RECLAMATION

Managing Water in the West

Flow Characterization Study

Instream Flow Assessment Big Eightmile Creek, Bohannon Creek, and Hayden Creek, Idaho

June 2005

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Flow Characterization Study

Instream Flow Assessment Big Eightmile Creek, Bohannon Creek, and Hayden Creek, Idaho

Prepared for:

U.S. Department of the Interior
Bureau of Reclamation
Snake River Area Office
Boise, Idaho

by:

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Abbreviations

BIA	Bureau of Indian Affairs
BiOp	Biological Opinion
BLM	Bureau of Land Management
DPS	Distinct Population Segment
ESA	Endangered Species Act
ESU	Evolutionary Significant Unit
FCRPS	Federal Columbia River Power System
FWS	Fish and Wildlife Service
GPS	Global Positioning System
HABTAE	Habitat program option in PHABSIM for Windows
HC	Hydraulic control
HSC	Habitat Suitability Criteria
IDEQ	Idaho Department of Environmental Quality
IDFG	Idaho Department of Fish and Game
MANSQ	Mannings equation
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PHABSIM	Physical Habitat Simulation System
Q	Discharge (flow)
Q.20	Daily mean discharge exceeded 20 percent of the time during a specified month
Q.50	Daily mean discharge exceeded 50 percent of the time during a specified month (same as median discharge)
Q.80	Daily mean discharge exceeded 80 percent of the time during a specified month
Reclamation	Bureau of Reclamation
RPA	Reasonable and Prudent Alternative
SI	Suitability index
STGQ	Stage-discharge relation
TMDL	Total Maximum Daily Limit
TSC	Technical Service Center
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
VAF	Velocity adjustment factor
WSL	Water surface elevation
WSP	Water surface profile
WUA	Weighted usable area

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Summary

The Bureau of Reclamation conducted flow characterization and habitat studies on Big Eightmile Creek, Bohannon Creek, and Hayden 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*). Average snowpack level in the Lemhi headwaters on April 1, 2004 was 70 percent of normal. Big Eightmile Creek and Bohannon Creek flows were continuously recorded upstream from major diversions using a stage recorder during the 2004 irrigation season. Big Eightmile Creek flows ranged from 96 cfs on June 6 to 9 cfs on September 10. Bohannon Creek flows ranged from 24 cfs on June 6 to 4.9 cfs on September 10. Water temperatures were also monitored in 2004 and compared to Idaho water quality standards. Reclamation characterized flow needs for various life stages of the selected species using the Physical Habitat Simulation (PHABSIM) model at each study site. Data were collected at a total of 13 study sites: five each on Big Eightmile Creek and Bohannon Creek and three on Hayden Creek. Study sites were selected in accessible areas to represent mesohabitat types within each stream reach distinguished by unique hydrology, channel morphology, slope, or land use characteristics. Attempts to conduct field surveys at low, medium, and high flows at most sites in Big Eightmile Creek and Bohannon Creek were confounded by upstream diversions. In most cases, only medium and low flows were measured. However, these conditions typically occur during the summer irrigation season with the diversions. This was not an issue on Hayden Creek. 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 Eightmile Creek and Bohannon Creek than upstream reaches. Thus, less flow was needed for optimal fish habitat in the lower reaches than the upper reaches given present stream channel morphology. For example, at Study Site 2 on lower Big Eightmile Creek, 12 cfs and 20 cfs provided optimal habitat for adult and spawning bull trout, respectively. These flows were less than optimal at Study Site 5, located upstream from the major diversions, where 24 cfs and 88 cfs optimized habitat for adults and spawning, respectively. On Bohannon Creek, flows that met the 0.6 depth adult passage criteria ranged from 6 cfs at Study Site 1 to 19 cfs further upstream at Study Site 3. Study results can be used to prioritize cost-effective actions to improve fish habitat for Endangered Species Act (ESA)–listed anadromous and native fish species in the sub-basin. These actions may include acquiring water during critical low-flow periods by leasing or modifying irrigation delivery systems to minimize out-of-stream diversions.

1.0 INTRODUCTION

The National Marine Fisheries Service (NMFS) (currently National Oceanic Atmospheric Administration (NOAA) Fisheries) issued a Biological Opinion (BiOp) in December 2000 on continued operation and configuration of the Federal Columbia River Power System (FCRPS) (NMFS 2000). Unless actions identified in the Reasonable and Prudent Alternative (RPA) of the BiOp are taken, a jeopardy opinion may be issued for continued operation of the FCRPS. As part of the RPA, NMFS identified the need to improve migration, spawning, and rearing habitat in priority subbasins as part of an off-site mitigation program. In part to address that need, RPA Action 149 of the BiOp requires that the Bureau of Reclamation (Reclamation) "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." Thus, the objective of Action 149 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. Reclamation is the lead agency for these initiatives and will facilitate their implementation.

The 2000 BiOp identified priority sub-basins where addressing flow, passage, and screening problems could produce short term benefits. 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.

On November 30, 2004, NOAA Fisheries issued a new BiOp for the FCRPS in response to a court order in June of 2003. Action 149 objectives are restated in terms of specific metric goals in selected subbasins for entrainment (screens), stream flow, and channel morphology (passage and complexity) in the 2004 BiOp. The work described in this report addresses Reclamation obligations to improve stream flow in selected subbasins under both the 2000 and 2004 BiOps.

To support this work, Action 149 stated that NMFS would supply Reclamation with "passage and screening criteria and one or more methodologies for determining instream flows that will satisfy Endangered Species Act (ESA) requirement." One of the methodologies recommended in NOAA Fisheries protocol for estimating tributary streamflow to protect salmon listed under the ESA was the Physical Habitat Simulation System (PHABSIM) (Arthaud et al. 2001). The only other method suggested was the hydrology-based Tennant method (Arthaud et al. 2001). However, PHABSIM was considered a more appropriate methodology since it considers the biological requirements of the fish. The NOAA Fisheries draft protocol describes methods to estimate annual flow regimes and minimum flow conditions necessary to protect sensitive salmonid life stages using PHABSIM results for Pacific and interior northwest streams (Arthaud et al. 2001).

PHABSIM predicts changes in relationships between instream flows and fish habitat for individual species and life stages. PHABSIM is best used for decision-making when alternative flows are being evaluated (Bovee et al. 1998). Stream flow and habitat data are used in a group of computer models called PHABSIM. Hydraulic models are used to calculate water surface elevations and depths and to simulate velocities for specific discharges. 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. It is, however, data intensive and it does take time to achieve results. 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, habitat versus flow relationship, must be integrated with species life history knowledge.

Priority streams have been identified in the Lemhi River sub-basin based on inventory and assessment needs. Reclamation's objective in 2004 was to conduct habitat studies on Big Eightmile Creek, Bohannon Creek, and Hayden Creek to identify stream flow needs to support relevant life history stages of summer steelhead (*Oncorhynchus mykiss*), spring/summer Chinook salmon (*O. tschawytscha*), and bull trout (*Salvelinus confluentus*). Previous similar studies conducted by Reclamation (Sutton and Morris 2004) and U.S. Geological Survey (USGS) (Maret et al. 2004) are available at the following web site: http://id.water.usgs.gov/projects/salmon_streamflow/index.html. Information obtained from these studies 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 adult holding 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 (USFS), and Shoshone-Bannock Tribes compiled professional biological recommendations and known anadromous and resident fish population densities and Chinook redd counts (Upper Salmon Basin Watershed Project Technical Team 2005). 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 (http://www.modelwatershed.org/Library.html). 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

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.

1.2.1 Steelhead

The Snake River Basin Ecologically Significant Unit (ESU) of steelhead trout was listed as threatened under ESA on August 18, 1997 (Federal Register, Vol. 62 , No. 159). Critical habitat for this ESU was designated February 16, 2000 (Federal Register, Vol. 65, No. 32), 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).

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 Sub-basin is summarized in Table 1.

Table 1. Periodicity chart for steelhead in Lemhi River Sub-basin (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).

Documentation of the presence of juvenile, and adult wild and hatchery steelhead has been found in the mainstem of Bohannon Creek, as well as attempted spawning of adult hatchery steelhead in the lower portion of Bohannon Creek (Murphy and Yanke, 2003). There is no known or written information to document the use of Big Eightmile Creek or its tributaries as spawning areas for steelhead (Murphy and Horsmon 2004).

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 serve 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. Juvenile and adult wild and hatchery steelhead have been found in Bohannon Creek (Murphy and Yanke 2003). Landowners have observed steelhead spawning near the BC-06 diversion downstream of the confluence of East Fork Bohannon Creek. There is also documentation of attempted spawning of adult hatchery steelhead in lower Bohannon Creek (Murphy and Yanke 2003).

Irrigation, grazing, and road construction have affected habitat conditions throughout the Lemhi Sub-basin (NPPC 2001). Limiting factors on the mainstem Lemhi 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.

1.2.2 Spring/Summer Chinook Salmon

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, No. 78, 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). These waters include Hayden, Bohannon, and Big Eightmile Creeks and their tributaries (Murphy and Yanke 2003; Murphy and Horsmon 2004).

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 over Bonneville Dam from March 1 to May 31 are considered "spring Chinook" and those that pass from June 1 to July 31 are considered "summer Chinook." Spring Chinook are the most prevalent and are found within the upper drainages of the Salmon basin. Summer Chinook are more limited in their distribution, being found in mainstem reaches of the upper Salmon basin (R2 Resource Consultants 2004). Spawning occurs in August through October. Eggs hatch in April and May, and the fry emerge approximately one month later. Juveniles rear for one year before out-migrating to the ocean (Simpson and Wallace 1982). Periodicity for Chinook salmon in the Lemhi River Sub-basin is summarized in Table 2.

Spring 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 (Bureau of Reclamation 2003). Most spring/summer 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 (Bureau of Reclamation 2003). Figure 1 shows locations of Hayden Creek Chinook salmon redds in 2003. Juveniles reside in rearing areas for approximately 12 months before migrating downstream the following April and May (Bugert et al. 1990; Cannamela 1992).

There is no known documentation that Chinook salmon use Bohannon Creek or Big Eightmile Creek or their tributaries as spawning areas (Murphy and Yanke 2003; Murphy and Horsmon 2004). Other threats to Chinook salmon are the same as those discussed for steelhead in the Lemhi Sub-basin.

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

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

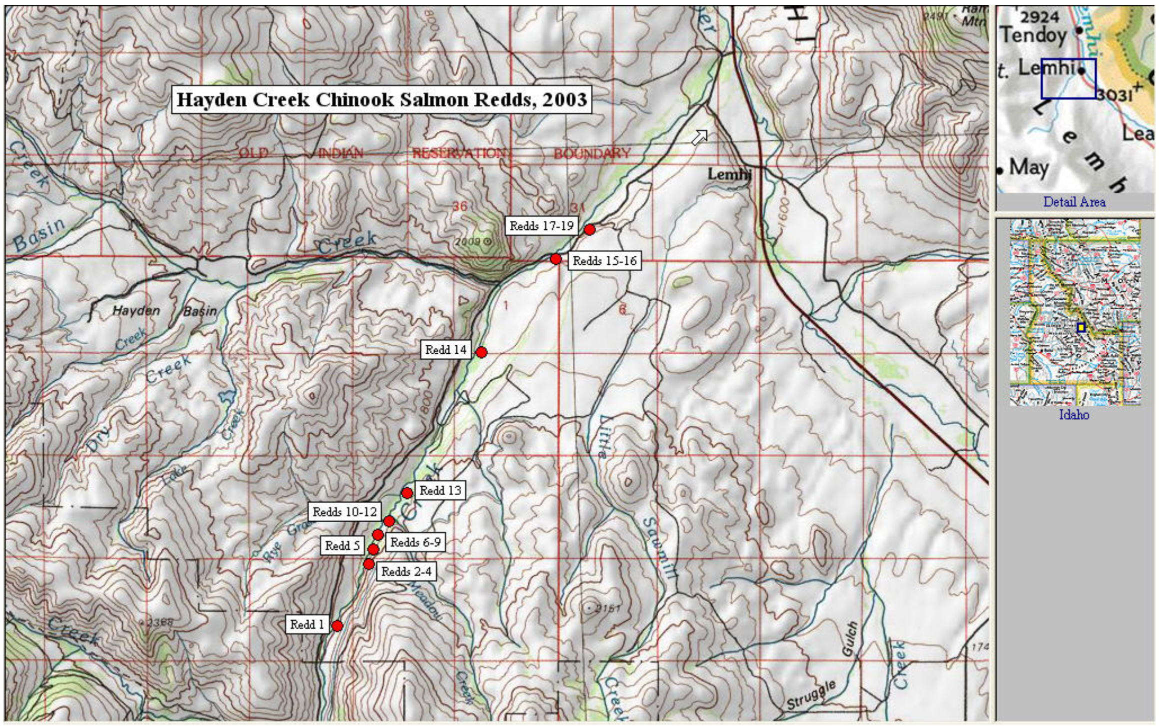

Figure 1. Chinook salmon redds in Hayden Creek, 2003 (IDFG, written communication, 2004).

1.2.3 Bull Trout

Bull trout are listed as threatened under the Federal ESA (Federal Register, Vol. 63, No. 111, June 10 1998) and as a species of concern by the State of Idaho. 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 Distinct Population Segments (DPS) of bull trout (Federal Register Vol. 68, No. 28, February 11, 2003). Final critical habitat designation by the FWS does not include the Lemhi River Sub-basin (Federal Register, Vol. 69, No. 193, October 6, 2004).

