	264	6208	8321	1666	21.4	71.8	73.4	78.1
7	19912	389	6751	9020	1722	31.6	78.1	79.6	80.7
9	20346	518	7297	9728	1820	42.0	84.4	85.8	85.3
11	20659	591	7833	10411	1938	48.0	90.6	91.8	90.8
13.9	20945	713	8425	11153	2122	57.8	97.4	98.4	99.5
15	21023	757	8466	11186	2134	61.4	97.9	98.7	100.0
19	21358	875	8643	11335	2088	70.9	99.9	100.0	97.9
19.9	21411	902	8648	11323	2076	73.2	100.0	99.9	97.3
21	21456	933	8625	11268	2053	75.7	99.7	99.4	96.2
23	21525	974	8518	11087	1993	79.0	98.5	97.8	93.4
25	21589	1003	8397	10897	1941	81.4	97.1	96.1	91.0
27	21649	1044	8336	10785	1962	84.7	96.4	95.1	92.0
31	21760	1109	8316	10710	1908	90.0	96.2	94.5	89.4
31.5	21773	1113	8310	10694	1905	90.3	96.1	94.3	89.3
33	21812	1123	8273	10628	1888	91.1	95.7	93.8	88.5
35	21861	1159	8131	10419	1808	94.0	94.0	91.9	84.7
37	21909	1184	8063	10310	1808	96.1	93.2	91.0	84.7
39	21955	1198	7917	10102	1785	97.2	91.5	89.1	83.7
41	21998	1209	7667	9764	1700	98.1	88.6	86.1	79.7
43	22041	1215	7533	9570	1714	98.5	87.1	84.4	80.4
45	22082	1220	7464	9465	1700	99.0	86.3	83.5	79.7
47	22121	1231	7349	9303	1666	99.9	85.0	82.1	78.1
49	22160	1233	7177	9072	1598	100.0	83.0	80.0	74.9
51	22206	1233	6788	8585	1393	100.0	78.5	75.7	65.3
53	22252	1231	6656	8401	1353	99.9	77.0	74.1	63.4
55	22295	1228	6482	8166	1357	99.7	75.0	72.0	63.6
57	22337	1222	6387	8016	1358	99.1	73.9	70.7	63.6
59	22378	1213	6283	7856	1355	98.4	72.7	69.3	63.5

Reach 7 (Reference Site):

Table F-19. Weighted usable area (WUA) versus discharge relationships for steelhead at Big Timber Creek, Reference Site (Study Site 7).

	Total	WUA (ft^2)/1,000 ft				Percent of optimal habitat			
Discharge (cfs)	(ft^2)/ 1,000 ft	Spawning	Adult	Juvenile	Juvenile cover	Spawning	Adult	Juvenile	Juvenile cover
5	19737	2383	7138	12490	817	23.8	54.1	75.7	20.2
10	21993	5898	9412	15300	1382	58.8	71.4	92.7	34.2
15	23080	7335	10831	16498	1794	73.1	82.2	100.0	44.4
17	23364	7678	11254	16475	1959	76.5	85.4	99.9	48.5
20	23620	8058	11747	15806	2184	80.3	89.1	95.8	54.0
25	23937	8630	12462	14574	2747	86.0	94.5	88.3	68.0
27	24036	8819	12679	13567	2963	87.9	96.2	82.2	73.3
30	24246	9073	12922	12038	3189	90.4	98.0	73.0	78.9
35	24729	9561	13133	9941	3464	95.3	99.6	60.3	85.7
40	25145	9833	13182	8846	3662	98.0	100.0	53.6	90.6
45	25933	9974	13096	8372	3849	99.4	99.3	50.7	95.2
47	26013	10008	13040	7933	3914	99.7	98.9	48.1	96.8
50	26096	10033	12901	7482	3972	100.0	97.9	45.3	98.3
55	26236	9840	12555	6948	4026	98.1	95.2	42.1	99.6
60	26367	9396	12184	6517	4041	93.7	92.4	39.5	100.0
65	26489	9276	12071	5897	3794	92.5	91.6	35.7	93.9
70	26605	8997	11704	5781	3862	89.7	88.8	35.0	95.5
75	26709	8583	11299	5616	3900	85.5	85.7	34.0	96.5
80	26805	7802	10609	5488	3865	77.8	80.5	33.3	95.6
85	26896	6889	9740	5288	3932	68.7	73.9	32.0	97.3
90	26980	6514	9347	5319	3977	64.9	70.9	32.2	98.4
95	27053	6020	8783	5286	3968	60.0	66.6	32.0	98.2
100	27109	5406	8160	5138	3863	53.9	61.9	31.1	95.6

Table F-20. Weighted usable area (WUA) versus discharge relationships for Chinook salmon at Big Timber Creek, Reference Site (Study Site 7).

Discharge (cfs)	Total (ft^2)/ 1,000 ft	WUA (ft^2)/1,000 ft Spawning	Adult	Juvenile	Juvenile cover	Percent of optimal habitat Spawning	Adult	Juvenile	Juvenile cover
5	19737	2383	7138	8272	482	23.8	54.1	90.1	21.5
10	21993	5898	9412	9184	700	58.8	71.4	100.0	31.1
15	23080	7335	10831	9045	1085	73.1	82.2	98.5	48.3
17	23364	7678	11254	8873	1227	76.5	85.4	96.6	54.6
20	23620	8058	11747	8462	1411	80.3	89.1	92.1	62.8
25	23937	8630	12462	7647	1658	86.0	94.5	83.3	73.8
27	24036	8819	12679	7247	1708	87.9	96.2	78.9	76.0
30	24246	9073	12922	6866	1758	90.4	98.0	74.8	78.2
35	24729	9561	13133	6059	1810	95.3	99.6	66.0	80.6
40	25145	9833	13182	5363	1854	98.0	100.0	58.4	82.5
45	25933	9974	13096	4846	1878	99.4	99.3	52.8	83.6
47	26013	10008	13040	4617	1875	99.7	98.9	50.3	83.5
50	26096	10033	12901	4521	1866	100.0	97.9	49.2	83.1
55	26236	9840	12555	4357	1930	98.1	95.2	47.4	85.9
60	26367	9396	12184	4061	2087	93.7	92.4	44.2	92.9
65	26489	9276	12071	3907	2214	92.5	91.6	42.5	98.6
70	26605	8997	11704	3785	2245	89.7	88.8	41.2	99.9
75	26709	8583	11299	3639	2247	85.5	85.7	39.6	100.0
80	26805	7802	10609	3486	2191	77.8	80.5	38.0	97.5
85	26896	6889	9740	3454	2220	68.7	73.9	37.6	98.8
90	26980	6514	9347	3352	2208	64.9	70.9	36.5	98.3
95	27053	6020	8783	3263	2153	60.0	66.6	35.5	95.8
100	27109	5406	8160	3166	2132	53.9	61.9	34.5	94.9

Table F-21. Weighted usable area (WUA) versus discharge relationships for bull trout at Big Timber Creek, Reference Site (Study Site 7).

Discharge (cfs)	Total (ft^2)/ 1,000 ft	WUA (ft^2)/1,000 ft Spawning	Adult	Juvenile	Juvenile cover	Percent of optimal habitat Spawning	Adult	Juvenile	Juvenile cover
5	19737	31	5936	7850	409	1.0	67.2	69.1	13.6
10	21993	289	8145	10666	782	9.2	92.3	93.9	26.0
15	23080	832	8677	11257	965	26.4	98.3	99.1	32.1
17	23364	1067	8748	11305	1072	33.9	99.1	99.5	35.7
20	23620	1317	8829	11361	1241	41.8	100.0	100.0	41.3
25	23937	1736	8812	11257	1652	55.1	99.8	99.1	55.0
27	24036	1917	8804	11227	1890	60.9	99.7	98.8	62.9
30	24246	2175	8560	10858	2074	69.0	97.0	95.6	69.1
35	24729	2531	7916	9969	2362	80.3	89.7	87.8	78.6
40	25145	2794	7213	9027	2488	88.7	81.7	79.5	82.8
45	25933	3027	6214	7704	2566	96.1	70.4	67.8	85.4
47	26013	3086	6066	7515	2589	98.0	68.7	66.1	86.2
50	26096	3107	5683	7033	2615	98.6	64.4	61.9	87.0
55	26236	3134	5148	6359	2718	99.5	58.3	56.0	90.5
60	26367	3150	4654	5774	2758	100.0	52.7	50.8	91.8
65	26489	3041	4095	5105	2773	96.5	46.4	44.9	92.3
70	26605	2947	3827	4801	2768	93.6	43.3	42.3	92.2
75	26709	2830	3816	4791	2887	89.9	43.2	42.2	96.1
80	26805	2780	3770	4744	3004	88.3	42.7	41.8	100.0
85	26896	2684	3581	4499	2809	85.2	40.6	39.6	93.5
90	26980	2569	3525	4440	2835	81.5	39.9	39.1	94.4
95	27053	2440	3533	4443	2824	77.5	40.0	39.1	94.0
100	27109	2236	3409	4270	2669	71.0	38.6	37.6	88.9

Comparison with EA Engineering Habitat Modeling Results at Reference Site (Study Site 7)

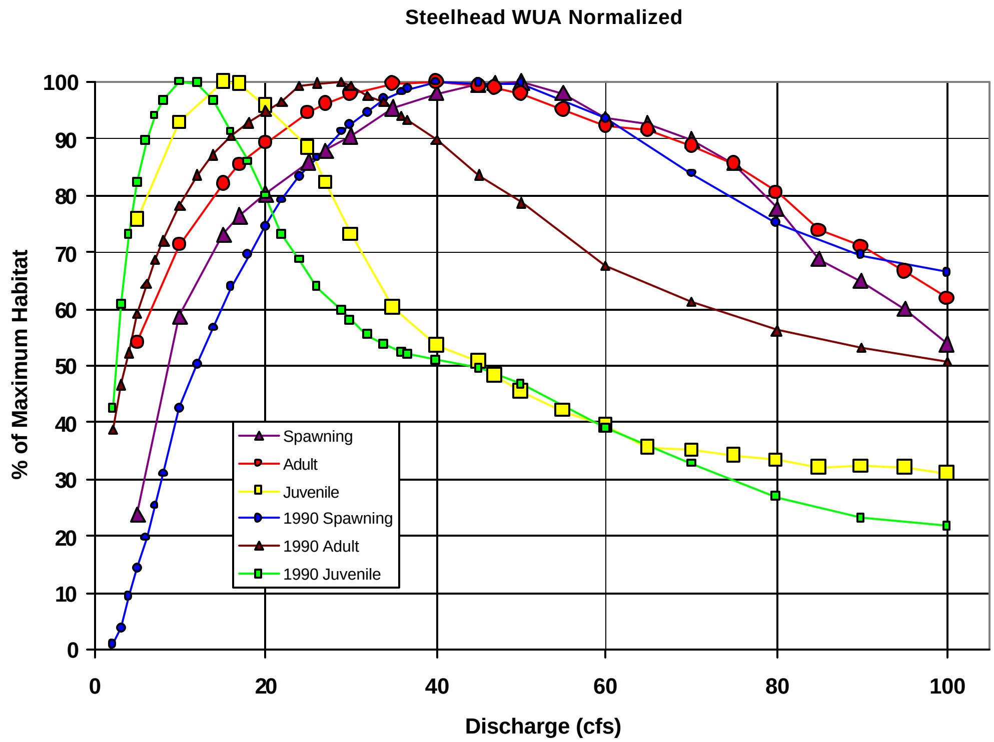


Figure F-1. Habitat versus flow relationships for steelhead in Big Timber Creek upstream from diversions comparing EA Engineering study and Reclamation's study (2003).