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 (10 cm) in length, they move to backwater and sidewater channels, eddies, or pools (Goetz 1989). Periodicity for bull trout in the Lemhi River Sub-basin is summarized in Table 3.

Table 3. Periodicity chart for bull trout in Lemhi River Sub-basin (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). Table 4 summarizes bull trout redd counts in Hayden Creek drainage between 2002 and 2004.

Table 4. Bull trout redd counts in Hayden Creek drainage (W. Koons, IDFG, written communication, December 10, 2004)

Date of Survey	Location	Number of Redds	Notes
9/4/2002	Bear Valley Creek	26	
9/4/2002	East Fork Hayden Creek	33	
9/8/2003	Bear Valley Creek	42	
9/8/2003	East Fork Hayden Creek	25	
9/8/2004	Bear Valley Creek	44	lots of adults, some in process of redd building. Number of adults observed - 24
9/8/2004	East Fork Hayden Creek	26	few redds relative to numbers of fish observed

Bull trout have been documented as present in the middle and headwaters of Bohannon and Big Eightmile Creeks, and it is likely that both fluvial and resident bull trout populations have occurred historically in these streams (Murphy and Yanke 2003; Murphy and Horsmon 2004). However, it is unknown if a fluvial life history is still present. Several barriers and obstacles are known to exist for bull trout in these streams, including navigating the dewatered sections in the spring/early summer seasons to reach potential headwater spawning areas and the presence of competition and hybridization with brook trout.

Other threats to bull trout and their habitat are the same as listed for steelhead in the Lemhi Sub-basin. Of particular concern to fluvial bull trout is dewatering of lower tributary reaches, elevated water temperatures, and un-screened diversion structures that inhibit downstream migration into mainstem waters.

2.0 STUDY REGION

The following definitions apply to the following discussion:
Study area – The study area is defined as one or more stream reaches impacted by flow alteration. Typically, a study area consists of stream reaches that represent small portions of each stream..
Stream segment – The portion of the study area that has a homogeneous stream flow and geomorphology (Bovee 1997). A study area may have one or more hydrologic segments (+/- 10% of the mean monthly flow (Q)).
Reach (*Study Site*) – A physical aspect of the channel within a stream segment that affects the microhabitat versus flow relationship (e.g., channel morphology, slope, or land use); contains multiple mesohabitat units (riffle, run, pool) within a stream segment.
Mesohabitat – Habitat types delineated by localized slope, channel shape, and structure (e.g., riffles, runs, pools).
Microhabitat – Habitats that represent relatively homogeneous area of about the size utilized by an individual fish (e.g., tree snags, undercut banks, velocity shelters).

Investigations were performed on three separate tributaries to the Lemhi River during the summer and fall of 2004. The study area consisted of five study sites on Big Eightmile Creek, five study sites on Bohannon Creek, and three on Hayden Creek. Field reconnaissance, topographic maps, and interviews with IDFG indicated that these creeks could be broken up into distinct hydrologic stream segments, defined as follows:

- Big Eightmile Creek: Considered one stream segment from the confluence of the Lemhi upstream to the confluence with Devil Canyon Creek.
- Bohannon Creek: Two distinct stream segments were defined: one from the confluence of the Lemhi upstream to the East Fork of Bohannon Creek, and the second upstream of the East Fork. The East Fork was not studied because of confounding flow effects from the Wimpy Creek transbasin diversion.
- Hayden Creek: Considered two stream segments: one from the confluence of the Lemhi River upstream to Basin Creek and the second segment between Basin Creek and Bear Creek.

Using USGS topographic maps, longitudinal gradient was plotted for each tributary (Figures 2-5). Within the different stream segments, several study sites were identified, distinguished primarily by differences in stream channel morphology and locations of major diversions for each tributary. These were distributed sequentially proceeding upstream. Each study site is described below and identified on Figures 2-5.

Big Eightmile Creek, Study Site 1: This reach was the most downstream site located between the Lemhi River confluence upstream to the first major diversion and contained very little flow throughout the year. It was characterized mainly by riffles and glides. Riparian vegetation was minimal at the study site.

Big Eightmile Creek, Study Site 2: This site was located downstream from a major diversion (LBEC-07). Another diversion located downstream from the study site representing this reach diverted most of the remaining flow. This reach primarily consisted of riffles and glides.

Big Eightmile Creek, Study Site 3: This site was located between two major diversions (LBEC-07 and LBEC-11). The study site was a mixture of riffle, pool and glide habitat types.

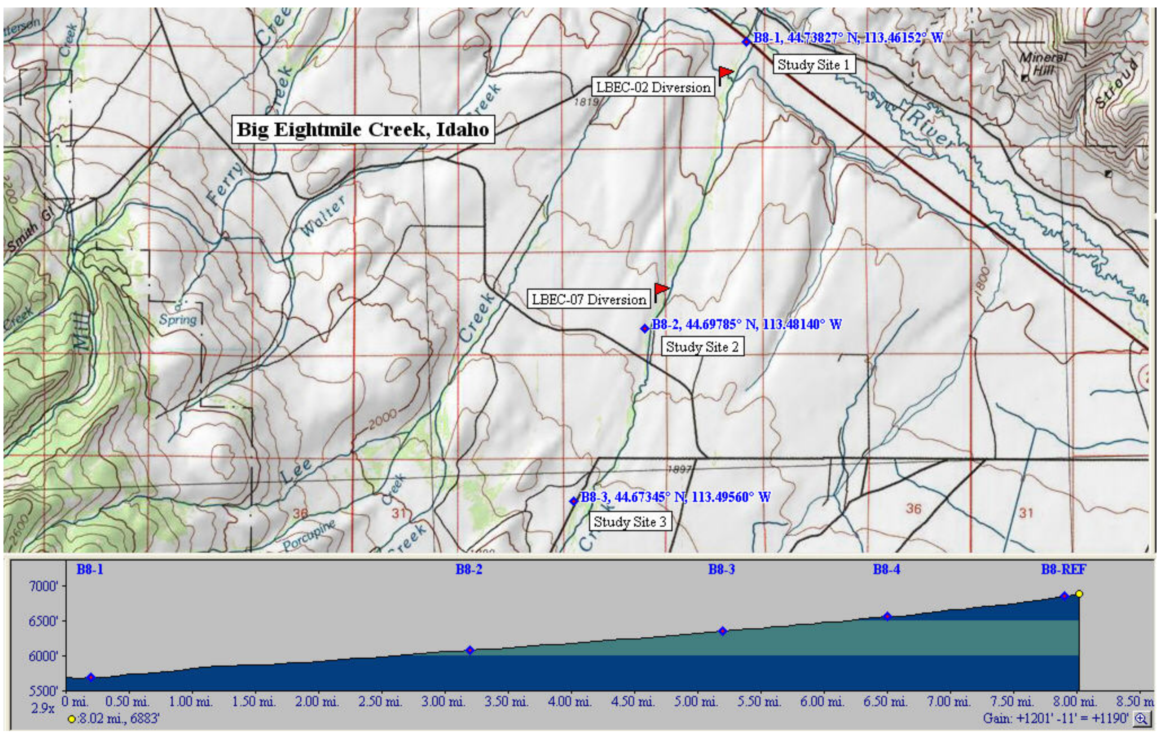

Figure 2. Big Eightmile Creek study area for flow characterization study and locations of study sites 1-3.

Big Eightmile Creek, Study Site 4: The upper and lower boundaries of the stream segment were two large diversions (LBEC-11 and LBEC-15). The study site for this reach was represented by a mixture of riffle and run habitat types. Riparian vegetation was thick in areas, consisting primarily of willows and cottonwood trees.

Big Eightmile Creek, Study Site 5 (Reference): This study site was located on Forest Service land, upstream of a large diversion (LBEC-15) and downstream of a small tributary (Devils Canyon). The study site represented natural flow conditions immediately upstream from the major diversions on Big Eightmile Creek.

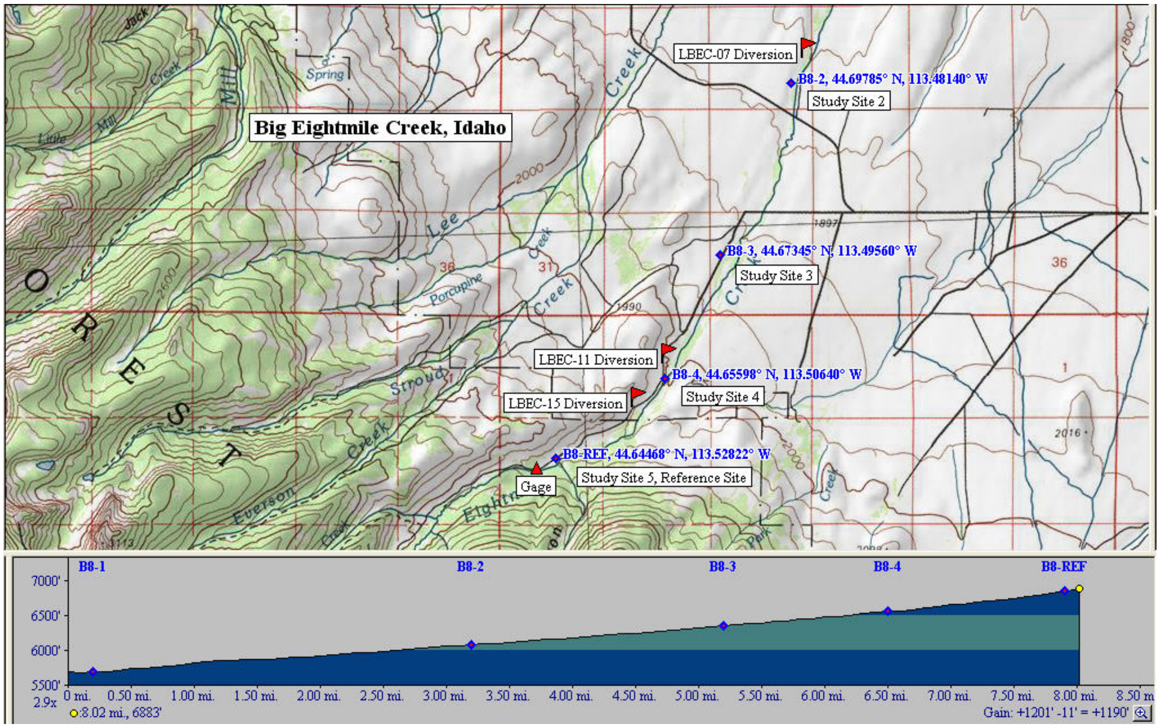

Figure 3. Big Eightmile Creek study area for flow characterization study and locations of study sites 2-5.

Bohannon Creek, Study Site 1: This site represented the stream from the confluence with the Lemhi River upstream to the first major diversion (BC-03). The stream channel was very narrow, and consisted of primarily glides and runs.

Bohannon Creek, Study Site 2: This stream segment extended from diversion BC-03 upstream to BC-04 diversion. The flow in this study site varied depending on how much water was taken or allowed to pass the next upper diversion.

Bohannon Creek, Study Site 3: This study site was located between BC-05 diversion upstream to the confluence with East Fork Bohannon Creek. Just upstream of the study site transects, the stream was braided for a short distance.

Bohannon Creek, Study Site 4: This study site represented the stream between the confluence of East Fork Bohannon Creek upstream to BC-07 diversion. This site had excellent riparian vegetation, and woody debris in and around the study site. Riparian vegetation was dominated by cottonwood trees and willows.

Bohannon Creek, Study Site 5 (Reference): This study site represented natural flow conditions immediately upstream from the last major diversion (BC-13).

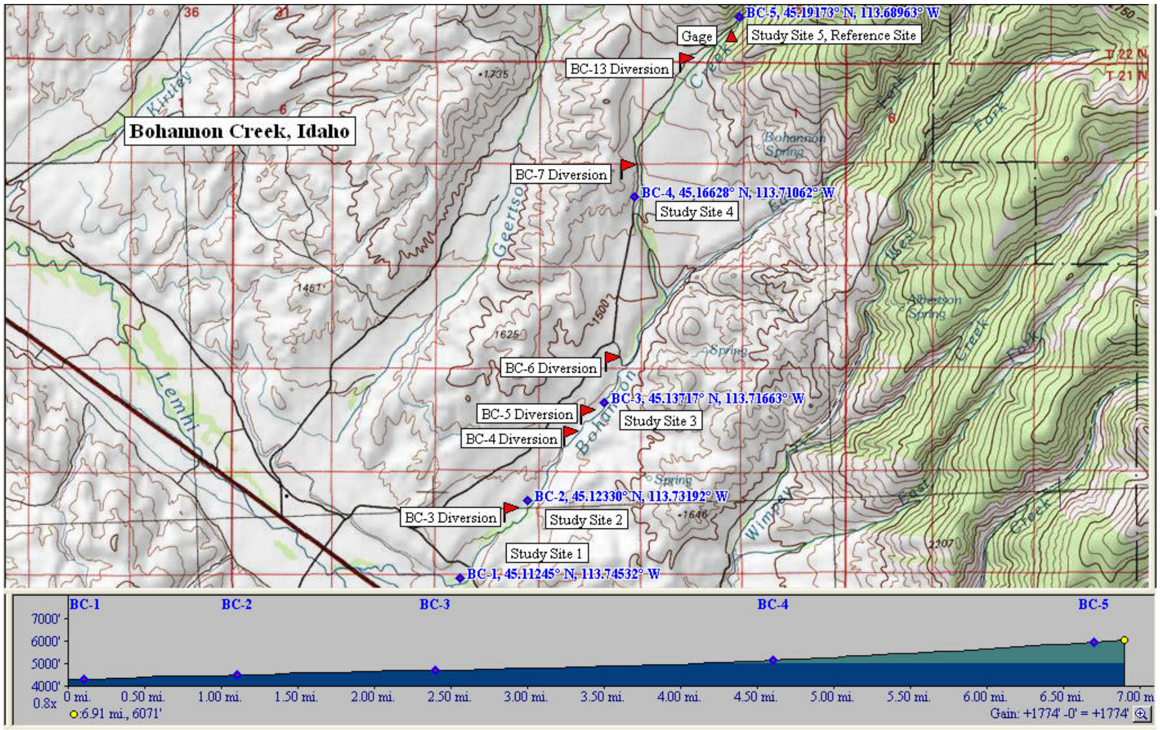

Figure 4. Bohannon Creek study area for flow characterization study and locations of study sites 1-5.

Hayden Creek, Study Site 1: This study site represented the stream segment between the confluence with the Lemhi River and the Basin Creek confluence. The study site was located immediately downstream of the first diversion.

Hayden Creek, Study Site 2: This study site represented the stream segement from Basin Creek upstream to a major diversion (LHC-10). This study site was characterized by a mixture of a pool, riffles and glides.

Hayden Creek, Study Site 3: This study site represented the stream segment between the LHC-10 diversion upstream to Bear Creek. This was the most upstream study site for Hayden Creek, representing the least impacted stretches of stream. This study site was the narrowest of the three study sites.

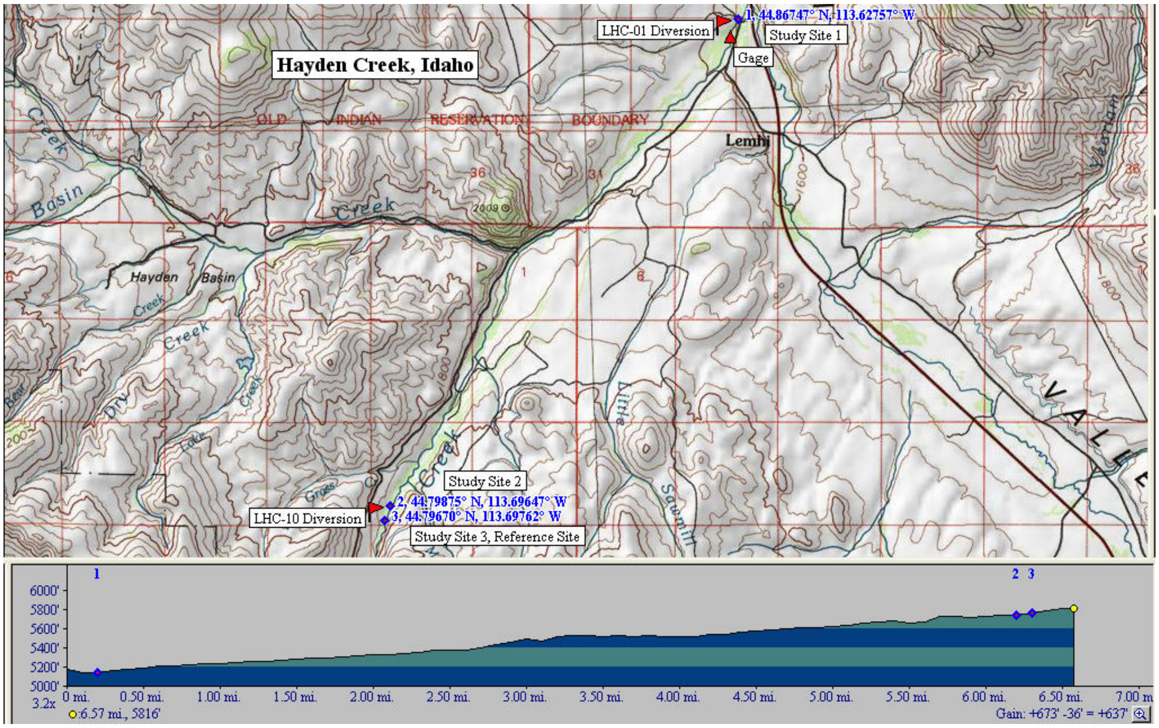

Figure 5. Hayden Creek study area for flow characterization study and locations of study sites 1-3.

3.0 LIMITING FACTORS ANALYSIS

The main components in this analysis were existing fish population, hydrology, and water quality data. Existing fish population data were used as an index of fish occurrence in the study streams (see Section 1.2). Existing USGS natural streamflow estimates and measured streamflows during 2004 were used to determine recent historic hydrology. Additionally, any existing water quality data, including water temperature, were evaluated to determine if water quality was limiting. Water temperature was monitored continuously at locations in Big Eightmile Creek (Study Site 2), Bohannon Creek (Study Site 1), and Hayden Creek (Study Site 1) by Reclamation between July and September, 2004 using Onset TidBit data loggers.

3.1 Climatic and Hydrologic Conditions

The average snowpack level in the Lemhi headwaters on April 1, 2004 was 70 percent of normal (Natural Resources Conservation Service 2005). The April 1 value is the most commonly used indicator of snowpack conditions since, in most years, it is the final value calculated before snowmelt begins. Streamflow forecast on April 1, 2004 mirrored the deteriorating snow conditions and called for only 41 percent of average in the Lemhi basin. The mean April 2004 air temperature at Salmon, Idaho was 9.6°C (49.3°F), compared to the 38-year mean of 8.2°C (46.8°F) (Western Regional Climate Center 2005).

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 conditions of Big Eightmile, Bohannon, and Hayden Creeks, upstream from the major diversions. An exceedance flow is defined as the flow that is equaled or exceeded a certain percentage of time. Flows calculated for 20, 50, and 80 percent exceedance for each creek at two separate locations are summarized in Tables 5-7. Flows were based on regional regression equations developed by USGS in Boise for the Forest Service (Hortness and Berenbrock 2001) (http://StreamStats.usgs.gov/html/index.html). Information on the accuracy of the regression equations is available in Hortness and Berenbrock (2001). Tables 8 and 9 are streamflows measured at temporary gage stations maintained by USGS on Big Eightmile and Bohannon Creeks during 2004.

The hydrology of Big Eightmile and Bohannon 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 Eightmile and Bohnannon Creeks are entirely or significantly diverted for irrigation purposes between late April and the end of October (IDEQ 1999). As a result, most available water in the two tributaries only reaches the Lemhi River during spring runoff. Figures 6-9 are graphical representations of tabular flows for Big Eightmile and Bohannon Creeks in summer 2004 using continuous gaging data and exceedance estimates.

Hayden Creek has a substantial amount of water year-round and is rarely, if ever, dewatered and disconnected at any point in the year, regardless of the many diversions. Figure 10 and Table 10 display the most recent available hydrology of Hayden Creek at a gage near its confluence with the Lemhi River.

Table 5. Monthly exceedance flows on Big Eightmile Creek using USGS regional regression equations (Hortness and Berenbrock 2001).

Month		**Flow Value (cfs)**	
		Study Site 1	**Reference Site**
January	Q.80=	3.12	3.84
	Q.50=	3.88	4.53
	Q.20=	5.95	5.9
February	Q.80=	3.03	3.7
	Q.50=	3.95	4.57
	Q.20=	6.1	5.89
March	Q.80=	3.14	3.78
	Q.50=	4.85	4.99
	Q.20=	7.36	6.74
April	Q.80=	6.1	5.46
	Q.50=	10.5	8.35
	Q.20=	21.3	16.7
May	Q.80=	15.9	23.8
	Q.50=	36.2	49.2
	Q.20=	73.1	95.4
June	Q.80=	30.2	47.8
	Q.50=	16.0	82.5
	Q.20=	114.0	136.0
July	Q.80=	8.46	19.0
	Q.50=	16.0	31.0
	Q.20=	29.6	48.9
August	Q.80=	5.24	10.4
	Q.50=	7.61	15.3
	Q.20=	13.8	21.3
September	Q.80=	4.36	7.77
	Q.50=	5.98	10.8
	Q.20=	9.99	13.9
October	Q.80=	3.11	3.93
	Q.50=	5.24	6.79
	Q.20=	8.77	8.75
November	Q.80=	3.88	4.75
	Q.50=	4.99	5.74
	Q.20=	7.96	7.52
December	Q.80=	3.33	4.09
	Q.50=	4.28	4.99
	Q.20=	6.61	6.38
Average annual Q average=		**15.56**	**20.57**

Table 6. Monthly exceedance flows on Bohannon Creek using USGS regional regression equations (Hortness and Berenbrock 2001).

Month		**Flow Value (cfs)**	
		Study Site 1	**Reference Site**
January	Q.80=	2.41	1.19
	Q.50=	2.84	1.36
	Q.20=	3.68	1.61
February	Q.80=	2.30	1.11
	Q.50=	2.84	1.33
	Q.20=	3.68	1.59
March	Q.80=	2.35	1.12
	Q.50=	3.10	1.36
	Q.20=	4.20	1.76
April	Q.80=	3.40	1.39
	Q.50=	4.89	1.87
	Q.20=	8.80	3.36
May	Q.80=	3.42	2.31
	Q.50=	9.31	6.08
	Q.20=	20.61	13.5
June	Q.80=	4.38	5.0
	Q.50=	12.95	11.3
	Q.20=	28.95	22.3
July	Q.80=	3.59	4.22
	Q.50=	5.47	5.74
	Q.20=	10.22	9.36
August	Q.80=	2.25	2.37
	Q.50=	3.14	3.32
	Q.20=	4.52	3.99
September	Q.80=	1.99	1.77
	Q.50=	2.59	2.34
	Q.20=	3.51	2.62
October	Q.80=	2.50	1.28
	Q.50=	4.35	2.26
	Q.20=	5.51	2.46
November	Q.80=	2.97	1.45
	Q.50=	3.59	1.7
	Q.20=	4.69	2.0
December	Q.80=	2.58	1.28
	Q.50=	3.13	1.5
	Q.20=	3.96	1.69
Average annual Q average=		**4.38**	**3.64**

Table 7. Monthly exceedance flows on Hayden Creek using USGS regional regression equations (Hortness and Berenbrock 2001).

Month		**Flow Value (cfs)**	
		Study Site 1	**Study Site 3**
January	Q.80=	19.5	14.1
	Q.50=	23.2	16.4
	Q.20=	31.4	21.0
February	Q.80=	19.6	13.9
	Q.50=	24.3	17.0
	Q.20=	31.5	20.8
March	Q.80=	20.2	14.3
	Q.50=	27.1	18.2
	Q.20=	31.5	23.6
April	Q.80=	30.4	19.4
	Q.50=	45.2	28.5
	Q.20=	80.7	53.7
May	Q.80=	56.7	64.4
	Q.50=	119.0	127.0
	Q.20=	227.0	236.0
June	Q.80=	96.8	145.0
	Q.50=	195.0	232.0
	Q.20=	344.0	368.0
July	Q.80=	38.1	45.1
	Q.50=	69.2	76.5
	Q.20=	120.0	122.0
August	Q.80=	22.8	25.3
	Q.50=	33.8	37.6
	Q.20=	52.7	52.4
September	Q.80=	20.8	20.9
	Q.50=	28.8	29.4
	Q.20=	41.8	37.8
October	Q.80=	19.1	14.0
	Q.50=	32.4	24.1
	Q.20=	45.0	30.3
November	Q.80=	24.7	17.7
	Q.50=	29.8	20.9
	Q.20=	40.2	26.4
December	Q.80=	20.5	14.8
	Q.50=	25.6	18.1
	Q.20=	34.6	22.8
Average annual Q average=		**59.1**	**57.48**

Table 8. Water resource records for Big Eightmile Creek upstream from major diversion structures, 2004.

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

STATION NUMBER 13304490 BIG EIGHTMILE CR. BEL DEVILS CANYON NR LEADORE ID SOURCE AGENCY USGS STATE 16 COUNTY 059

LATITUDE 443841 LONGITUDE 1133141 NAD83 DRAINAGE AREA CONTRIBUTING DRAINAGE AREA DATUM

Date Processed: 2004-12-20 12:40 By dfgreen

WORKING

DD #2

Discharge, cubic feet per second

WATER YEAR OCTOBER 2003 TO SEPTEMBER 2004

DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	e22	35	50	14	11
2	---	---	---	---	---	---	---	e25	38	45	16	11
3	---	---	---	---	---	---	---	e28	44	43	16	11
4	---	---	---	---	---	---	---	e31	60	44	14	11
5	---	---	---	---	---	---	---	34	80	40	14	11
6	---	---	---	---	---	---	---	37	96	37	13	11
7	---	---	---	---	---	---	---	38	85	36	13	10
8	---	---	---	---	---	---	---	38	71	34	13	10
9	---	---	---	---	---	---	---	35	73	32	12	9.9
10	---	---	---	---	---	---	---	33	91	31	12	9.1
11	---	---	---	---	---	---	---	33	69	29	12	9.4
12	---	---	---	---	---	---	---	29	60	27	11	11
13	---	---	---	---	---	---	---	26	56	26	11	11
14	---	---	---	---	---	---	---	25	54	25	11	11
15	---	---	---	---	---	---	---	23	55	25	11	11
16	---	---	---	---	---	---	---	24	55	24	12	11
17	---	---	---	---	---	---	---	23	53	23	14	9.8
18	---	---	---	---	---	---	---	27	53	23	14	13
19	---	---	---	---	---	---	---	27	53	22	13	17
20	---	---	---	---	---	---	---	28	52	22	13	15
21	---	---	---	---	---	---	---	29	52	20	12	15
22	---	---	---	---	---	---	---	30	52	20	11	15
23	---	---	---	---	---	---	---	29	54	19	13	15
24	---	---	---	---	---	---	---	29	57	18	12	15
25	---	---	---	---	---	---	---	28	58	18	14	15
26	---	---	---	---	---	---	---	28	58	18	14	15
27	---	---	---	---	---	---	---	32	59	17	13	15
28	---	---	---	---	---	---	---	40	56	16	12	15
29	---	---	---	---	---	---	---	39	54	16	12	14
30	---	---	---	---	---	---	---	36	55	15	12	14
31	---	---	---	---	---	---	---	34	---	14	11	---
TOTAL	---	---	---	---	---	---	---	940	1788	829	395	372.2
MEAN	---	---	---	---	---	---	---	30.3	59.6	26.7	12.7	12.4
MAX	---	---	---	---	---	---	---	40	96	50	16	17
MIN	---	---	---	---	---	---	---	22	35	14	11	9.1
AC-FT	---	---	---	---	---	---	---	1860	3550	1640	783	738

e Estimated

Table 9. Water resource records for Bohannon Creek upstream from major diversion structures, 2004.