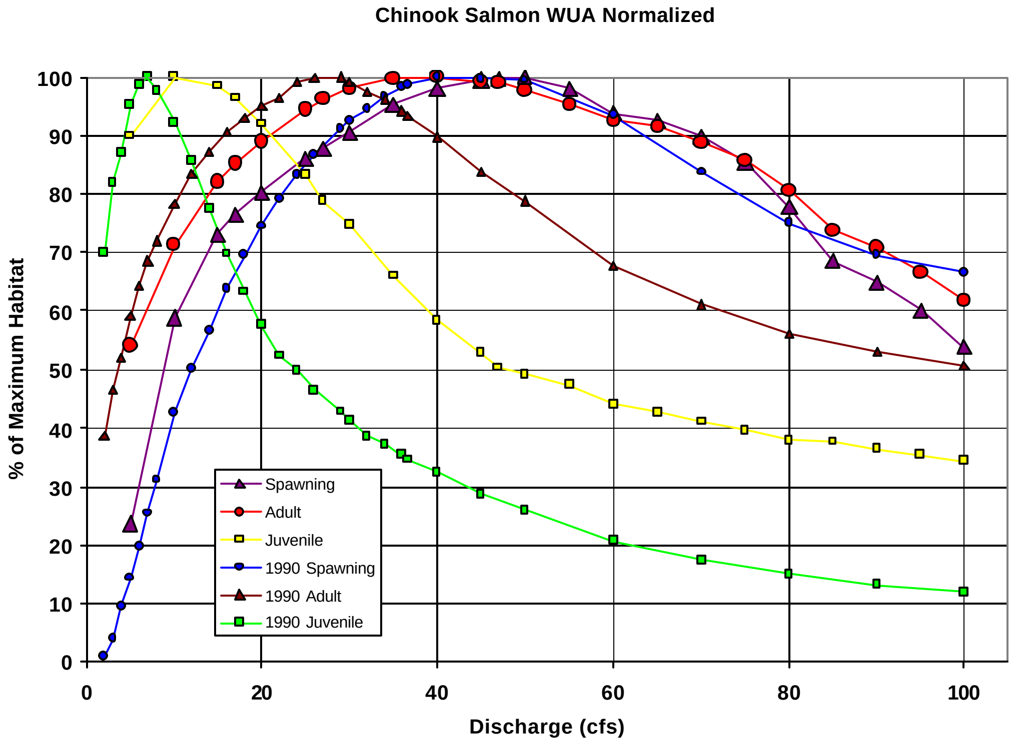


Figure F-2. Habitat versus flow relationships for Chinook salmon in Big Timber Creek upstream from diversions comparing EA Engineering study and Reclamation's study (2003)

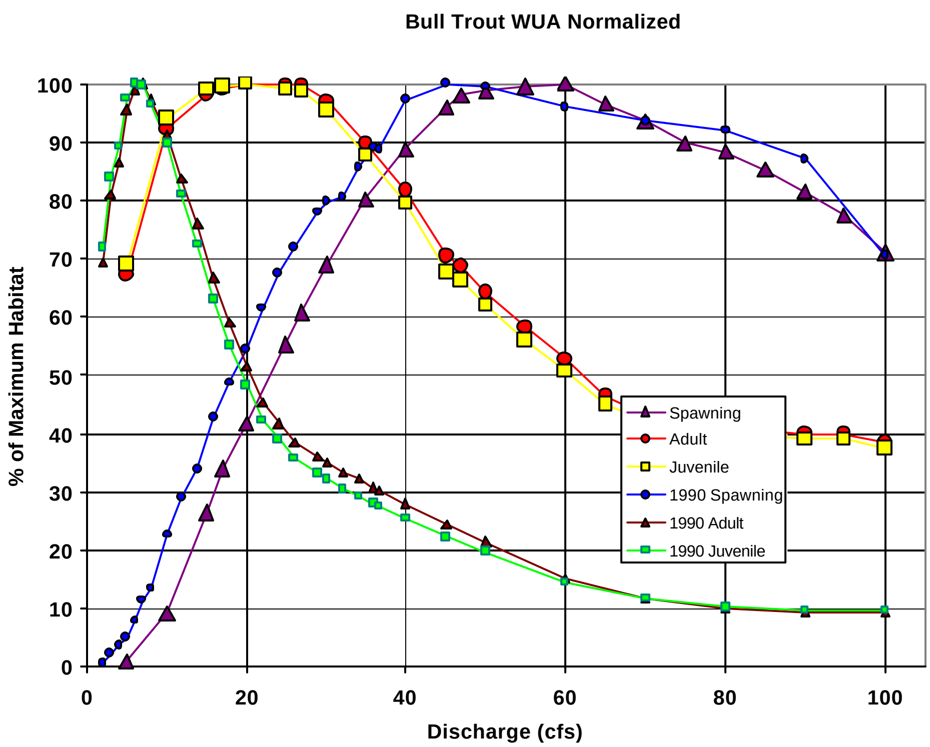


Figure F-3. Habitat versus flow relationships for bull trout in Big Timber Creek upstream from diversions comparing EA Engineering study and Reclamation's study (2003)