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

STATION NUMBER 13305260 BOHANNON CREEK ABV DIVERSIONS NR SALMON, ID STREAM SOURCE AGENCY USGS STATE 16 COUNTY 059

LATITUDE 451131 LONGITUDE 1134121 NAD83 DRAINAGE AREA CONTRIBUTING DRAINAGE AREA DATUM

Date Processed: 2004-12-20 12:41 By dfgreen

WORKING

DD #2

Discharge, cubic feet per second

WATER YEAR OCTOBER 2003 TO SEPTEMBER 2004

DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	16	15	8.7	5.4
2	---	---	---	---	---	---	---	---	16	15	8.8	5.4
3	---	---	---	---	---	---	---	---	18	14	8.8	5.3
4	---	---	---	---	---	---	---	---	20	14	8.5	5.3
5	---	---	---	---	---	---	---	16	23	14	8.2	5.2
6	---	---	---	---	---	---	---	17	24	14	7.9	5.1
7	---	---	---	---	---	---	---	17	20	14	7.7	5.1
8	---	---	---	---	---	---	---	17	18	14	7.6	5.0
9	---	---	---	---	---	---	---	16	20	14	7.4	5.0
10	---	---	---	---	---	---	---	15	22	13	7.2	4.9
11	---	---	---	---	---	---	---	15	18	13	7.0	4.9
12	---	---	---	---	---	---	---	13	16	13	6.9	5.3
13	---	---	---	---	---	---	---	12	16	12	6.8	5.5
14	---	---	---	---	---	---	---	12	16	12	6.6	5.4
15	---	---	---	---	---	---	---	11	16	12	6.5	5.2
16	---	---	---	---	---	---	---	12	15	12	6.4	5.2
17	---	---	---	---	---	---	---	12	15	12	6.4	5.3
18	---	---	---	---	---	---	---	12	15	12	6.4	6.3
19	---	---	---	---	---	---	---	13	15	12	6.5	6.9
20	---	---	---	---	---	---	---	14	15	13	6.3	6.8
21	---	---	---	---	---	---	---	16	15	12	6.1	6.6
22	---	---	---	---	---	---	---	17	15	12	6.1	6.5
23	---	---	---	---	---	---	---	18	15	12	6.8	6.7
24	---	---	---	---	---	---	---	17	15	11	6.6	6.8
25	---	---	---	---	---	---	---	15	15	11	6.4	6.8
26	---	---	---	---	---	---	---	15	15	10	6.7	6.6
27	---	---	---	---	---	---	---	16	15	10	6.6	6.4
28	---	---	---	---	---	---	---	18	15	9.8	6.1	6.3
29	---	---	---	---	---	---	---	18	15	9.5	5.9	6.2
30	---	---	---	---	---	---	---	17	15	9.2	5.7	6.1
31	---	---	---	---	---	---	---	16	---	9.0	5.5	---
TOTAL	---	---	---	---	---	---	---	---	504	379.5	215.1	173.5
MEAN	---	---	---	---	---	---	---	---	16.8	12.2	6.94	5.78
MAX	---	---	---	---	---	---	---		24	15	8.8	6.9
MIN	---	---	---	---	---	---	---		15	9.0	5.5	4.9
AC-FT	---	---	---	---	---	---	---	---	1000	753	427	344

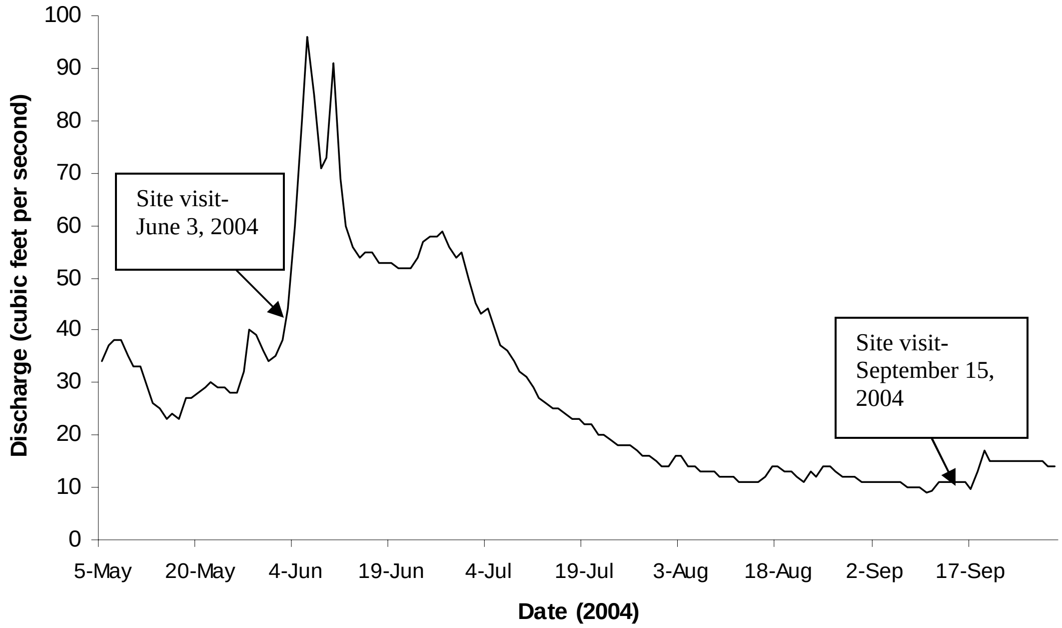

Figure 6. Graphical representation of data in Table 8 for unimpaired discharge (cfs) recorded in Big Eightmile Creek upstream from diversions (2004).

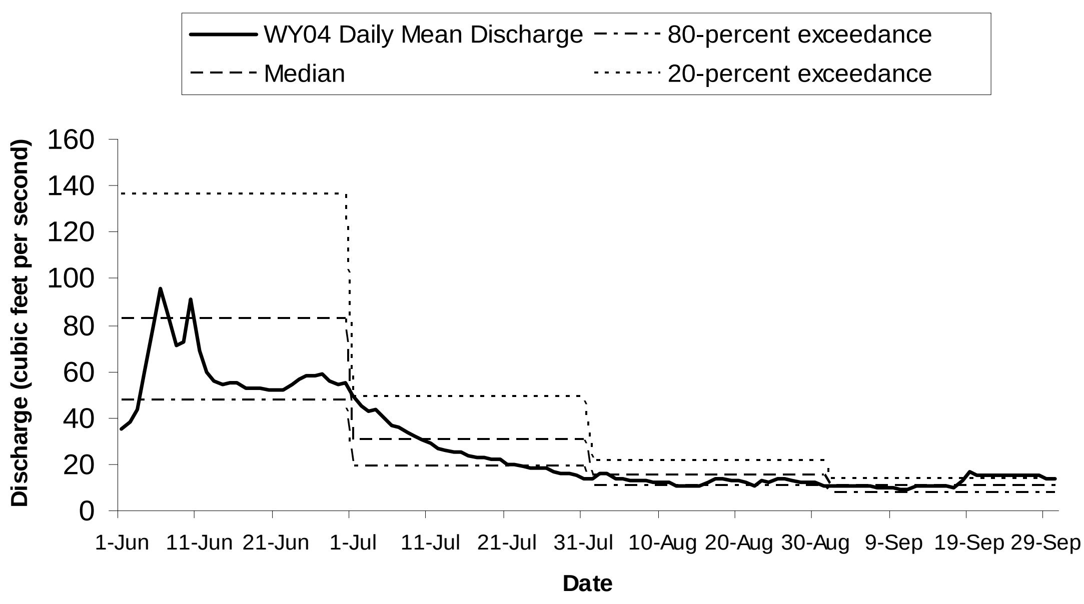

Figure 7. Graphical representation of Tables 8 and 5 for Big Eightmile Creek discharge (cfs) in spring/summer, 2004 using continuous gaging data and exceedance estimates.

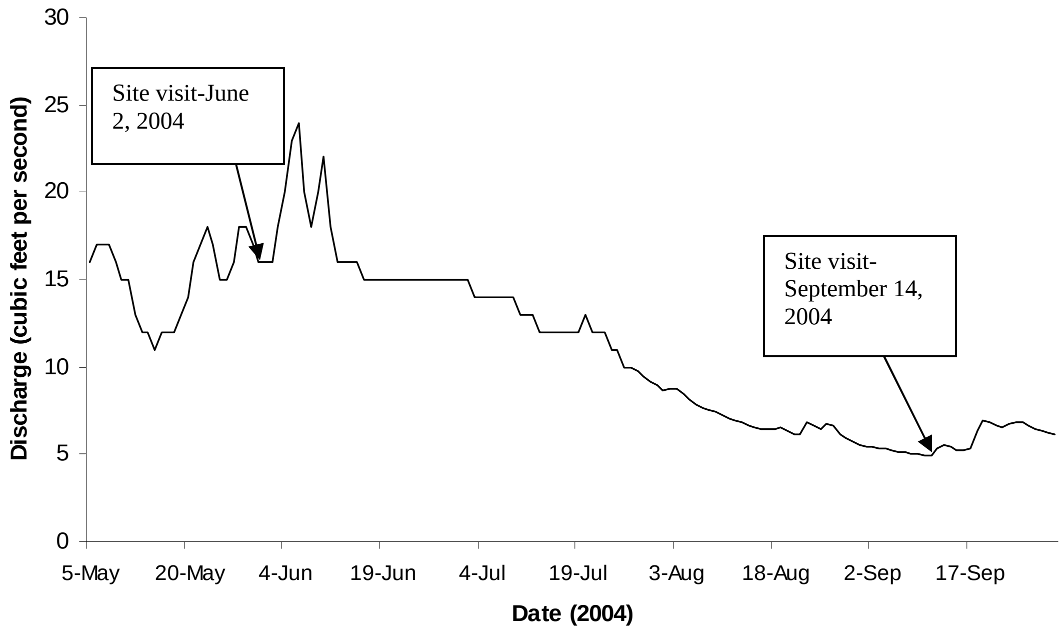

Figure 8. Graphical representation of data in Table 9 for unimpaired discharge (cfs) recorded in Bohannon Creek upstream from diversions (2004).

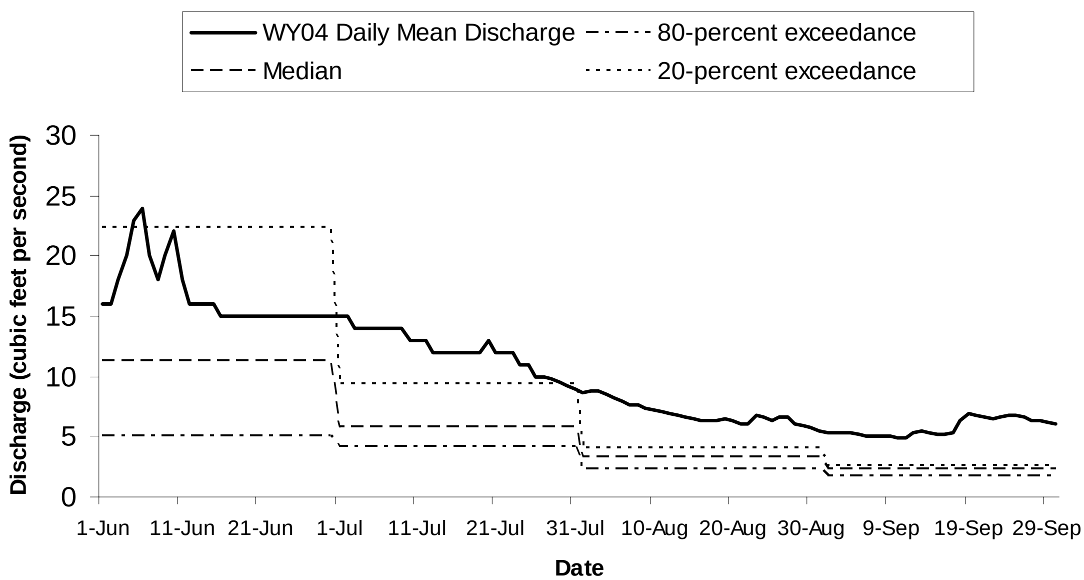

Figure 9. Graphical representation of Tables 9 and 6 for Bohannon Creek discharge (cfs) in spring/summer, 2004 using continuous gaging data and exceedance estimates.

Table 10. Hayden Creek mean monthly flows (cfs) at the confluence of Lemhi River (Rick Sager, Lemhi Water Master, written communication).

Year	April	May	June	July	August	September	October
1997	84	304	549	179	77	48	15
1998	65	198	326	282	110	43	49
1999	47	154	386	123	33	24	37
2000	53	106	158	47	33	19	32
2001	22	96	118	62	27	21	27
2002	29	94	200	67	32	19	24
2003	34	108	220	72	27	15	17

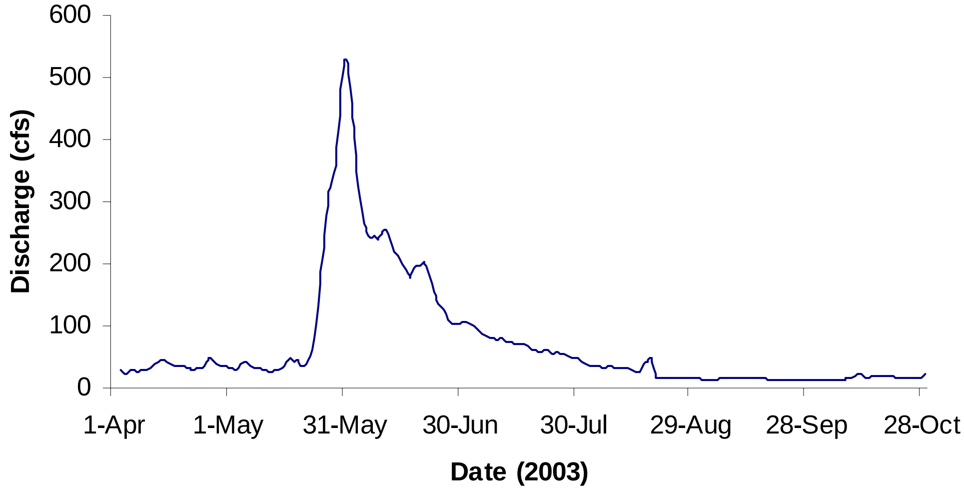

Figure 10. Hayden Creek daily flows (cfs) in 2003 at the confluence of Lemhi River (Rick Sager, Lemhi Water Master, written communication).

3.2 Water Quality

Water bodies are designated in Idaho to protect water quality for existing or designated uses. Big Eightmile (source to diversion (T16N, R24E, Sec. 21)), Bohannon (source to diversion (T21N, R23E, Sec. 22)) and Hayden (Basin Creek to mouth) Creeks are designated by Idaho Administrative Code (2005) - *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; and
b. Salmonid spawning: waters which provide or could provide a habitat for active self-propagating populations of salmonid fishes.

Although these three streams are 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). Hourly temperatures measured for Big Eightmile Creek (6/03/04 – 9/11/04), Bohannon Creek (6/02/04 – 9/10/04) and Hayden Creek (5/22/04 – 9/30/04) are plotted in Figures 11, 12 and 13, respectively. In 2004, all three streams met these standards. Reclamation's Hayden Creek results were confounded by exposure of the temperature sensor to air as flows declined during the summer. Thus, results are displayed from a nearby IDFG thermograph.

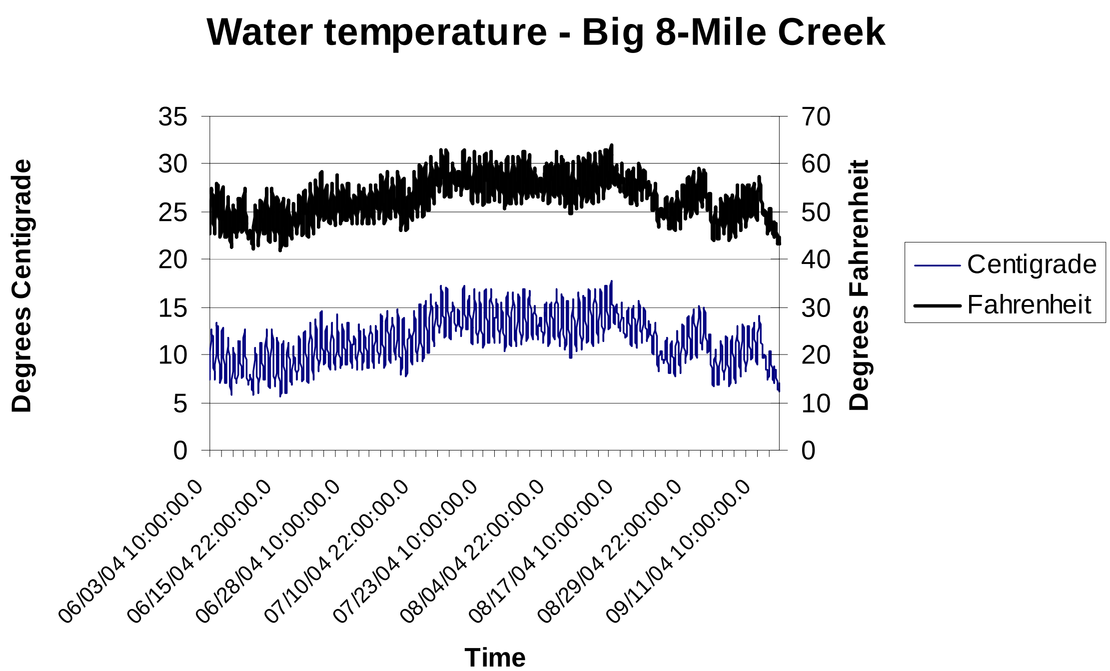

Figure 11. Water temperatures in Big Eightmile Creek during summer of 2004 near Study Site 2.

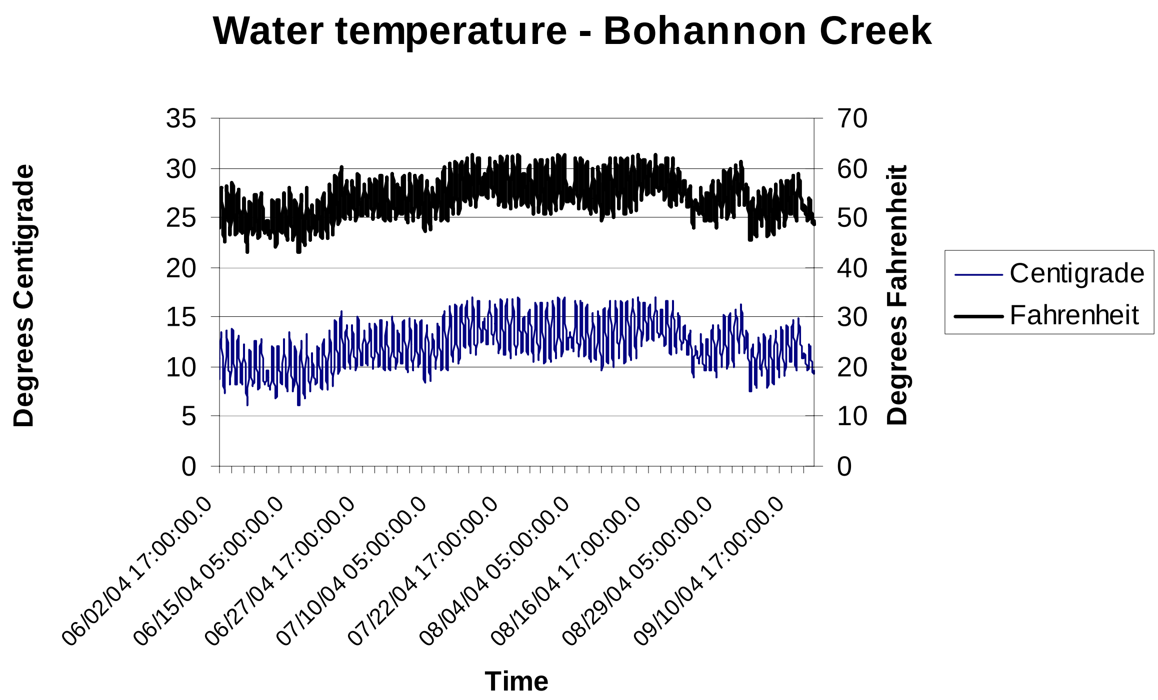

Figure 12. Water temperatures in Bohannon Creek during summer of 2004 near Study Site 2.

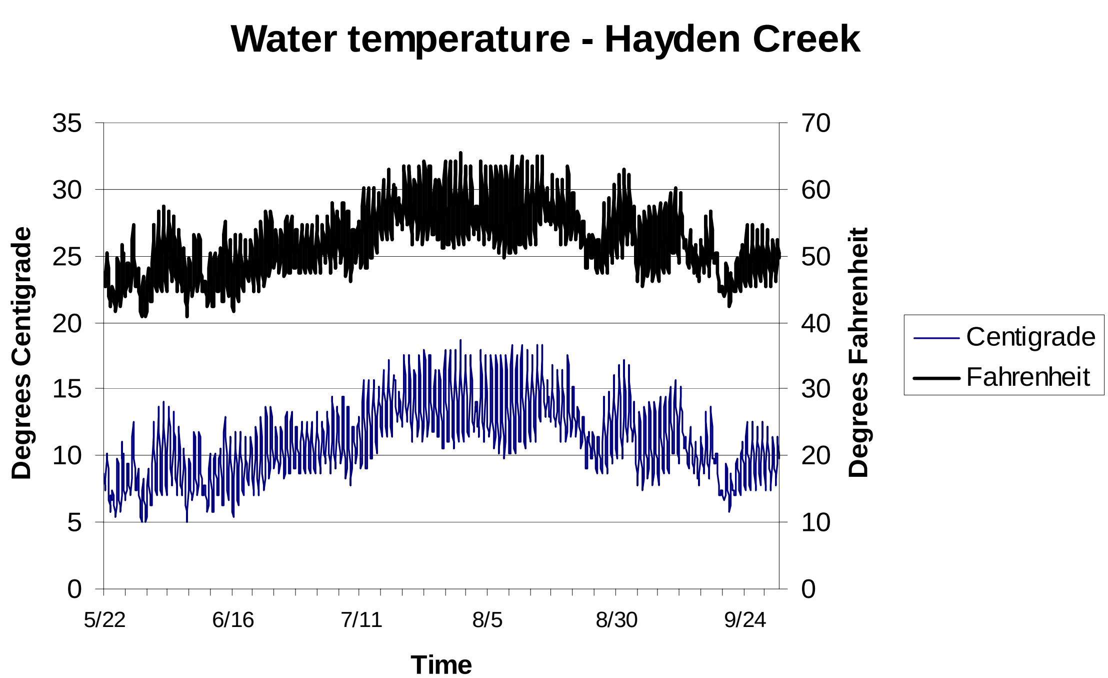

Figure 13. Water temperatures in Hayden Creek during summer of 2004 near Study Site 1. (W. Koons, IDFG, written communication, December 10, 2004).

Flow levels are affected by weather, snowpack, rainfall, and water withdrawal. Diverted water can reduce water quality. Shallow, slow water tends to warm faster than deep, fast 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, eutrophication is a partial result of nutrient enrichment from irrigation return flow (non-point source) and possibly cattle feedlots (point source).

Total Maximum Daily Limits (TMDLs) have been developed to address sediment in Bohannon Creek (source: http://www.deq.state.id.us/water/data_reports/surface_water/tmdls/lemhi_river/lemhi_river.cfm). Though Bohannon Creek is listed for nutrients as well, no conditions have been observed that necessitate the writing of TMDLs for nutrients based on narrative state water quality standards. The primary anthropogenic source of sediment having a deleterious effect on beneficial use support status within Bohannon Creek was identified as sediment from stream bank erosion. Excessive sedimentation has reduced the quality of spawning and rearing habitat for resident trout species and exceeded the same habitat parameters for anadromous species.

Water withdrawals have degraded the aquatic resources in the Lemhi River sub-basin by reducing flow in the river channels. Altered flow conditions resulting from diversion of surface waters for irrigation have eliminated migratory components of resident fish species and have elevated risks to isolated fish populations. 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.

3.3 Summary

Based on this analysis, the primary limiting factors for fisheries in Big Eightmile, Bohannon and Hayden Creeks appear to be summer temperature, sedimentation (Bohannon Creek), 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. Thermal modeling would help determine the benefits of additional flow, if any, to thermal regimes within the system. However, temperature modeling is beyond the scope of this study. Thus, PHABSIM was considered an appropriate methodology to use in Lemhi River Sub-basin rivers to evaluate flow-related habitat.

4.0 METHODS

The approach for characterizing flow needs in Big Eightmile, Bohannon and Hayden Creeks involved planning and execution of a 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

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:
    - riffles (slope),
    - glides/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 Stage-Discharge Relation (STGQ), Step-Backwater (WSP), and Manning's Equation (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 types present, 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 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 at 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. An attempt was made 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. Benchmark coordinates were recorded using a GARMIN Global Positioning System (GPS) Model 12 Navigator (NAD 83). 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 during the three surveys.

4.1.3 Depth, Velocity, Substrate, and Cover

Depths, mean velocities, substrates, and cover were measured at various points that defined cell boundaries 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) and Raleigh et al. (1986) (Table 11). A temporary staff gage was installed at each site so that fluctuations in WSL could be monitored during data collection.

Table 11. Lemhi Sub-basin 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] Sources: EA Engineering (1991b); R2 Resource Consultants (2004); Raleigh et al. (1986)

Velocity calibration sets were collected at three different time periods between June and September, 2004 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 of hydraulic simulations. The applicability of the range of flows simulated to actual flows in the stream was dependent on the flows measured.