Appendix G – IFG4 input files for PHABSIM

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Big Timber Study Site 1 - substrate
Export from PHABSIM for Windows
IOC       0000000100010000100000
QARD   1.4
QARD   2.0
QARD   3.0
QARD   4.0
QARD   5.0
QARD   6.0
QARD   6.5
QARD   7.0
QARD   8.0
QARD   9.0
QARD  10.0
QARD  11.0
QARD  12.0
QARD  13.0
QARD  14.0
QARD  15.0
QARD  16.0
QARD  17.0
QARD  18.0
QARD  19.0
QARD  20.0
XSEC   1.0        0.0 1.0     96.15   0.00083
       1.0  0.0 98.9  1.3 98.0  9.6 97.3 10.4 97.0 11.0 96.8 12.0 96.3
       1.0 13.6 96.3 14.0 96.3 14.5 96.3 15.0 96.3 16.0 96.2 16.5 96.3
       1.0 17.0 96.2 17.5 96.3 18.0 96.3 18.5 96.3 19.0 96.3 22.4 98.7
NS     1.0        1.0       1.0       2.0       2.0       2.0       4.0
NS     1.0        4.0       5.0       4.0       4.0       6.0       4.0
NS     1.0        4.0       4.0       3.0       2.0       2.0       1.0
WSL    1.0       97.1      97.2      97.2      97.3      97.3      97.3
WSL    1.0       97.3      97.4      97.4      97.4      97.4      97.4
WSL    1.0       97.5      97.5      97.5      97.5      97.5      97.5
WSL    1.0       97.5      97.5      97.5
CAL1   1.0      97.13      1.40      0.99
VEL1   1.0                 0.05 0.03 0.01 0.03 0.04 0.16 0.33 0.28 0.28
VEL1   1.0 0.37 0.29 0.10 0.01 0.01
CAL2   1.0      97.35      6.50      6.90
VEL2   1.0                 0.02 0.01 0.01 0.77 1.29 1.29 1.03 1.05 1.04
VEL2   1.0 1.09 1.15 0.87 0.31 0.06
XSEC   2.0       55.0 1.0     96.70   0.00280
       2.0  0.0 98.8  1.6 98.4  1.8 97.7  3.5 97.3  4.6 97.1  5.1 97.0
       2.0  6.1 97.0  7.1 96.9  8.1 96.8  9.1 96.9 10.1 96.8 11.1 96.7
       2.0 12.1 96.7 13.1 96.8 14.1 96.9 15.1 97.0 16.1 97.2 17.1 97.3
       2.0 18.0 97.4 20.3 97.2 20.7 98.4 23.5 98.8
NS     2.0        1.0       1.0       2.0       2.0       2.0       4.0
NS     2.0        4.0       4.0       4.0       4.0       4.0       4.0
NS     2.0        4.0       4.0       3.0       2.0       2.0       2.0
NS     2.0        2.0       2.0       2.0       1.0
WSL    2.0       97.1      97.2      97.2      97.3      97.3      97.3
WSL    2.0       97.4      97.4      97.4      97.4      97.4      97.5
WSL    2.0       97.5      97.5      97.5      97.5      97.5      97.6
WSL    2.0       97.6      97.6      97.6
CAL1   2.0      97.14      1.40      0.72
VEL1   2.0                                0.05 0.17 0.20 0.26 0.27 0.46
VEL1   2.0 0.44 0.40 0.24
CAL2   2.0      97.36      6.50      5.80
VEL2   2.0                 0.01 0.36 0.47 0.73 0.93 0.82 1.05 1.11 1.22
VEL2   2.0 1.19 1.05 1.20 0.47 0.05 0.04 0.01 0.01 0.01
XSEC   3.0        0.0 1.0     96.70   0.00023
       3.0  0.0 98.4  2.6 98.1  6.9 97.4  7.4 97.0  8.0 96.9  8.4 96.8
       3.0  9.4 96.2 10.4 95.9 11.4 95.8 12.4 95.7 13.4 95.8 14.4 95.9
       3.0 15.4 96.0 16.4 96.1 17.4 96.4 18.4 96.5 19.4 97.0 19.7 97.4
       3.0 21.9 98.8
NS     3.0        1.0       1.0       3.0       2.0       2.0       2.0
NS     3.0        2.0       4.0       3.0       5.0       5.0       5.0
NS     3.0        5.0       3.0       2.0       2.0       1.0       1.0
NS     3.0        1.0
```

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WSL    3.0      97.1      97.2      97.3      97.3      97.4      97.4
WSL    3.0      97.4      97.4      97.5      97.5      97.5      97.6
WSL    3.0      97.6      97.6      97.7      97.7      97.7      97.7
WSL    3.0      97.8      97.8      97.8
CAL1   3.0     97.15      1.40      1.10
VEL1   3.0                     0.11 0.03 0.02 0.05 0.10 0.15 0.20 0.11
VEL1   3.0 0.14 0.14 0.10 0.01
CAL2   3.0     97.42      6.50      6.10
VEL2   3.0                0.05 0.07 0.18 0.36 0.58 0.59 0.62 0.62 0.67
VEL2   3.0 0.04 0.15 0.02 0.02
XSEC   4.0     170.0 1.0     96.70   0.00048
       4.0  0.0 98.8  4.0 98.1  7.1 97.4  8.1 97.4  9.1 97.0 10.1 96.8
       4.0 11.1 96.6 12.1 96.4 13.1 96.3 14.1 96.2 15.1 96.2 16.1 96.1
       4.0 17.1 96.1 18.1 96.1 19.1 96.1 20.1 96.1 21.1 96.2 21.6 97.0
       4.0 22.6 97.0 25.7 99.1
NS     4.0       1.0       1.0       2.0       2.0       1.0       3.0
NS     4.0       3.0       4.0       3.0       3.0       3.0       4.0
NS     4.0       6.0       6.0       6.0       6.0       2.0       1.0
NS     4.0       1.0       1.0
WSL    4.0      97.1      97.2      97.3      97.3      97.4      97.4
WSL    4.0      97.4      97.5      97.5      97.5      97.6      97.6
WSL    4.0      97.6      97.7      97.7      97.7      97.8      97.8
WSL    4.0      97.8      97.8      97.9
CAL1   4.0     97.16      1.40      1.10
VEL1   4.0                     0.08 0.34 0.36 0.26 0.11 0.05 0.04 0.07
VEL1   4.0 0.11 0.05 0.03 0.02 0.01
CAL2   4.0     97.44      6.50      6.20
VEL2   4.0           0.01 0.01 0.75 0.70 1.00 0.50 0.87 0.84 0.80 0.60
VEL2   4.0 0.25 0.07 0.07 0.01 0.01 0.07 0.10
XSEC   5.0     170.0 1.0     96.95   0.00111
       5.0  0.0 98.8  2.9 98.5  3.4 97.0  3.9 97.0  4.9 97.0  5.9 97.0
       5.0  6.9 97.0  7.9 97.0  8.9 97.0  9.9 97.0 10.9 97.0 11.9 97.2
       5.0 12.9 97.0 13.9 97.0 14.9 97.0 15.9 97.2 17.9 97.2 19.0 97.5
       5.0 25.9 98.2 26.4 99.0 29.8 99.3
NS     5.0       1.0       1.0       1.0       2.0       4.0       4.0
NS     5.0       4.0       4.0       5.0       4.0       4.0       4.0
NS     5.0       4.0       4.0       3.0       2.0       2.0       2.0
NS     5.0       1.0       1.0       1.0
WSL    5.0      97.2      97.2      97.3      97.3      97.4      97.4
WSL    5.0      97.4      97.5      97.5      97.5      97.6      97.6
WSL    5.0      97.6      97.7      97.7      97.7      97.8      97.8
WSL    5.0      97.8      97.8      97.9
CAL1   5.0     97.17      1.40      0.64
VEL1   5.0                0.01 0.31 0.56 0.11 0.55 0.52 0.07 0.55 0.33
VEL1   5.0 0.25 0.34 0.31
CAL2   5.0     97.45      6.50      5.80
VEL2   5.0           0.02 0.18 1.09 1.06 1.07 1.04 1.35 0.88 1.35 1.44
VEL2   5.0 1.24 0.92 1.07 0.04 0.07 0.01
XSEC   6.0       0.0 1.0     96.95   0.00986
       6.0  0.0 98.6  2.5 98.1  3.0 97.5  3.8 97.5  4.2 97.3  4.9 97.0
       6.0  5.9 96.8  6.9 96.7  7.9 96.6  8.9 96.6  9.9 96.6 10.9 96.7
       6.0 11.9 96.7 12.9 96.9 13.9 97.1 14.9 97.5 15.1 98.3
NS     6.0       1.0       1.0       1.0       1.0       1.0       1.0
NS     6.0       3.0       4.0       4.0       5.0       4.0       4.0
NS     6.0       4.0       4.0       2.0       1.0       1.0
WSL    6.0      97.2      97.2      97.3      97.3      97.4      97.4
WSL    6.0      97.5      97.5      97.5      97.6      97.6      97.6
WSL    6.0      97.7      97.7      97.7      97.7      97.8      97.8
WSL    6.0      97.8      97.8      97.9
CAL1   6.0     97.18      1.40      1.00
VEL1   6.0                          0.13 0.18 0.19 0.24 0.30 0.20 0.30
VEL1   6.0 0.28 0.16 0.12
CAL2   6.0     97.46      6.50      6.30
VEL2   6.0                     0.03 0.35 0.76 0.53 0.85 1.20 1.16 1.21
VEL2   6.0 1.17 0.53 0.25 0.15
XSEC   7.0     170.0 0.9     97.50   0.01302
       7.0  0.0100.0  8.9 98.7  9.0 97.8  9.7 97.6 10.4 97.7 11.4 97.5
       7.0 12.4 97.7 13.4 97.7 14.4 97.7 15.4 97.6 16.4 97.7 17.4 97.7
       7.0 18.4 97.9 19.2 97.8 19.8 99.6 23.3 99.6
NS     7.0       1.0       1.0       1.0       5.0       5.0       4.0
NS     7.0       6.0       6.0       4.0       4.0       4.0       6.0
```

```
NS     7.0       6.0       2.0       1.0       1.0
WSL    7.0      98.0      98.0      98.1      98.1      98.1      98.1
WSL    7.0      98.2      98.2      98.2      98.2      98.2      98.2
WSL    7.0      98.2      98.2      98.3      98.3      98.3      98.3
WSL    7.0      98.3      98.3      98.3
CAL1   7.0     97.98      1.40      0.72
VEL1   7.0           0.01 0.61 0.75 0.79 0.22 0.31 0.48 0.53 0.35 0.18
VEL1   7.0 0.78 0.09
CAL2   7.0     98.15      6.50      6.80
VEL2   7.0           0.01 1.62 2.13 2.30 1.07 1.47 1.14 1.03 2.87 2.16
VEL2   7.0 1.44 0.04
XSEC   8.0     435.0 0.0     98.00   0.01302
       8.0  0.0100.3  4.2 99.2  4.5 98.4  5.9 98.1  7.4 98.0  8.4 98.0
       8.0  9.4 98.0 10.4 98.2 11.4 98.2 12.4 98.2 13.4 98.1 14.4 98.3
       8.0 15.4 98.4 16.4 98.4 17.7 98.7 25.9 98.7 26.5 99.6 27.7 99.7
NS     8.0       1.0       1.0       1.0       4.0       5.0       4.0
NS     8.0       4.0       4.0       4.0       4.0       4.0       4.0
NS     8.0       4.0       1.0  0.5  1.0  0.5  1.0       1.0       1.0
WSL    8.0      98.4      98.5      98.6      98.6      98.6      98.7
WSL    8.0      98.7      98.7      98.7      98.8      98.8      98.8
WSL    8.0      98.8      98.9      98.9      98.9      98.9      98.9
WSL    8.0      98.9      99.0      99.0
CAL1   8.0     98.45      1.40      0.71
VEL1   8.0                0.01 0.35 0.19 0.61 0.43 0.28 0.43 0.41 0.11
VEL1   8.0
CAL2   8.0     98.70      6.50      6.60
VEL2   8.0           0.01 0.80 1.00 1.19 1.09 1.35 1.08 1.34 0.89 1.03
VEL2   8.0 0.76 0.80 0.01
ENDJ

Big Timber Study Site 2 - substrate
Export from PHABSIM for Windows
IOC       0000000100010000100000
QARD   2.0
QARD   3.0
QARD   4.0
QARD   4.9
QARD   5.0
QARD   6.0
QARD   7.0
QARD   8.0
QARD   8.2
QARD   9.0
QARD  10.0
QARD  11.0
QARD  12.0
QARD  13.0
QARD  14.0
QARD  15.0
XSEC   1.0       0.0 1.0     97.00   0.00588
       1.0  0.0100.4  0.9100.0  3.5 97.6  3.7 97.6  3.8 97.4  5.5 97.1
       1.0  7.0 97.1  8.5 97.0 10.0 97.1 11.5 97.1 13.0 97.2 14.5 97.3
       1.0 16.0 97.3 17.5 97.5 18.9 97.6 19.5 97.7 24.6 98.4
NS     1.0       1.0       1.0       2.0       2.0       6.0       5.0
NS     1.0       6.0       6.0       7.0       6.0       6.0       6.0
NS     1.0       6.0       5.0       2.0       2.0       3.0
WSL    1.0      97.4      97.5      97.5       0.0      97.5      97.6
WSL    1.0      97.6      97.6       0.0      97.6      97.7      97.7
WSL    1.0      97.7      97.7      97.7      97.8
CAL1   1.0     97.60      8.20      6.40
VEL1   1.0                0.10 0.80 1.00 1.80 1.10 1.60 1.60 1.30 0.90
VEL1   1.0 1.00 0.60 0.10
CAL2   1.0     97.56      6.00      5.20
VEL2   1.0                0.10 0.30 0.90 1.60 0.90 0.90 1.50 1.00 0.80
VEL2   1.0 1.00 0.40 0.10
CAL3   1.0     97.51      4.90      4.50
VEL3   1.0                0.10 0.10 0.50 1.30 0.70 0.50 1.20 1.00 0.30
VEL3   1.0 0.90 0.30 0.10
XSEC   2.0     305.0 1.0     96.90   0.00370
       2.0  0.0 99.7  1.4 97.2  2.9 96.9  4.4 96.9  5.9 96.9  7.4 97.1
```

```
       2.0  8.9 97.0 10.4 97.3 11.9 97.5 14.6 97.6 15.0 97.6 19.8 98.2
       2.0 31.8100.7
NS     2.0       1.0       7.0       6.0       6.0       6.0       6.0
NS     2.0       6.0       6.0       6.0       2.0       2.0       3.0
NS     2.0       3.0
WSL    2.0      97.4      97.5      97.5       0.0      97.6      97.7
WSL    2.0      97.7      97.7       0.0      97.8      97.8      97.9
WSL    2.0      97.9      97.9      98.0      98.0
CAL1   2.0     97.70      8.20      6.90
VEL1   2.0      0.70 1.50 1.30 1.70 0.20 0.80 0.70 0.30 0.10 0.10
VEL1   2.0
CAL2   2.0     97.59      6.00      5.30
VEL2   2.0      0.10 1.50 1.20 1.70 0.20 0.60 0.40 0.20 0.10
VEL2   2.0
CAL3   2.0     97.58      4.90      4.40
VEL3   2.0      0.10 1.30 0.90 1.70 0.10 0.50 0.30 0.10 0.10
VEL3   2.0
XSEC   3.0     195.0 0.4     97.10    0.01111
       3.0  0.0 98.9  1.2 97.8  1.6 97.5  3.1 97.3  4.6 97.3  6.1 97.4
       3.0  7.6 97.3  9.1 97.7 10.6 97.1 12.1 97.3 13.6 97.6 15.1 97.6
       3.0 15.6 97.8 16.5 98.1 17.9 99.2
NS     3.0       1.0       2.0  1.0  2.0  1.0  5.0       5.0       6.0
NS     3.0       6.0       7.0       5.0  1.0  6.0       7.0       7.0
NS     3.0       2.0       1.0       1.0
WSL    3.0      97.6      97.6      97.7       0.0      97.8      97.8
WSL    3.0      97.8      97.9       0.0      97.9      98.0      98.0
WSL    3.0      98.0      98.0      98.1      98.1
CAL1   3.0     97.80      8.20      7.10
VEL1   3.0      0.10 0.40 0.90 1.70 2.20 1.70 1.70 1.60 0.80 1.30 0.20
VEL1   3.0 0.10
CAL2   3.0     97.78      6.00      6.00
VEL2   3.0      0.10 0.10 0.60 1.50 1.90 1.70 1.60 1.60 0.20 1.20 0.10
VEL2   3.0 0.10
CAL3   3.0     97.74      4.90      4.90
VEL3   3.0      0.10 0.10 0.20 1.20 1.60 1.50 1.10 1.40 0.10 1.00 0.10
VEL3   3.0 0.10
XSEC   4.0     500.0 0.0     97.10    0.01111
       4.0  0.0 98.8  2.6 98.2  3.3 97.8  3.5 97.8  4.3 97.4  5.3 97.4
       4.0  6.3 97.3  7.3 97.2  8.3 97.2  9.3 97.1 10.3 97.2 11.3 97.2
       4.0 12.3 97.4 13.3 97.4 14.3 97.4 15.3 97.8 15.9 98.6 17.5100.0
       4.0 18.0100.0
NS     4.0       1.0       1.0       1.0       6.0       6.0       6.0
NS     4.0       6.0       6.0       6.0       6.0       6.0       6.0
NS     4.0       6.0       6.0       7.0       7.0       1.0       1.0
NS     4.0       1.0
WSL    4.0      97.6      97.7      97.8       0.0      97.8      97.9
WSL    4.0      97.9      97.9       0.0      98.0      98.0      98.0
WSL    4.0      98.1      98.1      98.1      98.1
CAL1   4.0     97.85      8.20      8.20
VEL1   4.0                0.10 0.80 1.70 1.80 2.10 1.70 2.10 1.50 2.10
VEL1   4.0 1.20 0.40 0.70 0.10
CAL2   4.0     97.81      6.00      7.10
VEL2   4.0                0.10 0.80 0.30 0.90 2.10 1.60 1.50 1.40 1.50
VEL2   4.0 1.10 0.10 0.10 0.10
CAL3   4.0     97.80      4.90      5.40
VEL3   4.0                0.10 0.50 0.10 0.80 1.90 1.60 1.40 1.30 1.30
VEL3   4.0 0.30 0.10 0.10 0.10
ENDJ

Big Timber Study Site 3 - substrate
Export from PHABSIM for Windows
IOC      0000000100010000100000
QARD   2.0
QARD   3.0
QARD   4.0
QARD   5.0
QARD   6.0
QARD   7.0
QARD   8.0
QARD   9.0
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QARD  10.0
QARD  11.0
QARD  12.0
QARD  13.0
QARD  14.0
QARD  15.0
QARD  15.8
QARD  16.0
QARD  17.0
QARD  18.0
QARD  19.0
QARD  20.0
QARD  21.0
QARD  22.0
QARD  23.0
QARD  24.0
QARD  25.0
QARD  26.0
QARD  27.0
QARD  28.0
QARD  29.0
QARD  30.0
XSEC   1.0       0.0 1.0     93.90   0.01080
       1.0  0.0 96.8  2.7 96.4  5.5 94.9  5.9 94.7  6.2 94.3  7.2 94.5
       1.0  8.2 94.5  9.2 94.4 10.2 94.2 11.2 94.1 12.2 94.0 13.2 94.1
       1.0 14.2 93.9 15.2 93.9 16.2 93.9 17.2 93.9 18.2 94.1 19.2 94.2
       1.0 20.2 94.4 20.9 94.7 21.7 94.9 23.7 96.5 27.0 96.7
NS     1.0       1.0       1.0       1.0       2.0       3.0       4.0
NS     1.0  1.0  5.0       6.0       6.0       6.0       6.0       6.0
NS     1.0       5.0       6.0       6.0       6.0       6.0       5.0
NS     1.0       4.0       2.0       1.0       1.0       2.0
WSL    1.0      94.6      94.6      94.7      94.7      94.7      94.7
WSL    1.0      94.7      94.7      94.7      94.7      94.7      94.7
WSL    1.0      94.7      94.7      94.7      94.7      94.7      94.8
WSL    1.0      94.8      94.8      94.8      94.8      94.8      94.8
WSL    1.0      94.8      94.8      94.8      94.8      94.8      94.8
CAL1   1.0     94.74     15.77     16.00
VEL1   1.0                0.00 0.60 0.70 1.30 1.50 1.50 1.10 2.30 2.60
VEL1   1.0 2.70 2.80 2.30 2.40 1.00 1.60 0.80 0.00
CAL2   1.0     94.72      8.98     11.30
VEL2   1.0                0.00 0.10 0.00 0.50 1.00 0.90 0.80 2.00 1.90
VEL2   1.0 2.10 2.10 1.70 1.00 1.10 1.40 0.70 0.00
CAL3   1.0     94.70      8.00     10.70
VEL3   1.0                0.00 0.10 0.10 0.00 1.30 1.00 0.70 1.80 2.00
VEL3   1.0 2.30 1.80 1.70 1.50 0.80 1.40 0.70 0.00
XSEC   2.0      75.0 1.0     94.60   0.02190
       2.0  0.0100.5  6.2 98.4 14.7 95.6 15.1 95.6 15.7 95.3 16.7 95.0
       2.0 17.7 94.9 18.7 94.6 19.7 94.7 20.7 94.6 21.7 95.0 22.7 95.0
       2.0 23.7 95.0 24.7 95.1 25.7 94.9 26.7 95.2 27.7 95.3 28.2 95.4
       2.0 29.6 95.6 30.2 95.7 33.2 96.8 48.8 98.3
NS     2.0       1.0       1.0       6.0       3.0       3.0       6.0
NS     2.0       5.0       6.0       6.0       6.0       6.0       5.0
NS     2.0       5.0       5.0       5.0       5.0       5.0       5.0
NS     2.0       3.0       3.0       3.0       1.0
WSL    2.0      95.1      95.2      95.3      95.3      95.3      95.4
WSL    2.0      95.4      95.4      95.4      95.5      95.5      95.5
WSL    2.0      95.5      95.5      95.6      95.6      95.6      95.6
WSL    2.0      95.6      95.6      95.6      95.6      95.7      95.7
WSL    2.0      95.7      95.7      95.7      95.7      95.7      95.7
CAL1   2.0     95.55     15.77     14.50
VEL1   2.0                0.00 0.60 2.40 2.20 2.10 1.80 1.70 1.90 2.00
VEL1   2.0 2.10 2.10 2.10 2.20 1.10 0.90 0.00
CAL2   2.0     95.40      8.98      7.90
VEL2   2.0                0.00 0.30 1.40 1.80 1.90 1.50 1.20 1.30 1.60
VEL2   2.0 1.30 1.30 1.50 1.60 0.40 0.00 0.00
CAL3   2.0     95.41      8.00      7.20
VEL3   2.0                0.00 0.10 1.30 1.00 1.50 1.30 1.60 1.90 1.30
VEL3   2.0 1.60 1.50 1.00 1.10 0.60 0.00 0.00
XSEC   3.0      75.0 1.0     96.10   0.01580
       3.0  0.0101.0  5.5 98.5  8.8 97.7 10.3 97.2 10.5 96.2 11.5 96.3
       3.0 12.5 96.2 13.5 96.2 14.5 96.1 15.5 96.1 16.5 96.3 17.5 96.5
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       3.0 18.5 96.4 19.5 96.7 20.5 96.8 21.5 97.0 22.7 97.2 23.0 97.3
       3.0 27.0 98.5 33.3 99.8
NS     3.0       1.0       1.0       3.0       2.0       3.0       3.0
NS     3.0       5.0       5.0       6.0       6.0       6.0       4.0
NS     3.0       4.0       4.0       4.0       4.0       2.0       3.0
NS     3.0       2.0       1.0
WSL    3.0      97.0      97.0      97.1      97.1      97.1      97.1
WSL    3.0      97.1      97.1      97.2      97.2      97.2      97.2
WSL    3.0      97.2      97.2      97.2      97.2      97.2      97.2
WSL    3.0      97.2      97.2      97.2      97.2      97.2      97.2
WSL    3.0      97.2      97.3      97.3      97.3      97.3      97.3
CAL1   3.0     97.19     15.77     12.80
VEL1   3.0                0.00 0.30 0.90 1.20 1.60 1.70 1.80 1.50 1.60
VEL1   3.0 1.80 1.80 1.50 0.80 0.00
CAL2   3.0     97.16      8.98      8.90
VEL2   3.0                0.00 0.30 0.60 0.80 1.20 1.30 1.40 1.20 1.30
VEL2   3.0 1.00 1.10 0.80 0.20 0.00
CAL3   3.0     97.13      8.00      8.50
VEL3   3.0                0.00 0.10 0.50 0.80 1.20 1.30 1.30 1.20 1.30
VEL3   3.0 1.30 0.90 1.10 0.30 0.00
XSEC   4.0      40.0 0.5     96.80   0.01380
       4.0  0.0100.1  6.1 98.4 11.2 97.8 12.9 97.7 13.9 97.7 14.9 97.6
       4.0 15.9 97.2 16.9 97.0 17.9 96.9 18.9 96.9 19.9 96.8 20.9 96.9
       4.0 21.9 96.8 22.9 96.8 23.9 96.8 24.9 96.9 25.9 96.9 26.6 97.3
       4.0 28.4 97.9 28.8 97.9 31.9 99.7 39.5101.3
NS     4.0       1.0       2.0       3.0  1.0  5.0  1.0  5.0       5.0
NS     4.0       5.0       6.0       6.0       6.0       6.0       6.0
NS     4.0       6.0       4.0       4.0       4.0       3.0  1.0  3.0
NS     4.0       7.0       7.0       3.0       3.0
WSL    4.0      97.5      97.6      97.6      97.6      97.7      97.7
WSL    4.0      97.7      97.7      97.8      97.8      97.8      97.8
WSL    4.0      97.8      97.8      97.8      97.8      97.8      97.8
WSL    4.0      97.9      97.9      97.9      97.9      97.9      97.9
WSL    4.0      97.9      97.9      97.9      97.9      97.9      97.9
CAL1   4.0     97.82     15.77     15.10
VEL1   4.0                0.00 0.30 1.00 2.60 2.40 2.30 2.30 2.00 1.60
VEL1   4.0 1.20 0.90 0.70 0.50 0.40 0.00 0.00
CAL2   4.0     97.75      8.98      9.90
VEL2   4.0                     0.00 0.10 0.80 2.40 2.20 1.90 1.00 0.80
VEL2   4.0 1.00 0.90 0.60 0.40 0.30 0.00
CAL3   4.0     97.71      8.00      9.50
VEL3   4.0                0.00 0.00 1.00 2.50 2.00 1.60 1.60 1.50 1.30
VEL3   4.0 0.90 0.30 0.50 0.30 0.10 0.00
XSEC   5.0       8.0 0.0     96.80   0.01380
       5.0  0.0 98.8  0.9 98.4  4.3 98.0  4.6 97.9  4.9 97.7  5.9 97.3
       5.0  6.9 96.6  7.9 96.3  8.9 96.3  9.9 96.1 10.9 95.9 11.9 95.5
       5.0 12.9 96.1 13.9 96.0 14.9 96.6 15.9 96.8 16.9 96.1 17.9 95.7
       5.0 18.9 96.4 19.9 96.7 20.9 97.6 21.1 97.9 22.3 98.0 23.6 99.6
       5.0 25.1 99.6
NS     5.0       3.0       3.0       3.0       4.0  0.5  3.0       3.0
NS     5.0       3.0       5.0       6.0       6.0       6.0       7.0
NS     5.0       7.0       7.0       7.0       7.0  2.0  6.0       6.0
NS     5.0       7.0       6.0       1.0       1.0       1.0       1.0
NS     5.0       3.0
WSL    5.0      97.6      97.7      97.7      97.7      97.8      97.8
WSL    5.0      97.8      97.8      97.8      97.9      97.9      97.9
WSL    5.0      97.9      97.9      97.9      97.9      97.9      98.0
WSL    5.0      98.0      98.0      98.0      98.0      98.0      98.0
WSL    5.0      98.0      98.0      98.0      98.0      98.0      98.1
CAL1   5.0     97.93     15.77     20.00
VEL1   5.0                0.00 0.20 0.30 0.20 0.60 1.30 2.00 2.70 2.00
VEL1   5.0 1.50 0.50 0.40 0.20 0.10 0.20 0.30 0.30 0.20 0.00
VEL1   5.0
CAL2   5.0     97.83      8.98      9.60
VEL2   5.0                0.00 0.10 0.20 0.10 0.20 0.80 1.60 1.30 1.00
VEL2   5.0 1.00 0.20 0.10 0.10 0.10 0.10 0.10 0.10 0.00 0.00
VEL2   5.0
CAL3   5.0     97.81      8.00     13.90
VEL3   5.0                0.00 0.20 0.60 0.50 0.30 0.20 1.90 1.60 1.60
VEL3   5.0 0.70 0.10 0.10 0.10 0.20 0.20 0.20 0.10 0.00 0.00 0.00
VEL3   5.0
```