4.1.4 Habitat Suitability Criteria (HSC)

Species HSC are required for PHABSIM analyses. Habitat suitability criteria, or suitability 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 life stages 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 approach is to use existing curves and literature to develop suitability criteria for the life stages 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 Eightmile Creek, Bohannon Creek, and Hayden Creek. While such information may become available in the future through a separate study, HSC information was derived from previous Snake River Adjudication work by the Bureau of Indian Affairs (BIA) and USFS in the Salmon River Basin (EA Engineering 1991b; R2

Resource Consultants 2004; Rubin et al. 1991). Initially, upon review of this information, the Interagency Technical Workgroup (see "Acknowledgments" for list of members) directed Reclamation to target the ESA-listed species bull trout, Chinook salmon, and steelhead trout for juvenile, adult, and spawning life stages. Results of the juvenile life stage (50-100 mm) modeling are not included in this report because of questionable HSCs that were developed during drought conditions (Rubin et al. 1991) and the potential inability to accurately measure microhabitat parameters at a scale that would be meaningful using PHABSIM. Until juvenile habitat modeling can be improved, modeling results for the juvenile life stage will not be included in this report.

4.1.5 Hydraulic Model Selection and Calibration

Reclamation used the USGS Windows version of PHABSIM (Waddle 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 (Waddle 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) (Waddle 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 12 shows various life stages and variables used to describe microhabitat. Since the velocity HSC for adult bull trout was 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 this life stage of bull trout.

Table 12. Life stages for species of interest and microhabitat variables used to describe habitat.

Life Stage	Depth	Velocity	Substrate
Adult passage	X		
Adult	X	X	X
Adult spawning	X	X	X

The following example describes how habitat weighting factors (WF) were determined. In an example study site that had five cross sections: one deep run, three shallow runs, and one moderate gradient riffle. Within this example site, based on example habitat mapping percentages, 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', and 114') to represent the three shallow runs at the example study site. 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 13).

Table 13. 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 14 illustrates this procedure.

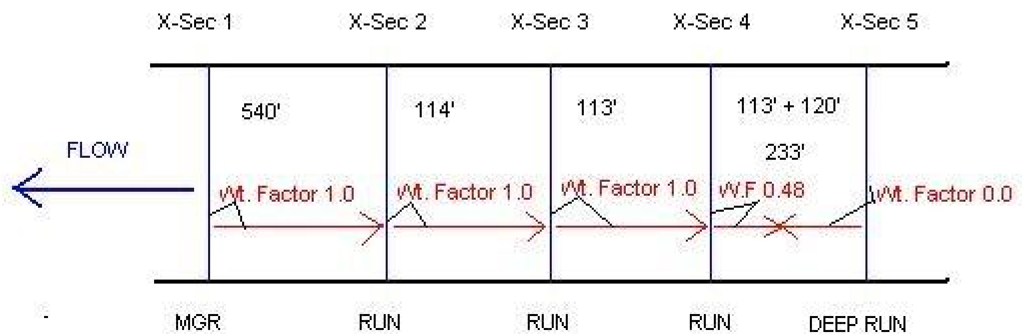

Figure 14. Example of weighting factor assignments at a PHABSIM study site.

If there was a 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 another example study site are listed in Table 14.

Table 14. 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 in the HABTAE sub-model of PHABSIM using the geometric mean option to multiply the depth, velocity, and substrate HSC values for a life stage at predicted hydraulic conditions, and cell surface area. 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 13 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).

4.2 Passage

Suggested passage criteria for adult Chinook salmon, steelhead trout, and bull trout followed guidelines adopted by Oregon Department of Fish and Wildlife and taken from Thompson (1972) and Scott et al. (1981) (Table 15). 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 15 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 15. Suggested adult 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. 2001). 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 adult holding conditions for salmon, steelhead, and bull trout. Table 16 provides suggested critical life stage assignments for each stream in this study which could be used to determine target flows from the PHABSIM analysis. This information was obtained through a survey of local biologists familiar with fish species of interest in these streams (J. Spinazola, Reclamation, written communication, January 12, 2005).

Table 16. Suggested critical life-stage assignments for applying flow recommendations in selected streams.

Stream	Steelhead	Chinook salmon	Bull trout
Big Eightmile Creek	None	None	Passage
Bohannon Creek	None	None	Passage
Hayden Creek	None	None	Passage

5.0 RESULTS AND DISCUSSION

Results of the PHABSIM analysis are summarized for each stream in separate sections below. 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, longitudinal profiles, and measured WSLs are illustrated in Appendix C. Hydraulic model calibration results are summarized in Appendix D. Simulated WSLs were within 0.07 ft of measured WSLs for all transects except Bohannon Creek Study Site 4, transect 4 at high flow (WSL difference = 0.088 ft) (Appendix D). Thus, the ability to simulate much higher flows at this study site was restricted. Habitat suitability criteria (HSCs) are presented in Appendix E. Complete habitat modeling output results (i.e., WUA vs discharge and passage assessments) are summarized in Appendix F for each stream reach.

5.1 Big Eightmile Creek

Measured discharges and dates of field surveys are summarized in Table 17. Attempts to measure low, medium, and high flows at most sites downstream from the reference site (Study Site 5) in Big Eightmile Creek were confounded by diversions. In most cases, only medium and low flows were measured. However, these conditions typically occur during the summer irrigation season with diversions.

Table 17. Discharges measured from highest to lowest at Big Eightmile Creek study sites during field surveys in 2004.

Stream Site	Discharge (cfs)	Survey Dates
Study Site 1	1.2	September 15
	0.4	June 03
Study Site 2	9.6	June 03
	7.7	May 03
	3.0	September 15
Study Site 3	21.1	June 03
	8.3	May 03
	5.2	September 15
Study Site 4	33.5	June 03
	15.7	May 03
	10.1	September 15
Study Site 5 (Reference)	46.1	June 03
	20.1	May 03
	10.4	September 15

Graphical representations of final normalized WUA versus discharge relationships are presented in Figures 15-29 for each site. Passage flow results for total and contiguous widths at depths greater than the passage criteria (Table 15) are illustrated in Figures 30-39. Summary results, including flows required for optimal (i.e., maximum) WUAs and flows needed to meet the 0.6 feet deep passage criteria are presented in Table 18. Summary results reflected differences in stream channel hydraulics among study sites.

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 Eightmile Creek than the upstream reaches (e.g., Study Site 5). At any given flow, more wetted area occurred at Study Site 5 than Study Site 1. For example, at 4 cfs, 9,445 ft^2 of wetted area per linear 1,000 ft of stream occurred at Study Site 1. This compared with 14,795 ft^2 of wetted area per 1,000 ft of stream at Study Site 5 (Appendix F). With a smaller channel, less flow was needed to optimize habitat in the lower reaches than the upper reaches (Table 18). For example, at Study Site 2, 12 and 20 cfs provided optimal habitat for bull trout adult and spawning, respectively. These flows were less than Study Site 5 where 24 cfs provided optimal habitat for adults and 88 cfs for spawning. The shallowest riffle that could affect adult fish passage occurred at Study Site 3 (transect 1), where 19 cfs was required to meet the 0.6 ft depth passage criteria (Table 18).

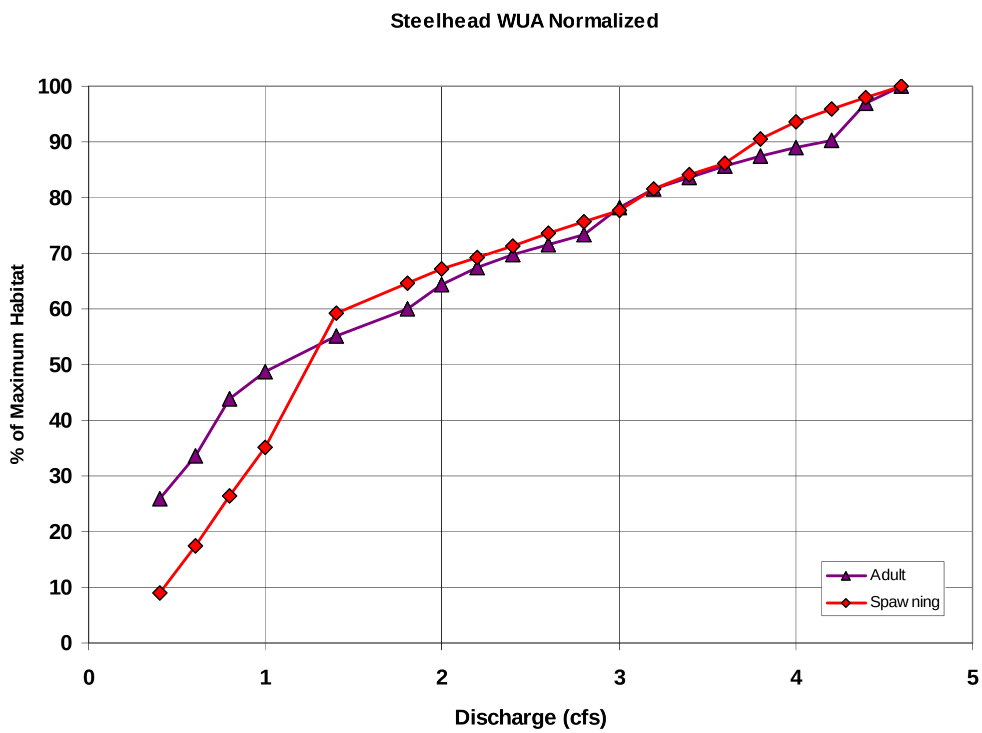

Figure 15. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Big Eightmile Creek, Study Site 1.

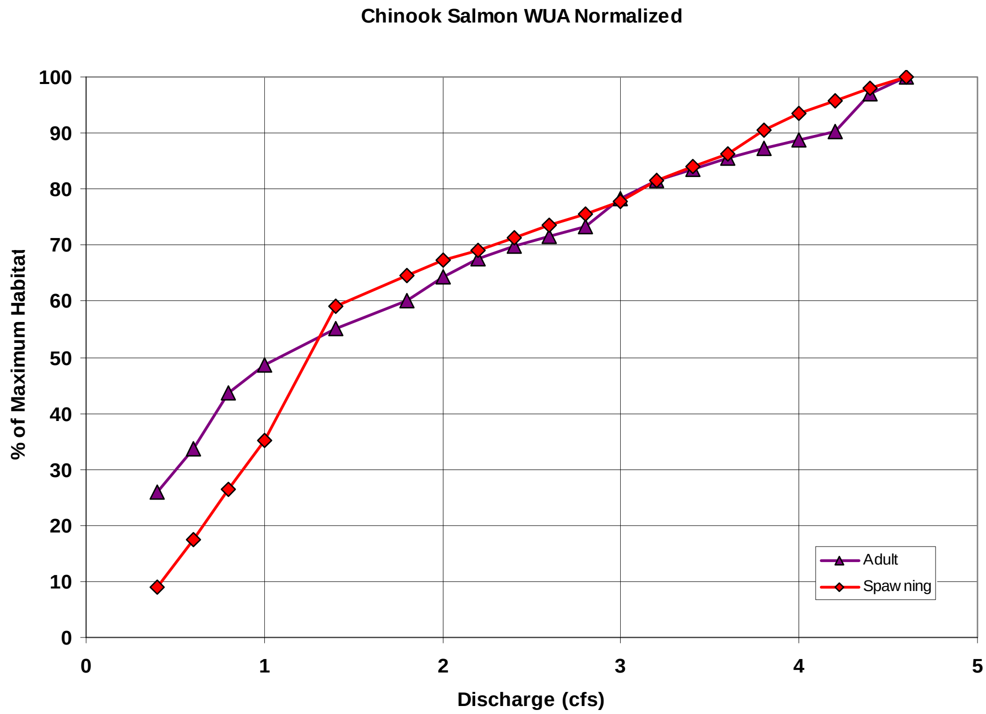

Figure 16. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Big Eightmile Creek, Study Site 1.

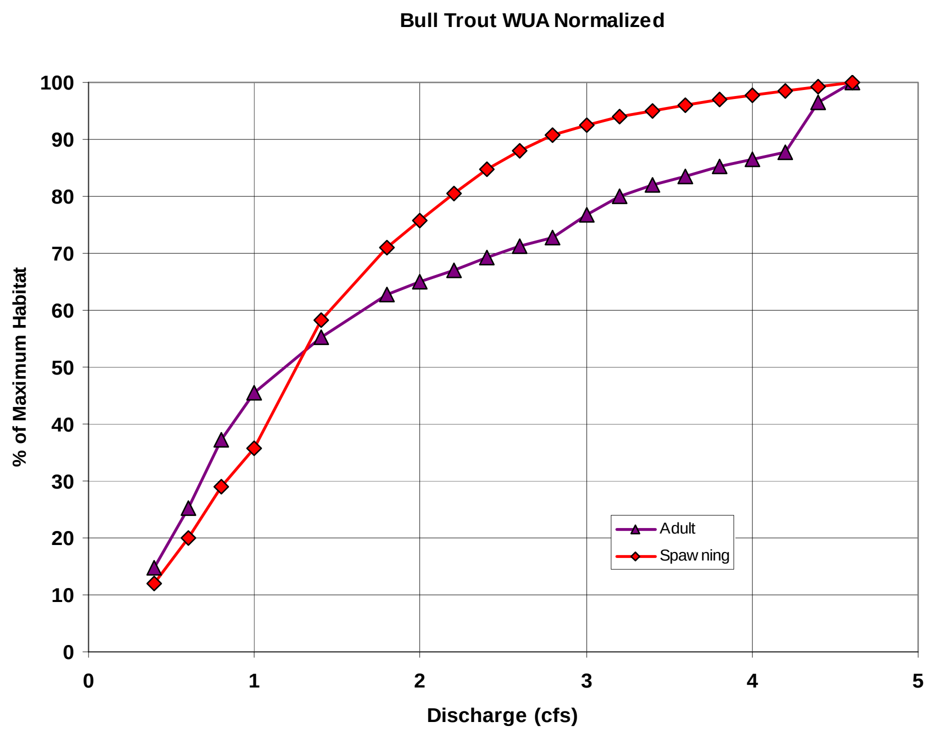

Figure 17. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Big Eightmile Creek, Study Site 1.