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ENDJ

Big Timber Study Site 4 - substrate
Export from PHABSIM for Windows
IOC        0000000100010000100000
QARD   2.0
QARD   3.0
QARD   4.0
QARD   5.0
QARD   6.0
QARD   7.0
QARD   8.0
QARD   9.0
QARD  10.0
QARD  11.0
QARD  12.0
QARD  13.0
QARD  14.0
QARD  15.0
QARD  16.0
QARD  17.0
QARD  18.0
QARD  19.0
QARD  20.0
QARD  21.0
QARD  22.0
QARD  23.0
QARD  24.0
QARD  25.0
QARD  26.0
QARD  27.0
QARD  28.0
QARD  29.0
QARD  30.0
XSEC   1.0        0.0 0.0      85.40   0.00294
       1.0  0.0 87.8  2.3 87.2  3.6 85.9  3.8 85.9  4.3 85.6  5.8 85.5
       1.0  7.3 85.5  8.8 85.4 10.3 85.5 11.8 85.5 13.3 85.6 14.8 85.6
       1.0 16.3 85.4 17.8 85.4 19.3 85.4 20.8 85.4 22.3 85.5 23.8 85.4
       1.0 25.3 85.4 26.3 85.7 27.4 85.9 28.2 85.9 41.1 89.0 41.5 89.0
NS     1.0        1.0       1.0       1.0       1.0       3.0       5.0
NS     1.0        5.0       4.0       5.0       5.0       5.0       6.0
NS     1.0        5.0       5.0       6.0       5.0       6.0       5.0
NS     1.0        5.0       2.0       1.0       2.0       6.0       6.0
WSL    1.0       85.6      85.6      85.6      85.7      85.7      85.7
WSL    1.0       85.8      85.8      85.8      85.8      85.9      85.9
WSL    1.0       85.9      85.9      86.0      86.0      86.0      86.0
WSL    1.0       86.0      86.1      86.1      86.1      86.1      86.1
WSL    1.0       86.1      86.2      86.2      86.2      86.2
CAL1   1.0      85.85     11.00      9.60
VEL1   1.0                 0.10 0.90 0.80 1.00 0.90 1.30 1.30 1.10 1.50
VEL1   1.0 1.50 1.60 1.40 1.40 1.40 1.10 1.10 0.90 0.10
CAL2   1.0      85.79      9.00      7.30
VEL2   1.0                 0.10 0.80 0.60 0.90 0.80 1.20 1.10 1.00 1.30
VEL2   1.0 1.40 1.40 1.20 1.30 1.10 0.50 1.00 0.60 0.10
CAL3   1.0      85.78      8.00      6.60
VEL3   1.0                 0.10 0.50 0.50 0.80 0.80 1.10 0.90 1.00 0.60
VEL3   1.0 1.30 1.40 0.90 1.20 1.00 0.40 0.80 0.40 0.10
XSEC   2.0        1.0 1.0      85.40   0.00032
       2.0  0.0 86.7  0.5 86.7  4.2 86.0  4.5 85.9  4.8 85.7  6.3 85.5
       2.0  7.8 85.5  9.3 85.4 10.8 85.3 12.3 85.4 13.8 85.2 15.3 85.1
       2.0 16.8 85.1 18.3 85.2 19.8 85.1 21.3 85.6 22.3 85.9 22.7 86.0
       2.0 41.0 86.5 55.4 89.5 56.2 89.8
NS     2.0        2.0       2.0       2.0       2.0       2.0       5.0
NS     2.0        5.0       5.0       4.0       5.0       5.0       4.0
NS     2.0        4.0       5.0       6.0       2.0       2.0       3.0
NS     2.0        3.0       2.0       2.0
WSL    2.0       85.6      85.7      85.7      85.7      85.8      85.8
WSL    2.0       85.8      85.8      85.9      85.9      85.9      85.9
WSL    2.0       86.0      86.0      86.0      86.0      86.0      86.1
WSL    2.0       86.1      86.1      86.1      86.1      86.1      86.2
```

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WSL    2.0      86.2      86.2      86.2      86.2      86.2
CAL1   2.0     85.90     11.00     10.10
VEL1   2.0                0.10 0.60 0.70 0.70 1.00 1.00 1.30 1.20 1.30
VEL1   2.0 1.20 1.20 1.90 0.60 0.10
CAL2   2.0     85.84      9.00      9.50
VEL2   2.0                0.10 0.10 0.70 0.70 0.90 0.90 1.10 1.10 1.20
VEL2   2.0 1.20 1.00 0.90 0.40 0.10
CAL3   2.0     85.82      8.00      7.50
VEL3   2.0                0.10 0.10 0.60 0.50 0.80 0.80 1.10 1.00 1.10
VEL3   2.0 1.10 1.00 0.80 0.40 0.10
XSEC   3.0     154.0 1.0     85.40   0.00147
       3.0  0.0 86.8  8.0 86.7 10.3 86.0 10.4 85.9 12.0 85.7 13.5 85.4
       3.0 15.0 85.4 16.5 85.2 18.0 84.9 19.5 84.7 21.0 84.6 22.5 84.5
       3.0 23.0 84.7 25.0 85.1 26.3 85.2 26.7 85.9 27.1 86.7 38.1 87.0
       3.0 50.1 86.7 63.0 86.9 74.0 86.4 77.6 88.3 78.9 88.2
NS     3.0       6.0       6.0       6.0       3.0       2.0       5.0
NS     3.0       5.0       5.0       5.0       6.0       6.0       5.0
NS     3.0       4.0       2.0       2.0       2.0       4.0       3.0
NS     3.0       3.0       3.0       3.0       6.0       6.0
WSL    3.0      85.6      85.7      85.7      85.8      85.8      85.8
WSL    3.0      85.9      85.9      85.9      85.9      85.9      86.0
WSL    3.0      86.0      86.0      86.0      86.1      86.1      86.1
WSL    3.0      86.1      86.1      86.2      86.2      86.2      86.2
WSL    3.0      86.2      86.3      86.3      86.3      86.3
CAL1   3.0     85.91     11.00      8.80
VEL1   3.0                0.10 0.40 0.80 1.00 1.20 1.00 1.00 1.60 0.90
VEL1   3.0 0.70 0.20 0.30 0.10
CAL2   3.0     85.84      9.00      7.90
VEL2   3.0                0.10 0.10 0.70 1.00 1.10 0.90 1.00 1.00 0.40
VEL2   3.0 0.30 0.20 0.20 0.10
CAL3   3.0     85.84      8.00      9.90
VEL3   3.0                0.10 0.10 0.60 0.70 0.90 0.90 0.90 0.90 0.30
VEL3   3.0 0.10 0.10 0.10 0.10
XSEC   4.0     153.0 1.0     85.40   0.00260
       4.0  0.0 88.0  7.1 87.8 14.8 86.8 16.9 86.0 17.4 86.0 17.6 85.5
       4.0 18.6 85.4 19.6 85.2 20.6 85.0 21.6 84.8 22.6 84.7 23.6 84.5
       4.0 24.6 85.0 25.6 85.0 26.6 85.5 27.7 86.0 27.8 86.0 32.7 87.5
       4.0 43.2 87.3 49.4 87.1 61.1 87.5 72.3 86.8 77.1 88.8 78.2 88.9
NS     4.0       6.0       6.0       6.0       6.0       4.0       4.0
NS     4.0       4.0       5.0       5.0       6.0       6.0       6.0
NS     4.0       1.0       1.0       1.0       1.0       6.0       6.0
NS     4.0       6.0       6.0       6.0       6.0       2.0       1.0
WSL    4.0      85.6      85.7      85.7      85.8      85.8      85.8
WSL    4.0      85.9      85.9      85.9      86.0      86.0      86.0
WSL    4.0      86.0      86.0      86.1      86.1      86.1      86.1
WSL    4.0      86.1      86.2      86.2      86.2      86.2      86.2
WSL    4.0      86.3      86.3      86.3      86.3      86.3
CAL1   4.0     85.96     11.00      7.90
VEL1   4.0                     0.10 0.30 0.60 0.70 0.90 1.10 1.20 1.20
VEL1   4.0 1.40 0.70 0.40 0.10
CAL2   4.0     85.90      9.00      6.20
VEL2   4.0                     0.10 0.20 0.40 0.50 0.70 1.00 1.10 1.00
VEL2   4.0 1.00 0.50 0.30 0.10
CAL3   4.0     85.88      8.00      5.60
VEL3   4.0                     0.10 0.20 0.40 0.40 0.60 0.80 1.00 0.60
VEL3   4.0 0.70 0.40 0.10 0.10
XSEC   5.0     153.0 1.0     85.40   0.02615
       5.0  0.0 88.1  5.8 88.5 10.0 86.6 10.4 86.1 10.5 85.9 11.3 85.5
       5.0 12.3 85.4 13.3 85.3 14.3 85.6 15.3 85.7 16.3 85.7 17.3 85.7
       5.0 18.3 85.8 19.3 85.9 20.3 85.9 21.6 86.1 23.1 86.4 29.2 87.9
       5.0 46.1 87.6 51.2 87.8 56.7 90.2 57.1 90.2
NS     5.0       6.0       6.0       6.0       6.0       6.0       6.0
NS     5.0       6.0       6.0       6.0       6.0       6.0       6.0
NS     5.0       6.0       6.0       6.0       6.0       6.0       5.0
NS     5.0       5.0       3.0       4.0       4.0
WSL    5.0      85.8      85.8      85.9      85.9      86.0      86.0
WSL    5.0      86.0      86.0      86.1      86.1      86.1      86.1
WSL    5.0      86.1      86.2      86.2      86.2      86.2      86.3
WSL    5.0      86.3      86.3      86.3      86.3      86.4      86.4
WSL    5.0      86.4      86.4      86.4      86.5      86.5
CAL1   5.0     86.09     11.00     10.50
```

```
VEL1   5.0                0.10 0.10 3.70 3.70 4.30 1.80 1.60 3.20 3.90
VEL1   5.0 3.40 2.50 0.10 0.10
CAL2   5.0     86.06      9.00      8.80
VEL2   5.0                0.10 0.10 0.80 3.60 4.30 1.50 1.60 2.10 3.40
VEL2   5.0 3.10 1.70 0.10 0.10
CAL3   5.0     86.00      8.00      8.80
VEL3   5.0                0.10 0.10 0.40 3.60 3.50 1.40 1.60 0.10 1.20
VEL3   5.0 3.10 1.50 0.10 0.10
XSEC   6.0      70.0 1.0     85.90   0.01583
       6.0  0.0 88.6 15.1 88.7 24.8 88.6 28.4 87.0 28.8 86.1 29.8 85.9
       6.0 31.3 86.2 32.8 86.2 34.3 86.2 35.8 86.4 37.3 86.4 38.8 86.4
       6.0 40.3 86.5 41.8 86.5 43.3 86.4 44.8 86.5 45.3 86.8 46.0 87.3
       6.0 52.9 88.5 61.8 87.8 67.9 89.6 68.6 89.6

NS     6.0       1.0       6.0       6.0       6.0       1.0       6.0
NS     6.0       6.0       6.0       6.0       6.0       6.0       6.0
NS     6.0       6.0       6.0       6.0       7.0       6.0       5.0
NS     6.0       5.0       5.0       2.0       1.0
WSL    6.0      86.4      86.5      86.5      86.6      86.6      86.7
WSL    6.0      86.7      86.7      86.7      86.8      86.8      86.8
WSL    6.0      86.8      86.8      86.9      86.9      86.9      86.9
WSL    6.0      86.9      86.9      87.0      87.0      87.0      87.0
WSL    6.0      87.0      87.0      87.0      87.0      87.1
CAL1   6.0     86.76     11.00     11.80
VEL1   6.0                     0.60 2.20 2.40 2.50 2.80 3.00 1.40 0.90
VEL1   6.0 0.20 1.10 0.90 1.10 0.10
CAL2   6.0     86.70      9.00      9.70
VEL2   6.0                     0.20 1.40 2.30 2.30 2.70 1.70 1.10 0.90
VEL2   6.0 0.20 0.40 0.50 1.10 0.10
CAL3   6.0     86.69      8.00      7.80
VEL3   6.0                     0.10 1.30 2.00 1.80 1.70 1.70 0.50 0.60
VEL3   6.0 0.20 0.20 0.50 0.50 0.10
XSEC   7.0     370.0 1.0     86.20   0.00143
       7.0  0.0 89.1 11.3 88.0 14.2 86.9 14.4 87.0 14.6 86.8 15.6 86.5
       7.0 17.1 86.4 18.6 86.2 20.1 86.3 21.6 86.3 23.1 86.2 24.6 86.6
       7.0 26.1 86.5 27.1 86.8 28.1 87.0 29.1 87.0 34.1 88.3 44.1 88.0
       7.0 53.0 88.9 56.1 90.3 57.2 90.3
NS     7.0       5.0       5.0       6.0       2.0       2.0       3.0
NS     7.0       5.0       4.0       5.0       5.0       6.0       6.0
NS     7.0       6.0       6.0       6.0       5.0       4.0       3.0
NS     7.0       6.0       1.0       1.0
WSL    7.0      86.6      86.7      86.7      86.8      86.8      86.8
WSL    7.0      86.9      86.9      86.9      87.0      87.0      87.0
WSL    7.0      87.0      87.0      87.1      87.1      87.1      87.1
WSL    7.0      87.1      87.2      87.2      87.2      87.2      87.2
WSL    7.0      87.2      87.2      87.3      87.3      87.3
CAL1   7.0     86.96     11.00      9.10
VEL1   7.0                0.10 0.30 1.00 1.50 1.50 1.50 1.40 1.40 1.30
VEL1   7.0 1.20 0.80 0.10
CAL2   7.0     86.90      9.00      7.60
VEL2   7.0                0.10 0.10 0.90 1.40 1.40 1.30 1.30 1.30 1.20
VEL2   7.0 1.00 0.60 0.10
CAL3   7.0     86.88      8.00      7.00
VEL3   7.0                0.10 0.10 0.70 1.30 1.30 1.20 1.30 1.20 1.10
VEL3   7.0 0.80 0.10 0.10
XSEC   8.0       1.0 0.0     86.20   0.00143
       8.0  0.0 88.5  2.3 88.2  3.3 84.8  4.5 84.6  5.5 84.5  6.5 84.9
       8.0  7.5 85.2  8.5 85.4  9.5 85.9 10.5 85.8 11.5 86.4 12.5 86.7
       8.0 13.2 87.0 13.4 87.0 16.0 88.0 25.0 88.4 30.0 88.3 39.7 88.8
       8.0 41.3 90.5 43.3 90.6
NS     8.0       6.0       1.0       1.0       3.0       3.0       5.0
NS     8.0       6.0       6.0       1.0       3.0       6.0       5.0
NS     8.0       5.0       5.0       5.0       4.0       4.0       1.0
NS     8.0       1.0       1.0
WSL    8.0      86.6      86.7      86.7      86.8      86.8      86.9
WSL    8.0      86.9      86.9      87.0      87.0      87.0      87.1
WSL    8.0      87.1      87.1      87.1      87.1      87.2      87.2
WSL    8.0      87.2      87.2      87.2      87.3      87.3      87.3
WSL    8.0      87.3      87.3      87.3      87.4      87.4
CAL1   8.0     86.98     11.00     11.00
VEL1   8.0           1.10 1.70 1.30 1.00 0.50 0.10 0.10 0.30 0.40 0.20
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```
VEL1   8.0 0.10
CAL2   8.0     86.90      9.00     10.50
VEL2   8.0           0.10 1.20 1.20 0.80 0.30 0.10 0.10 0.30 0.30 0.20
VEL2   8.0 0.10
CAL3   8.0     86.89      8.00      6.70
VEL3   8.0           0.10 0.80 1.10 0.60 0.20 0.10 0.10 0.20 0.10 0.10
VEL3   8.0 0.10
XSEC   9.0     100.0 0.0      86.20   0.00143
       9.0  0.0 88.5  2.3 88.2  3.3 84.8  4.5 84.6  5.5 84.5  6.5 84.9
       9.0  7.5 85.2  8.5 85.4  9.5 85.9 10.5 85.8 11.5 86.4 12.5 86.7
       9.0 13.2 87.0 13.4 87.0 16.0 88.0 25.0 88.4 30.0 88.3 39.7 88.8
       9.0 41.3 90.5 43.3 90.6
NS     9.0       6.0       1.0       1.0       3.0       3.0       5.0
NS     9.0       6.0       6.0       1.0       3.0       6.0       5.0
NS     9.0       5.0       5.0       5.0       4.0       4.0       1.0
NS     9.0       1.0       1.0
WSL    9.0      86.6      86.7      86.7      86.8      86.8      86.9
WSL    9.0      86.9      86.9      87.0      87.0      87.0      87.1
WSL    9.0      87.1      87.1      87.1      87.1      87.2      87.2
WSL    9.0      87.2      87.2      87.2      87.3      87.3      87.3
WSL    9.0      87.3      87.3      87.3      87.4      87.4
CAL1   9.0     86.98     11.00     11.00
VEL1   9.0           1.10 1.70 1.30 1.00 0.50 0.10 0.10 0.30 0.40 0.20
VEL1   9.0 0.10
CAL2   9.0     86.90      9.00     10.50
VEL2   9.0           0.10 1.20 1.20 0.80 0.30 0.10 0.10 0.30 0.30 0.20
VEL2   9.0 0.10
CAL3   9.0     86.89      8.00      6.70
VEL3   9.0           0.10 0.80 1.10 0.60 0.20 0.10 0.10 0.20 0.10 0.10
VEL3   9.0 0.10
ENDJ

Big Timber Study Site 5 - substrate
Export from PHABSIM for Windows
IOC       0000000100010000100000
QARD   2.0
QARD   4.0
QARD   6.0
QARD   8.0
QARD  10.0
QARD  12.0
QARD  14.0
QARD  15.0
QARD  16.0
QARD  18.0
QARD  20.0
QARD  22.0
QARD  24.0
QARD  25.0
QARD  26.0
QARD  28.0
QARD  30.0
QARD  32.0
QARD  34.0
QARD  36.0
QARD  38.0
QARD  40.0
QARD  42.0
QARD  44.0
QARD  46.0
QARD  48.0
QARD  50.0
QARD  52.0
QARD  54.0
XSEC   1.0       0.0 0.0      97.70   0.00368
       1.0  0.0101.4  0.9100.8  1.9 98.6  3.4 98.6  4.9 98.6  6.4 98.4
       1.0  7.9 98.5  9.4 98.2 10.9 98.2 12.4 98.2 13.9 98.1 15.4 98.2
       1.0 16.9 98.1 18.4 98.0 19.9 97.7 21.4 97.9 22.9 97.8 24.4 98.1
       1.0 25.9 98.3 28.2 98.5 29.0 99.8 30.2 99.9
NS     1.0       2.0       2.0       3.0       4.0       5.0       5.0
```

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NS     1.0       5.0       5.0       6.0       6.0       6.0       6.0
NS     1.0       6.0       7.0       6.0       4.0       4.0       6.0
NS     1.0       4.0       3.0       1.0       1.0
WSL    1.0      98.5      98.6      98.6      98.6      98.6      98.7
WSL    1.0      98.7      98.7      98.7      98.7      98.7      98.7
WSL    1.0      98.7      98.7      98.7      98.7      98.7      98.7
WSL    1.0      98.7      98.8      98.8      98.8      98.8      98.8
WSL    1.0      98.8      98.8      98.8      98.8      98.8
CAL1   1.0     98.73     28.00     25.10
VEL1   1.0           0.80 1.40 0.20 1.00 1.80 1.50 1.60 2.30 2.50 2.30
VEL1   1.0 2.40 2.80 2.50 2.30 2.20 1.30 1.00 0.30

CAL2   1.0     98.72     25.00     22.30
VEL2   1.0           0.70 0.70 0.20 1.00 1.70 1.20 1.30 2.20 2.20 2.10
VEL2   1.0 1.10 2.10 2.20 2.20 1.70 1.30 0.90 0.20
CAL3   1.0     98.68     15.00     15.30
VEL3   1.0           0.60 0.10 0.10 0.70 0.10 0.60 0.90 1.50 1.80 1.70
VEL3   1.0 1.00 1.90 1.90 1.60 1.20 0.80 0.80 0.10
XSEC   2.0       1.0 1.0     97.70   0.00154
       2.0  0.0101.2  1.2101.3  7.6 99.0  8.4 98.9  9.6 98.7 11.1 98.5
       2.0 12.6 98.3 14.1 98.1 15.6 98.0 17.1 97.8 18.6 97.6 20.1 97.7
       2.0 21.6 97.3 23.1 97.6 24.6 98.0 26.1 98.3 27.1 98.4 28.0100.0
       2.0 29.6100.5
NS     2.0       1.0       2.0       2.0       7.0       4.0       5.0
NS     2.0       5.0       5.0       5.0       3.0       6.0       7.0
NS     2.0       4.0       3.0       3.0       3.0  1.0  3.0       1.0
NS     2.0       1.0
WSL    2.0      98.5      98.6      98.6      98.7      98.7      98.7
WSL    2.0      98.7      98.7      98.7      98.7      98.8      98.8
WSL    2.0      98.8      98.8      98.8      98.8      98.8      98.8
WSL    2.0      98.9      98.9      98.9      98.9      98.9      98.9
WSL    2.0      99.0      99.0      99.0      99.0      99.0
CAL1   2.0     98.86     28.00     23.40
VEL1   2.0                0.10 0.80 1.30 1.40 1.90 2.00 2.10 1.40 2.90
VEL1   2.0 2.20 1.10 0.70 0.30 0.10
CAL2   2.0     98.84     25.00     22.20
VEL2   2.0                0.10 0.30 1.00 1.30 1.40 1.60 2.00 1.10 2.60
VEL2   2.0 2.00 0.50 0.40 0.10 0.10
CAL3   2.0     98.77     15.00     14.40
VEL3   2.0                0.10 0.10 0.50 0.70 0.90 1.30 1.50 0.80 1.90
VEL3   2.0 1.70 0.40 0.10 0.10 0.10
XSEC   3.0     290.0 1.0     97.70   0.03625
       3.0  0.0101.6  2.6101.7 15.1 98.9 15.4 98.8 16.4 98.6 18.4 98.4
       3.0 19.4 98.4 20.4 98.2 21.4 98.0 22.4 97.8 23.4 97.5 24.4 97.8
       3.0 25.4 98.0 26.4 96.8 27.4 97.1 28.4 97.6 29.4 97.5 30.4 97.7
       3.0 31.7 97.8 33.4101.5 34.2100.9
NS     3.0       3.0       3.0       3.0       3.0       3.0       3.0
NS     3.0       3.0       3.0       6.0       6.0       6.0       7.0
NS     3.0       7.0       6.0       4.0       7.0       4.0       4.0
NS     3.0       1.0       1.0       1.0
WSL    3.0      98.5      98.6      98.6      98.7      98.7      98.7
WSL    3.0      98.7      98.7      98.7      98.8      98.8      98.8
WSL    3.0      98.8      98.8      98.9      98.9      98.9      98.9
WSL    3.0      98.9      98.9      99.0      99.0      99.0      99.0
WSL    3.0      99.0      99.1      99.1      99.1      99.1
CAL1   3.0     98.86     28.00     25.70
VEL1   3.0                0.10 0.20 0.10 0.50 1.00 1.60 2.20 2.60 3.00
VEL1   3.0 3.70 3.10 2.70 1.60 0.50 0.20 0.10
CAL2   3.0     98.84     25.00     25.40
VEL2   3.0                0.10 0.10 0.10 0.10 0.50 1.30 1.80 2.40 2.60
VEL2   3.0 2.80 2.80 2.10 1.50 0.20 0.20 0.10
CAL3   3.0     98.74     15.00     15.20
VEL3   3.0                0.10 0.10 0.10 0.10 0.30 0.50 0.80 1.30 1.70
VEL3   3.0 2.00 2.00 2.10 1.40 0.10 0.10 0.10
XSEC   4.0     100.0 0.3     98.50   0.02167
       4.0  0.0102.1  3.4101.2 16.7 99.4 19.7 99.4 24.0 99.3 26.0 98.9
       4.0 28.0 98.8 30.0 98.9 32.0 99.0 34.0 99.2 36.0 99.1 38.0 99.1
       4.0 40.0 99.2 41.0 99.2 43.0 99.3 45.0 99.1 47.0 98.9 49.0 98.6
       4.0 51.0 98.5 53.0 98.6 54.2 99.1 54.7100.7 56.3100.7
NS     4.0       3.0       3.0       2.0       6.0       6.0       6.0
NS     4.0       6.0       6.0       6.0       6.0       4.0       5.0
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NS     4.0       5.0       5.0       5.0       5.0       6.0       6.0
NS     4.0       5.0       5.0       2.0       1.0       1.0
WSL    4.0      99.1      99.2      99.3      99.3      99.3      99.4
WSL    4.0      99.4      99.4      99.4      99.4      99.4      99.5
WSL    4.0      99.5      99.5      99.5      99.5      99.5      99.5
WSL    4.0      99.5      99.6      99.6      99.6      99.6      99.6
WSL    4.0      99.6      99.6      99.6      99.6      99.6
CAL1   4.0     99.51     28.00     42.70
VEL1   4.0                0.10 0.10 4.00 4.20 3.80 3.50 3.80 3.70 2.10
VEL1   4.0 1.80 2.70 0.60 2.00 2.90 3.50 4.10 2.80 0.90
CAL2   4.0     99.49     25.00     46.60
VEL2   4.0                0.10 0.10 3.20 2.60 2.60 3.40 3.60 2.10 2.10
VEL2   4.0 0.80 2.10 0.10 1.90 2.80 3.20 3.50 2.50 0.40
CAL3   4.0     99.40     15.00     19.40
VEL3   4.0                0.10 0.10 0.90 1.70 0.10 0.90 1.40 2.00 0.90
VEL3   4.0 0.10 0.10 0.10 0.10 1.60 2.40 3.30 2.40 0.70
XSEC   5.0     610.0 0.0     99.50   0.02167
       5.0  0.0101.6  1.0101.8  7.1100.4  7.4100.2  7.9100.0  9.9 99.9
       5.0 11.9 99.8 13.9 99.7 15.9 99.7 17.9 99.8 19.9 99.9 21.9 99.5
       5.0 23.9 99.6 25.9 99.7 27.9 99.7 29.9 99.7 31.9 99.7 33.9 99.6
       5.0 35.5 99.5 37.5 99.5 39.3 99.7 41.4102.1 42.5102.4
NS     5.0       1.0       1.0       1.0       3.0       8.0  1.0  8.0
NS     5.0  1.0  8.0  1.0  8.0  1.0  8.0  1.0  8.0  1.0  8.0  1.0  8.0
NS     5.0  1.0  8.0  1.0  8.0  1.0  8.0  1.0  8.0  1.0  8.0  1.0  8.0
NS     5.0  1.0  8.0  1.0  8.0  1.0  8.0       6.0       8.0
WSL    5.0      99.7      99.8      99.8      99.9      99.9      99.9
WSL    5.0      99.9      99.9     100.0     100.0     100.0     100.0
WSL    5.0     100.0     100.0     100.0     100.0     100.1     100.1
WSL    5.0     100.1     100.1     100.1     100.1     100.1     100.1
WSL    5.0     100.1     100.2     100.2     100.2     100.2
CAL1   5.0    100.05     28.00     18.90
VEL1   5.0                0.10 0.50 1.50 2.30 1.80 1.50 2.40 2.50 2.00
VEL1   5.0 1.50 2.20 1.90 2.60 1.50 2.20 2.50 2.50 0.80
CAL2   5.0    100.03     25.00     19.10
VEL2   5.0                0.10 0.40 1.10 2.00 1.30 1.20 2.20 1.90 2.00
VEL2   5.0 1.30 2.20 1.70 1.80 1.40 2.00 2.40 2.20 0.70
CAL3   5.0     99.95     15.00      9.90
VEL3   5.0                0.10 0.10 0.10 0.10 0.10 0.80 1.00 1.00 1.60
VEL3   5.0 1.10 1.70 1.10 1.30 0.70 1.50 2.30 1.30 0.40
ENDJ