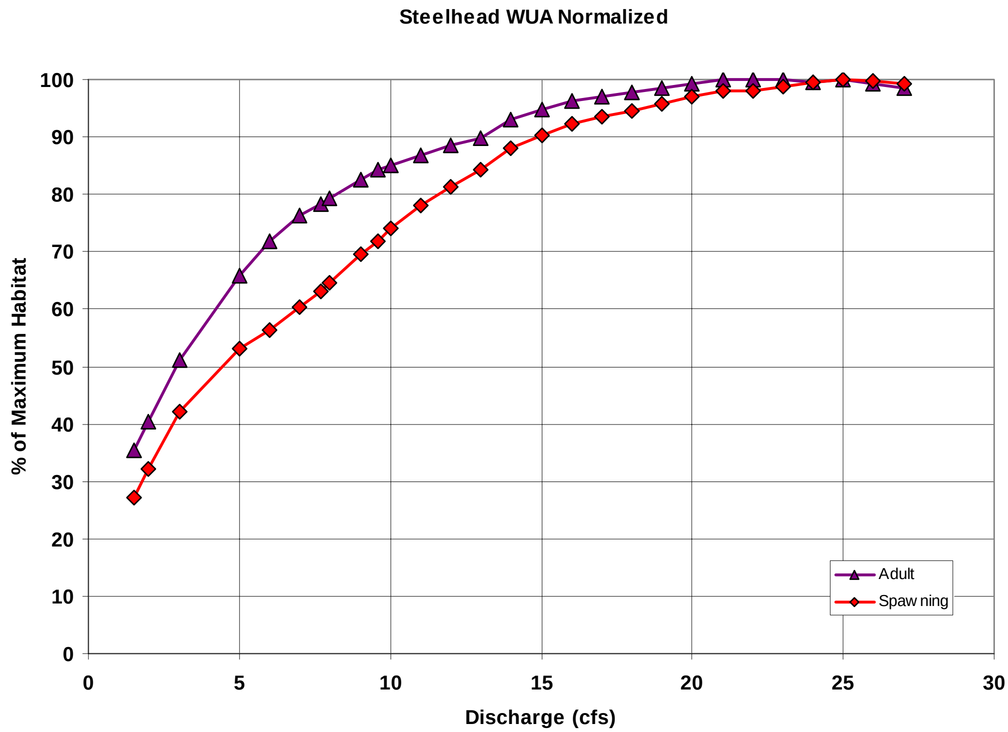

Figure 18. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Big Eightmile Creek, Study Site 2.

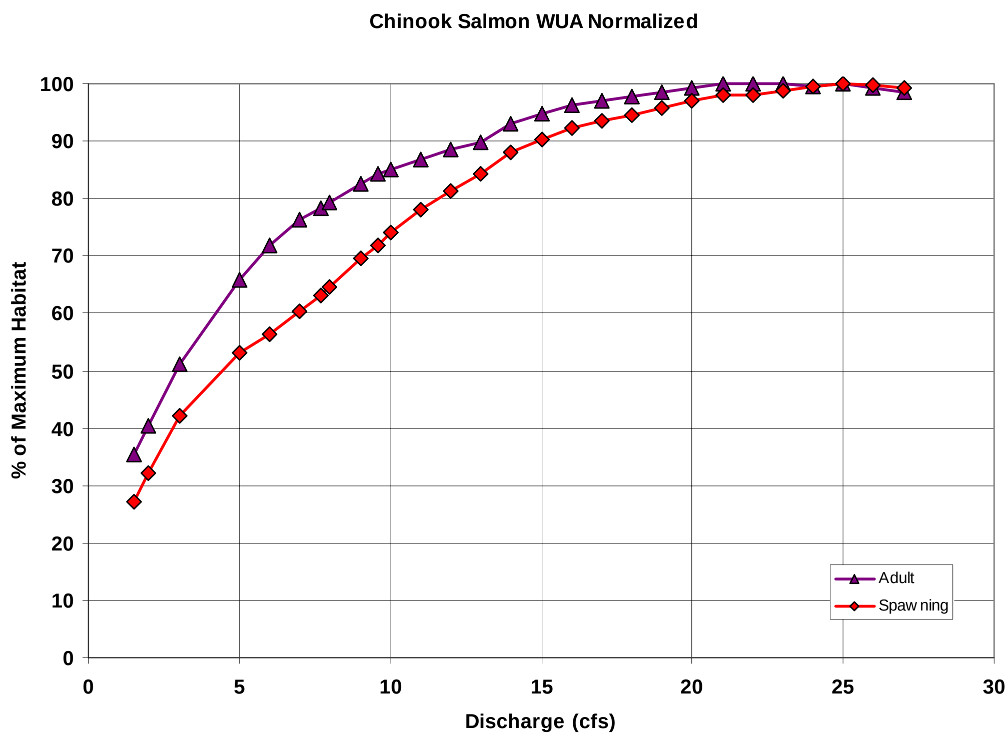

Figure 19. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Big Eightmile Creek, Study Site 2.

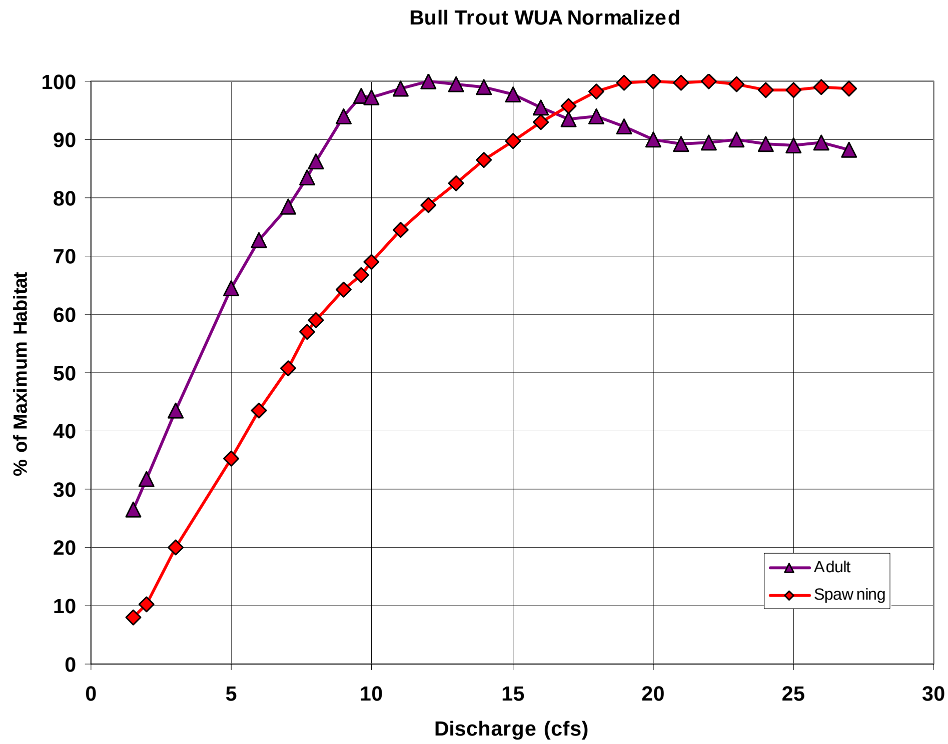

Figure 20. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Big Eightmile Creek, Study Site 2.

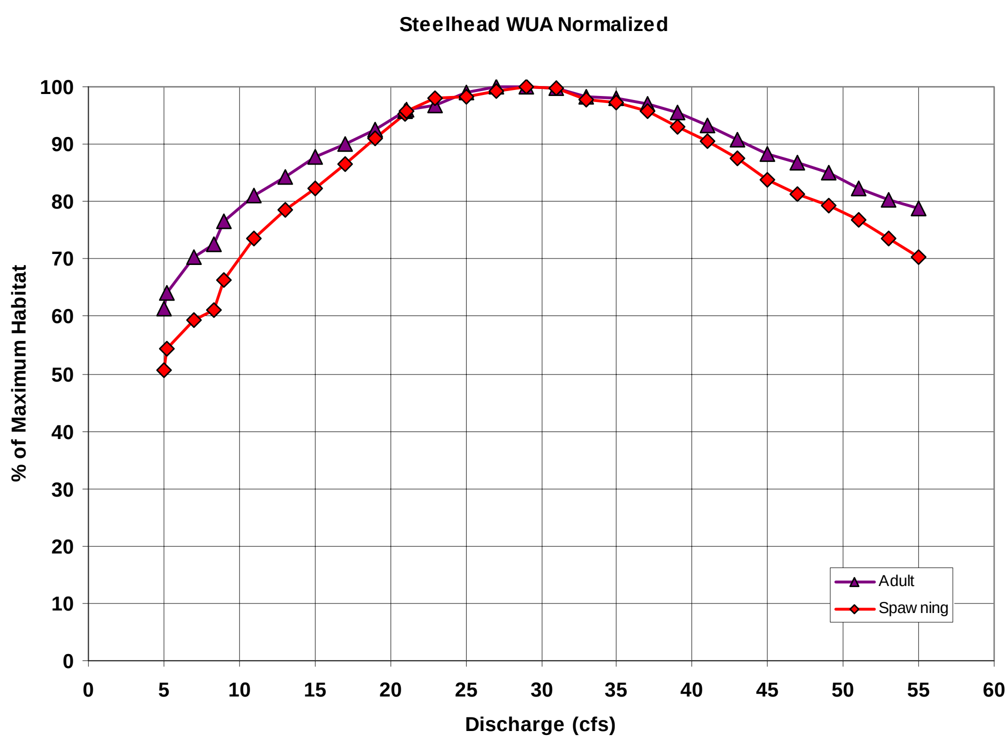

Figure 21. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Big Eightmile Creek, Study Site 3.

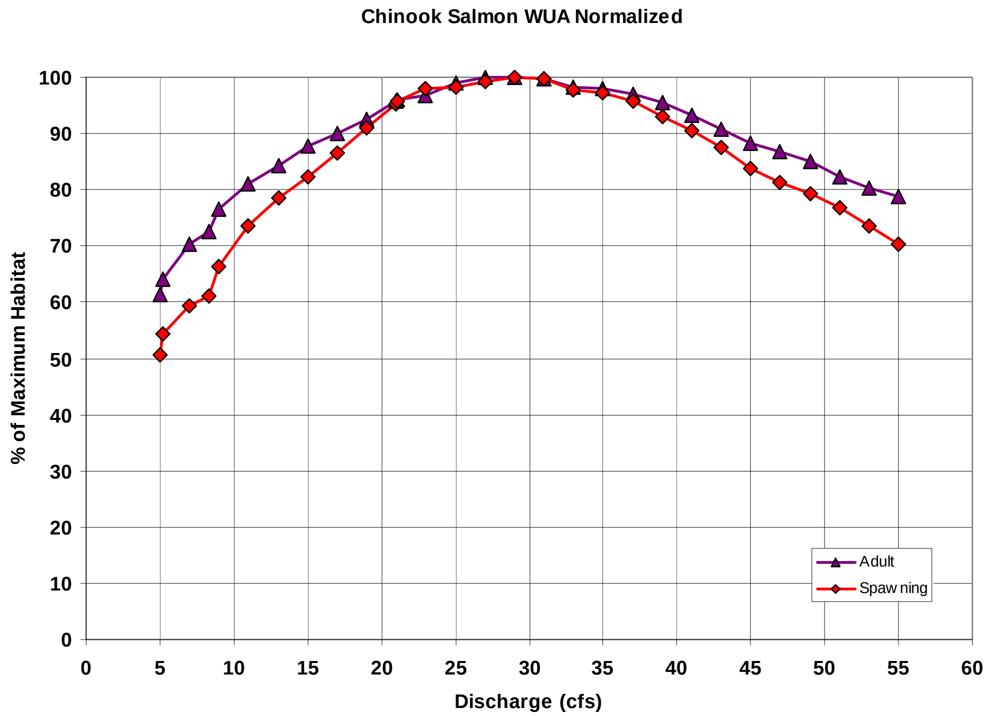

Figure 22. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Big Eightmile Creek, Study Site 3.