Big_Timber Study Site 6 - substrate
Export from PHABSIM for Windows
IOC       0000000100010000100000
QARD   3.0
QARD   5.0
QARD   7.0
QARD   9.0
QARD  11.0
QARD  13.0
QARD  15.0
QARD  17.0
QARD  19.0
QARD  21.0
QARD  23.0
QARD  25.0
QARD  27.0
QARD  29.0
QARD  31.0
QARD  33.0
QARD  35.0
QARD  37.0
QARD  39.0
QARD  41.0
QARD  43.0
QARD  45.0
QARD  47.0
QARD  49.0
QARD  51.0
QARD  53.0
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QARD  55.0
QARD  57.0
QARD  59.0
XSEC   1.0       0.0 0.0     88.70   0.00263
       1.0  0.0 92.5  2.5 91.9  5.0 89.9  6.9 89.6  7.5 89.4  9.5 89.2
       1.0 11.5 89.1 13.5 89.1 15.5 89.1 17.5 89.1 19.5 89.0 21.5 88.9
       1.0 23.5 88.8 25.5 88.7 27.5 88.9 29.5 88.7 31.5 88.8 33.5 88.9
       1.0 35.5 88.9 37.5 89.0 39.3 89.6 39.9 90.2 42.1 90.9
NS     1.0       1.0       1.0       1.0       6.0       6.0       4.0
NS     1.0       5.0       5.0       6.0       6.0       6.0       6.0
NS     1.0       6.0       6.0       7.0       6.0       6.0       6.0
NS     1.0       6.0       5.0       4.0       7.0       1.0
WSL    1.0      89.2      89.3      89.4      89.4      89.5      89.6
WSL    1.0      89.6      89.6      89.7      89.8      89.8      89.8
WSL    1.0      89.9      89.9      89.9      90.0      90.0      90.0
WSL    1.0      90.1      90.1      90.1      90.2      90.2      90.2
WSL    1.0      90.2      90.3      90.3      90.3      90.3
CAL1   1.0     89.92     29.00     34.60
VEL1   1.0          0.10 0.10 0.60 0.60 0.70 0.80 0.70 1.00 1.20 1.10
VEL1   1.0 1.50 1.20 1.50 1.50 1.50 1.70 1.20 0.90 0.70
CAL2   1.0     89.65     17.00     22.10
VEL2   1.0               0.10 0.30 0.50 0.60 0.70 0.60 0.60 1.00 1.00
VEL2   1.0 1.30 0.80 1.20 1.40 1.30 1.30 0.90 0.70 0.30
CAL3   1.0     89.59     13.00     16.90
VEL3   1.0                    0.10 0.20 0.60 0.40 0.60 0.60 0.70 0.80
VEL3   1.0 1.30 0.70 0.70 0.90 1.30 1.10 0.70 0.50 0.00
XSEC   2.0       0.0 1.0     88.70   0.01500
       2.0  0.0 92.5  4.2 91.9  5.9 89.8  6.4 89.7  8.4 89.1 10.4 89.2
       2.0 12.4 89.2 14.4 89.3 16.4 89.3 18.4 88.8 19.9 88.7 21.4 88.6
       2.0 22.9 88.4 24.4 88.7 25.9 88.8 27.4 89.1 28.3 89.3 29.5 90.2
       2.0 31.9 90.9
NS     2.0       2.0       2.0       2.0       2.0       6.0       6.0
NS     2.0       4.0       7.0       7.0       6.0       6.0       6.0
NS     2.0       6.0       6.0       5.0       5.0       6.0       1.0
NS     2.0       1.0
WSL    2.0      89.3      89.4      89.5      89.6      89.6      89.6
WSL    2.0      89.7      89.8      89.8      89.9      89.9      89.9
WSL    2.0      90.0      90.0      90.0      90.1      90.1      90.1
WSL    2.0      90.1      90.2      90.2      90.2      90.2      90.3
WSL    2.0      90.3      90.3      90.3      90.3      90.4
CAL1   2.0     89.97     29.00     23.90
VEL1   2.0          0.10 0.10 0.30 0.60 0.80 0.80 1.60 1.00 1.60 2.20
VEL1   2.0 2.20 1.60 1.00 0.60 0.20
CAL2   2.0     89.82     17.00     16.20
VEL2   2.0          0.10 0.10 0.20 0.30 0.50 0.10 1.10 0.50 1.50 1.90
VEL2   2.0 1.10 1.60 0.90 0.40 0.10
CAL3   2.0     89.66     13.00      8.70
VEL3   2.0               0.10 0.20 0.20 0.40 0.10 0.10 0.40 1.30 1.70
VEL3   2.0 1.10 1.20 0.70 0.30 0.10
XSEC   3.0     245.0 1.0     89.10   0.01850
       3.0  0.0 94.6  7.0 94.4  7.5 90.4  8.3 89.8  9.8 89.6 11.3 89.3
       3.0 12.8 89.1 14.3 89.3 15.8 89.4 17.3 89.4 18.8 89.8 20.3 89.6
       3.0 21.8 89.6 23.3 89.7 24.8 90.1 26.3 90.1 27.8 90.0 29.3 90.2
       3.0 30.8 90.3 31.5 90.4 32.3 90.7 36.3 93.0 37.2 93.2
NS     3.0       1.0       1.0       7.0       7.0       7.0       6.0
NS     3.0       6.0       7.0       7.0       7.0       6.0       6.0
NS     3.0       6.0       6.0       6.0       6.0       6.0       6.0
NS     3.0  1.0  2.0  1.0  2.0       2.0       1.0       1.0
WSL    3.0      90.2      90.3      90.3      90.4      90.4      90.4
WSL    3.0      90.5      90.5      90.5      90.5      90.5      90.6
WSL    3.0      90.6      90.6      90.6      90.6      90.6      90.6
WSL    3.0      90.7      90.7      90.7      90.7      90.7      90.7
WSL    3.0      90.7      90.7      90.7      90.7      90.7
CAL1   3.0     90.59     29.00     38.60
VEL1   3.0          0.10 0.40 1.70 2.50 3.20 0.90 1.10 4.20 3.00 2.20
VEL1   3.0 0.70 3.80 2.50 1.40 2.20 2.10 0.20 0.10
CAL2   3.0     90.46     17.00     23.10
VEL2   3.0          0.10 0.40 1.40 1.90 2.10 0.30 0.30 3.20 1.10 0.80
VEL2   3.0 0.60 2.70 1.70 1.10 1.40 1.80 0.40 0.10
CAL3   3.0     90.44     13.00     13.60
VEL3   3.0          0.10 0.10 1.30 1.60 1.90 0.10 0.10 0.50 0.20 0.40
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VEL3   3.0 0.10 2.00 1.30 0.20 1.20 0.90 0.10 0.10
XSEC   4.0     310.0 1.0     89.90   0.00001
       4.0  0.0 94.7  4.8 94.6  5.8 91.0  8.3 90.1  9.8 90.0 11.3 89.9
       4.0 12.8 90.2 14.3 89.9 15.8 90.0 16.8 90.1 17.8 90.2 19.4 90.3
       4.0 20.8 90.4 22.3 90.7 22.4 91.0 26.0 93.1 28.1 93.4
NS     4.0       7.0       7.0       7.0       7.0       7.0       6.0
NS     4.0       7.0       7.0       7.0       6.0       6.0       6.0
NS     4.0       5.0       5.0       5.0       7.0       7.0
WSL    4.0      90.5      90.6      90.7      90.7      90.8      90.8
WSL    4.0      90.9      91.0      91.0      91.0      91.1      91.1
WSL    4.0      91.1      91.1      91.2      91.2      91.2      91.3
WSL    4.0      91.3      91.3      91.3      91.3      91.4      91.4
WSL    4.0      91.4      91.4      91.4      91.5      91.5
CAL1   4.0     91.14     29.00     25.00
VEL1   4.0           0.10 1.90 0.90 2.20 2.90 2.30 2.10 1.00 1.30 1.20
VEL1   4.0 0.90 0.70 0.10
CAL2   4.0     90.96     17.00     16.80
VEL2   4.0           0.10 1.90 0.80 1.60 1.90 1.50 1.40 0.80 0.70 1.10
VEL2   4.0 0.70 0.50 0.10
CAL3   4.0     90.85     13.00     11.50
VEL3   4.0                1.50 0.70 1.30 1.40 1.40 1.00 0.80 0.40 1.10
VEL3   4.0 0.50 0.50
XSEC   5.0       0.0 1.0     89.90   0.03300
       5.0  0.0 93.7  2.2 91.8  2.8 91.0  3.3 90.7  4.3 90.2  5.3 90.0
       5.0  6.3 89.8  7.3 89.9  8.8 89.9 10.3 89.9 11.3 90.0 12.3 89.5
       5.0 13.3 89.4 14.3 89.5 15.3 90.4 16.3 90.4 17.3 89.4 18.3 89.7
       5.0 20.0 92.0 23.1 93.5 24.4 94.0
NS     5.0       6.0       6.0       2.0       3.0       4.0       6.0
NS     5.0       6.0       6.0       7.0       7.0       7.0       7.0
NS     5.0       7.0       6.0       7.0       7.0       6.0       7.0
NS     5.0       7.0       7.0       1.0
WSL    5.0      90.6      90.7      90.8      90.8      90.9      90.9
WSL    5.0      91.0      91.0      91.0      91.1      91.1      91.1
WSL    5.0      91.2      91.2      91.2      91.2      91.3      91.3
WSL    5.0      91.3      91.3      91.3      91.4      91.4      91.4
WSL    5.0      91.4      91.4      91.4      91.5      91.5
CAL1   5.0     91.15     29.00     31.40
VEL1   5.0           0.10 0.20 0.10 1.70 2.40 0.30 0.40 2.30 3.20 4.00
VEL1   5.0 3.80 3.00 1.60 0.40 0.10 0.20
CAL2   5.0     91.04     17.00     18.80
VEL2   5.0           0.10 0.10 0.10 1.30 2.00 0.20 0.10 0.70 1.60 2.30
VEL2   5.0 2.50 2.40 1.10 0.20 0.10 0.10
CAL3   5.0     90.90     13.00     10.20
VEL3   5.0           0.10 0.10 0.10 0.50 1.20 0.10 0.10 0.20 0.50 0.20
VEL3   5.0 1.90 2.30 0.90 0.10 0.10 0.10
XSEC   6.0      70.0 0.3     90.40   0.34780
       6.0  0.0 95.4  4.2 92.8  6.2 91.1  7.2 90.6  8.2 90.6  9.2 90.5
       6.0 10.2 90.7 11.2 90.6 12.2 90.4 13.2 91.3 14.2 91.2 15.2 90.8
       6.0 16.2 90.9 17.2 91.1 18.2 91.0 19.2 90.9 20.2 91.0 21.7 91.2
       6.0 22.4 91.5 24.7 93.0 29.5 94.3
NS     6.0       2.0       1.0       6.0       6.0       6.0       6.0
NS     6.0       7.0       6.0       7.0       7.0       7.0       7.0
NS     6.0       6.0       7.0       7.0       7.0       6.0       7.0
NS     6.0       6.0       1.0       1.0
WSL    6.0      91.0      91.1      91.2      91.3      91.3      91.4
WSL    6.0      91.4      91.4      91.5      91.5      91.6      91.6
WSL    6.0      91.6      91.6      91.7      91.7      91.7      91.7
WSL    6.0      91.8      91.8      91.8      91.8      91.8      91.9
WSL    6.0      91.9      91.9      91.9      91.9      91.9
CAL1   6.0     91.63     29.00     28.10
VEL1   6.0           1.20 1.20 1.10 1.90 5.70 1.20 1.90 5.30 3.70 2.60
VEL1   6.0 2.80 4.20 4.20 3.40 2.50 3.20 0.10
CAL2   6.0     91.46     17.00     17.70
VEL2   6.0           0.30 0.40 0.80 1.80 3.10 0.40 1.80 4.20 2.60 2.30
VEL2   6.0 2.40 0.80 0.90 1.60 2.50 2.00 0.10
CAL3   6.0     91.36     13.00     12.10
VEL3   6.0           0.10 0.10 0.10 1.50 2.30 0.20 1.30 2.30 2.40 1.40
VEL3   6.0 1.00 0.20 0.10 0.80 0.60 0.10 0.10
XSEC   7.0     375.0 0.0     91.30   0.34780
       7.0  0.0 95.9  3.3 95.8  4.6 95.4  4.9 92.2  5.2 91.9  6.7 91.7
       7.0  8.2 91.3  9.7 91.4 11.2 91.5 12.7 92.0 14.2 91.6 15.7 91.5
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       7.0 17.2 91.6 18.7 91.4 20.2 91.5 21.7 91.6 23.2 91.8 24.6 92.2
       7.0 24.8 92.2 29.2 93.7 31.7 94.7
NS     7.0       1.0       1.0       2.0       7.0       7.0       7.0
NS     7.0       6.0       6.0       6.0       7.0       6.0       6.0
NS     7.0       6.0       6.0       6.0       6.0       6.0       6.0
NS     7.0       6.0       2.0       1.0
WSL    7.0      91.8      91.9      92.0      92.0      92.1      92.1
WSL    7.0      92.2      92.2      92.2      92.3      92.3      92.3
WSL    7.0      92.3      92.4      92.4      92.4      92.4      92.4
WSL    7.0      92.4      92.5      92.5      92.5      92.5      92.5
WSL    7.0      92.5      92.6      92.6      92.6      92.6
CAL1   7.0     92.34     29.00     31.30
VEL1   7.0               0.10 2.10 3.10 2.90 4.30 3.70 3.00 3.00 3.10
VEL1   7.0 2.50 2.20 1.90 0.50 0.40 0.10
CAL2   7.0     92.22     17.00     19.70
VEL2   7.0               0.10 0.50 1.90 2.50 2.20 3.40 2.70 2.00 1.80
VEL2   7.0 1.70 1.60 1.60 0.10 0.30 0.10
CAL3   7.0     92.12     13.00     15.50
VEL3   7.0                    0.10 0.70 2.40 0.90 3.10 2.20 1.40 1.50
VEL3   7.0 1.30 1.10 1.40 0.10 0.10 0.10
ENDJ

Big_Timber Study Site 7 - substrate
Export from PHABSIM for Windows
IOC      000000010001000010000
QARD   5.0
QARD  10.0
QARD  15.0
QARD  17.0
QARD  20.0
QARD  25.0
QARD  27.0
QARD  30.0
QARD  35.0
QARD  40.0
QARD  45.0
QARD  47.0
QARD  50.0
QARD  55.0
QARD  60.0
QARD  65.0
QARD  70.0
QARD  75.0
QARD  80.0
QARD  85.0
QARD  90.0
QARD  95.0
QARD 100.0
XSEC   1.0       0.0 1.0     92.70   0.01550
       1.0  0.0 96.0  8.3 95.1  8.4 94.5  8.6 94.1  9.6 93.9 10.6 94.2
       1.0 11.6 94.0 12.6 93.9 13.6 93.7 14.6 93.5 15.6 93.3 16.6 92.8
       1.0 17.6 92.8 18.6 92.7 19.6 92.8 20.6 92.9 21.6 93.5 22.6 92.8
       1.0 23.6 92.8 24.6 93.6 25.6 93.5 26.6 93.7 27.6 93.8 28.6 94.0
       1.0 28.8 94.9 30.3 95.9 31.8 96.0
NS     1.0       6.0       6.0       6.0       6.0       6.0       6.0
NS     1.0       6.0       6.0       8.0       8.0       8.0       8.0
NS     1.0       8.0       8.0       8.0       8.0       8.0       8.0
NS     1.0       8.0       8.0       8.0       6.0       6.0       6.0
NS     1.0       6.0       6.0       6.0
WSL    1.0      93.9      94.1      94.2      94.2      94.3      94.3
WSL    1.0      94.4      94.4      94.4      94.5      94.5      94.6
WSL    1.0      94.6      94.6      94.7      94.7      94.7      94.7
WSL    1.0      94.8      94.8      94.8      94.8      94.9
CAL1   1.0     94.56     47.00     54.20
VEL1   1.0          0.10 0.60 0.60 0.80 0.80 0.90 1.40 1.80 2.50 3.10
VEL1   1.0 3.30 3.00 2.70 3.00 4.00 2.40 2.50 2.90 1.40 1.70 0.80 0.10
VEL1   1.0
CAL2   1.0     94.35     27.00     31.20
VEL2   1.0          0.10 0.10 0.30 0.40 0.50 0.70 0.60 1.10 1.30 1.70
VEL2   1.0 1.80 2.30 2.50 3.00 2.90 2.10 1.60 1.50 0.90 0.70 0.10 0.10
VEL2   1.0
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CAL3   1.0     94.21     17.00     18.10
VEL3   1.0                              0.10 0.30 0.60 0.80 0.90 1.00
VEL3   1.0 1.30 1.50 0.80 1.90 2.00 1.50 1.30 1.00 0.70 0.10 0.10 0.10
VEL3   1.0
XSEC   2.0     310.0 1.0     94.10   0.26500
       2.0  0.0 97.2  8.3 95.8  9.0 95.3  9.9 95.4 10.0 95.2 11.5 94.7
       2.0 13.0 94.4 14.5 94.8 16.0 94.7 17.5 94.8 19.0 94.5 20.5 94.9
       2.0 22.0 94.4 23.5 94.5 25.0 94.3 26.5 94.1 28.0 94.4 29.5 94.6
       2.0 31.0 94.8 32.5 94.8 34.0 95.0 35.5 95.1 37.8 95.4 38.5 95.6
       2.0 40.3 97.3 42.6 97.3
NS     2.0       6.0       6.0  1.5  6.0  1.0  6.0  1.0  6.0  1.0  6.0
NS     2.0       6.0       8.0       8.0       8.0       8.0       8.0
NS     2.0       8.0       8.0       8.0       8.0       8.0       8.0
NS     2.0       8.0       8.0       8.0       8.0       3.0       1.0
NS     2.0       1.0       1.0
WSL    2.0      94.9      95.1      95.1      95.2      95.2      95.3
WSL    2.0      95.3      95.3      95.3      95.4      95.4      95.4
WSL    2.0      95.4      95.5      95.5      95.5      95.5      95.5
WSL    2.0      95.6      95.6      95.6      95.6      95.6
CAL1   2.0     95.41     47.00     53.30
VEL1   2.0                    0.10 0.60 0.60 3.20 1.40 2.40 4.00 4.20 3.70
VEL1   2.0 2.50 3.30 3.10 3.30 2.40 3.00 2.30 2.20 1.80 1.00 0.10
VEL1   2.0
CAL2   2.0     95.27     27.00     33.00
VEL2   2.0                    0.10 0.10 0.10 2.60 0.80 2.20 3.10 2.80 3.50
VEL2   2.0 2.50 2.20 2.20 2.90 1.60 2.60 1.70 1.30 1.70 0.80 0.10
VEL2   2.0
CAL3   2.0     95.17     17.00     20.30
VEL3   2.0                              0.10 0.60 0.30 1.70 1.70 2.20 2.10
VEL3   2.0 1.30 1.60 1.90 2.00 1.40 1.40 1.00 1.10 0.10
VEL3   2.0

XSEC   3.0     560.0 1.0     95.00   0.00250
       3.0  0.0 98.8  7.7 96.6  8.5 96.4  9.5 96.0 11.5 95.7 13.5 95.7
       3.0 15.5 95.7 17.5 95.6 19.5 95.6 21.5 95.4 23.5 95.4 25.5 95.9
       3.0 27.5 95.8 29.5 95.7 31.5 95.5 33.5 95.0 35.5 95.6 37.5 95.4
       3.0 39.5 95.4 41.5 95.5 43.6 95.7 46.6100.2
NS     3.0       8.0       6.0       6.0       8.0       6.0       1.0
NS     3.0       8.0       8.0       8.0       8.0       8.0       8.0
NS     3.0       8.0       8.0       8.0       8.0       8.0       8.0
NS     3.0       8.0       8.0       8.0       2.0
WSL    3.0      95.8      95.9      96.0      96.1      96.1      96.2
WSL    3.0      96.2      96.2      96.3      96.3      96.3      96.4
WSL    3.0      96.4      96.4      96.4      96.5      96.5      96.5
WSL    3.0      96.5      96.5      96.6      96.6      96.6
CAL1   3.0     96.36     47.00     48.40
VEL1   3.0               0.10 0.30 2.50 3.00 3.50 3.30 2.80 2.10 1.50 1.20
VEL1   3.0 1.60 1.70 1.60 1.50 1.30 1.20 1.20 0.90 1.60
CAL2   3.0     96.16     27.00     27.90
VEL2   3.0               0.10 0.20 1.40 2.30 3.20 2.90 2.40 1.80 1.30 1.10
VEL2   3.0 1.00 1.20 0.80 1.00 1.10 1.10 1.10 1.00 1.10
CAL3   3.0     96.09     17.00     21.00
VEL3   3.0                    0.10 1.00 1.70 2.10 2.10 2.30 1.70 1.30 0.80
VEL3   3.0 0.60 0.50 0.50 0.60 1.10 1.00 1.00 1.00 0.70
XSEC   4.0       1.0 0.5     95.00   0.01250
       4.0  0.0100.1 11.1 97.3 12.3 96.7 13.5 96.4 13.9 96.3 15.9 96.2
       4.0 17.9 95.9 19.9 95.7 21.9 95.4 23.9 95.4 25.9 95.6 27.9 95.9
       4.0 28.9 95.9 30.9 95.4 32.9 94.9 34.9 94.6 36.9 94.4 38.9 94.8
       4.0 40.9 94.5 42.9 94.5 44.9 95.3 46.9 95.9 47.7 96.4 48.7 96.6
       4.0 51.4 97.6 52.2 97.6 55.2100.0 56.6100.1
NS     4.0       8.0       8.0       8.0       1.0       1.0       8.0
NS     4.0       8.0       8.0       8.0       8.0       8.0       8.0
NS     4.0       8.0       8.0       8.0       8.0       8.0       8.0
NS     4.0       8.0       8.0       8.0       8.0       8.0       8.0
NS     4.0       5.0       7.0       2.0       1.0
WSL    4.0      95.8      96.0      96.1      96.1      96.1      96.2
WSL    4.0      96.2      96.2      96.3      96.3      96.4      96.4
WSL    4.0      96.4      96.4      96.5      96.5      96.5      96.6
WSL    4.0      96.6      96.6      96.6      96.7      96.7
CAL1   4.0     96.38     47.00     46.10
VEL1   4.0                    0.10 0.10 1.40 3.30 3.70 3.60 3.10 2.00 1.80
```

```
VEL1   4.0 1.30 0.10 0.30 0.70 2.70 0.80 0.20 0.90 0.30 0.70 0.10
VEL1   4.0
CAL2   4.0     96.17     27.00     27.00
VEL2   4.0                0.10 0.10 1.10 2.40 3.70 3.10 2.50 1.90 1.30
VEL2   4.0 1.00 0.10 0.10 0.60 1.90 0.20 0.20 0.50 0.10 0.10
VEL2   4.0
CAL3   4.0     96.14     17.00     19.10
VEL3   4.0                          0.10 1.60 2.30 2.50 2.30 1.50 1.00
VEL3   4.0 0.70 0.10 0.10 0.20 1.10 0.10 0.10 0.40 0.10
VEL3   4.0
XSEC   5.0     130.0 0.0     94.60   0.01250
       5.0  0.0 97.9  5.3 97.1  8.5 96.3  8.8 96.6 11.5 97.9 12.9 97.6
       5.0 15.9 98.3 17.7 95.4 19.4 94.9 23.4 95.4 24.2 94.9 24.5 94.8
       5.0 25.7 94.6 26.3 97.1 27.9 96.8 28.3 96.8 34.3 96.8 35.2 97.9
       5.0 41.3100.2
NS     5.0       6.0       6.0  1.0  6.0  1.0  8.0       8.0       8.0
NS     5.0       8.0       8.0       8.0       8.0       8.0       8.0
NS     5.0       8.0       8.0  1.0  8.0  1.0  6.0  1.0  6.0  1.0  6.0
NS     5.0       8.0
WSL    5.0      95.9      96.1      96.3      96.4      96.4      96.5
WSL    5.0      96.6      96.6      96.7      96.8      96.8      96.9
WSL    5.0      96.9      96.9      97.0      97.0      97.1      97.1
WSL    5.0      97.2      97.2      97.2      97.3      97.3
CAL1   5.0     96.86     47.00     43.30
VEL1   5.0                                     2.80 6.20 0.10 6.20 5.60
VEL1   5.0 4.50
CAL2   5.0     96.55     27.00     37.60
VEL2   5.0                                     0.10 4.30 0.10 5.90 5.00
VEL2   5.0 0.90
CAL3   5.0     96.36     17.00     11.30
VEL3   5.0                                     0.10 0.80 0.10 1.60 2.40
VEL3   5.0 0.60
ENDJ
```