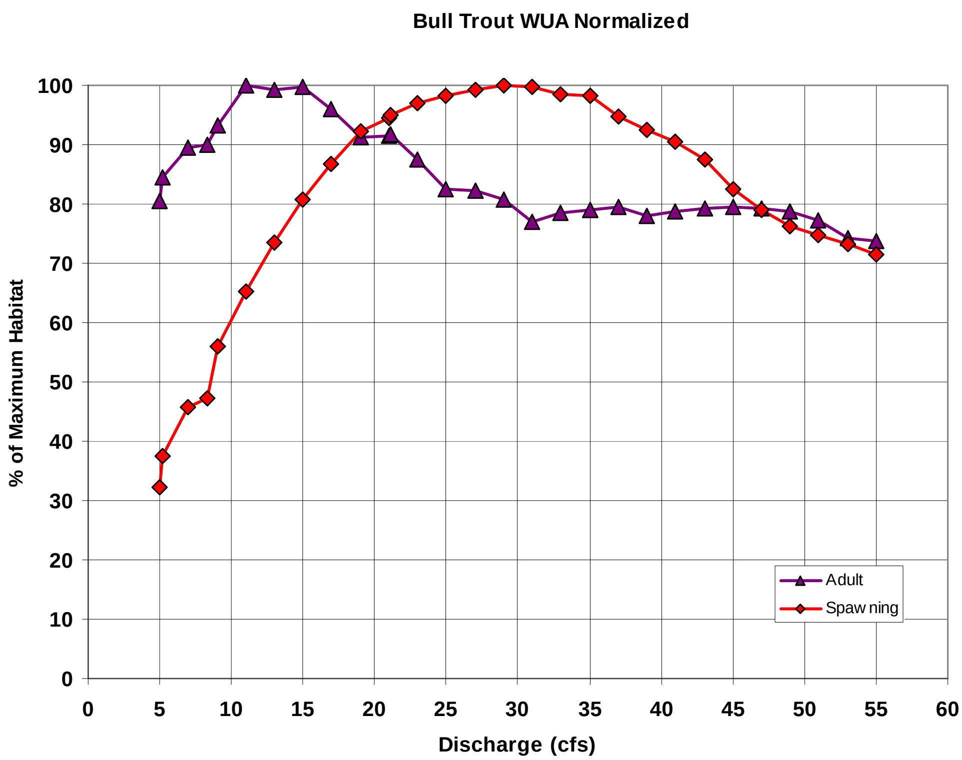

Figure 23. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Big Eightmile Creek, Study Site 3.

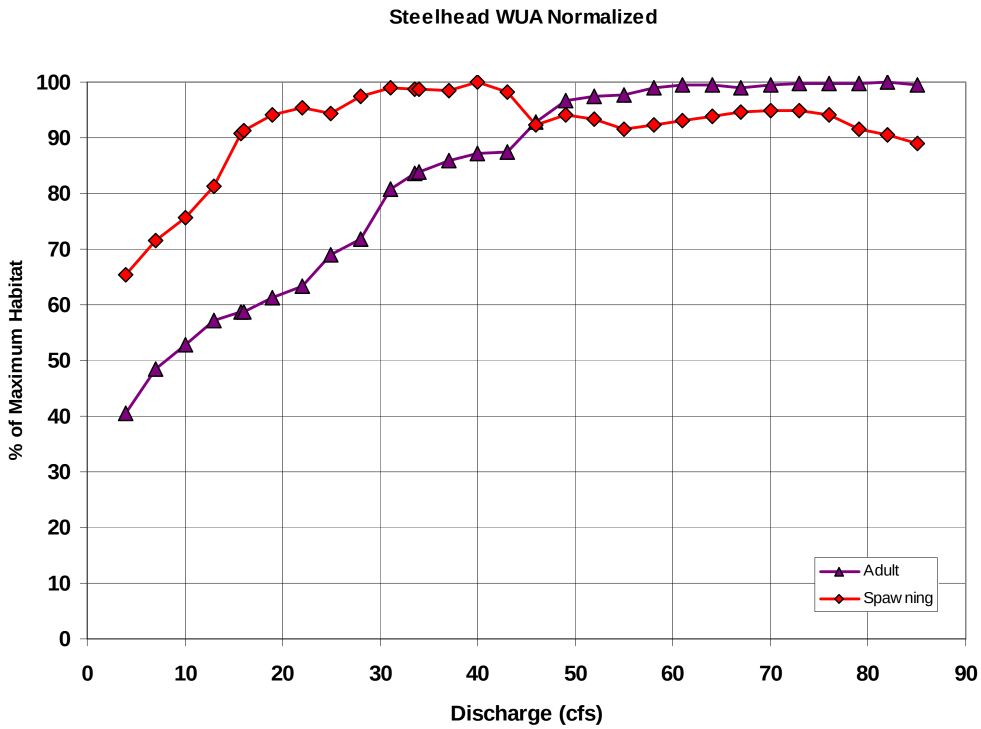

Figure 24. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Big Eightmile Creek, Study Site 4.

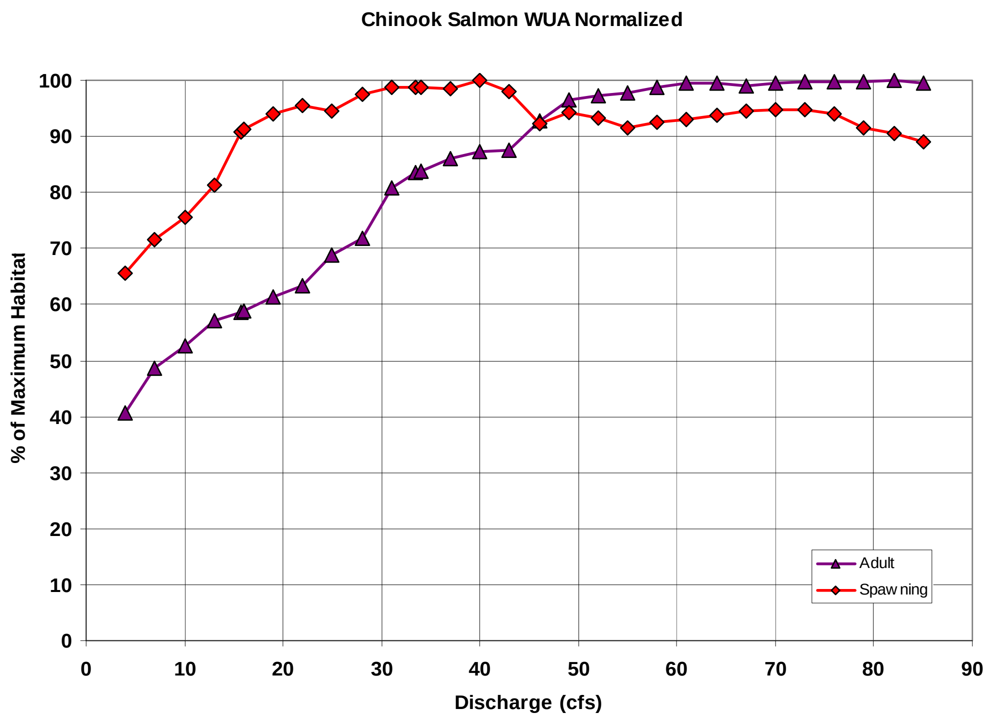

Figure 25. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Big Eightmile Creek, Study Site 4.

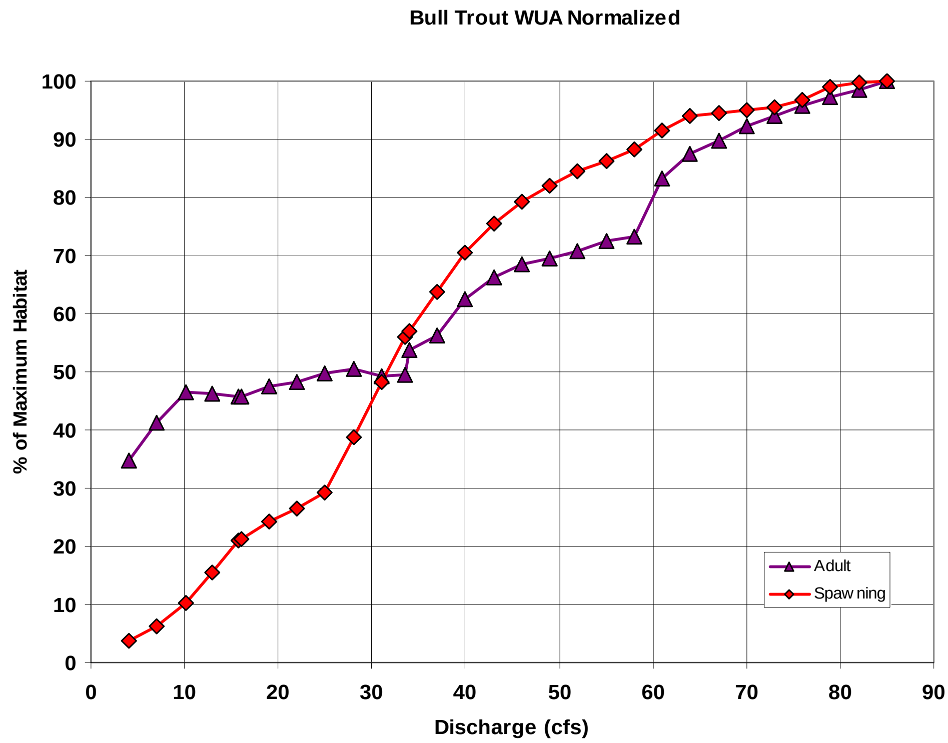

Figure 26. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Big Eightmile Creek, Study Site 4.

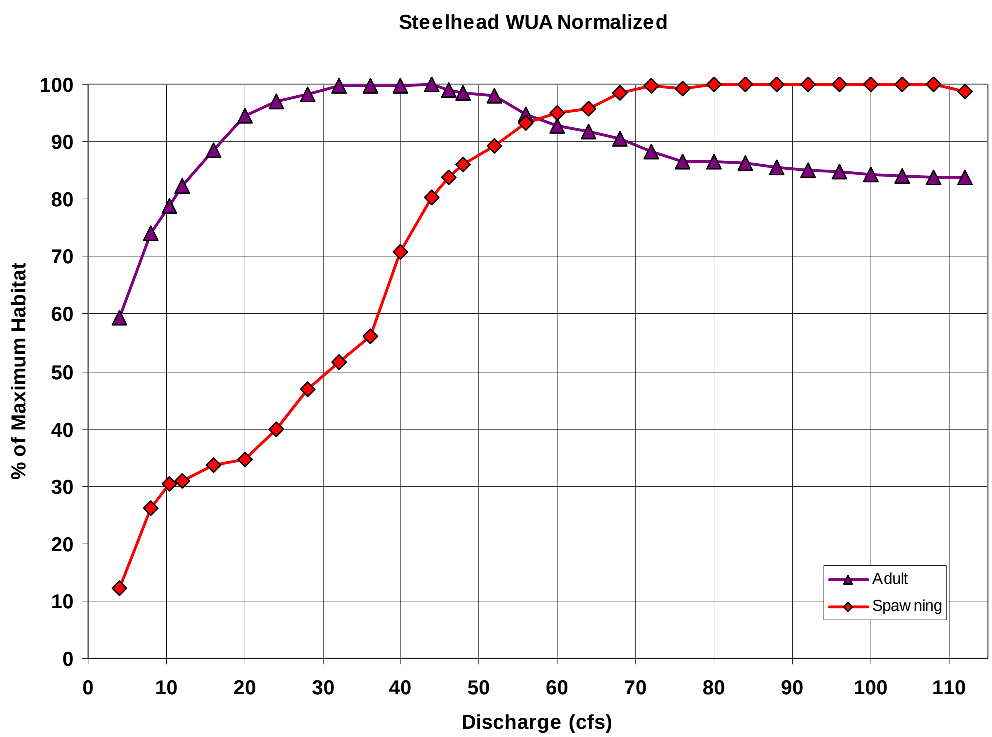

Figure 27. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Big Eightmile Creek, Reference Site.

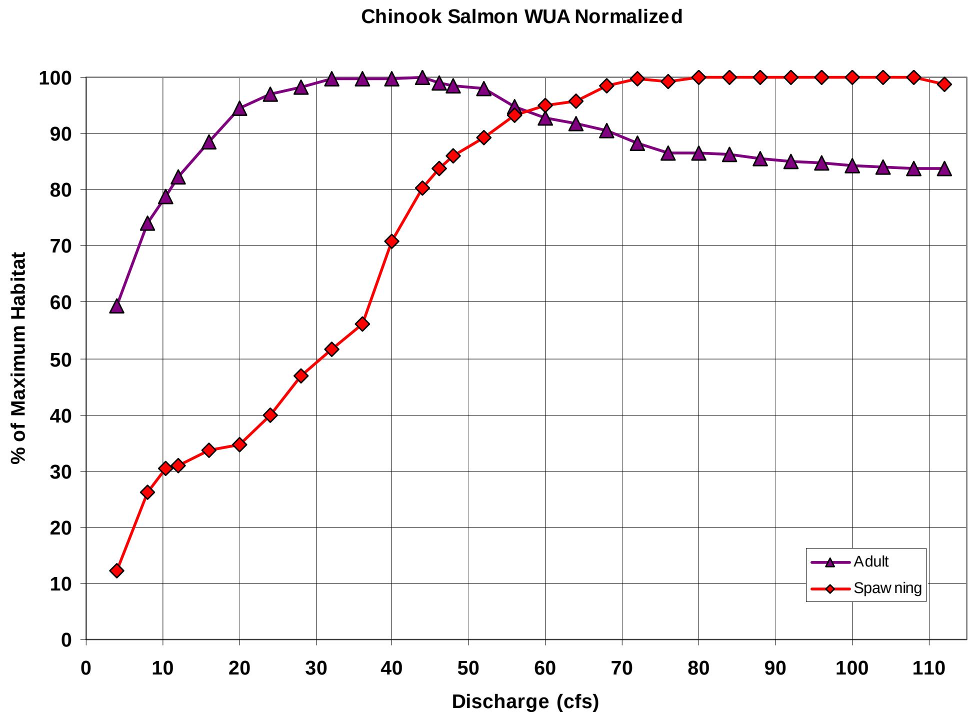

Figure 28. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Big Eightmile Creek, Reference site.

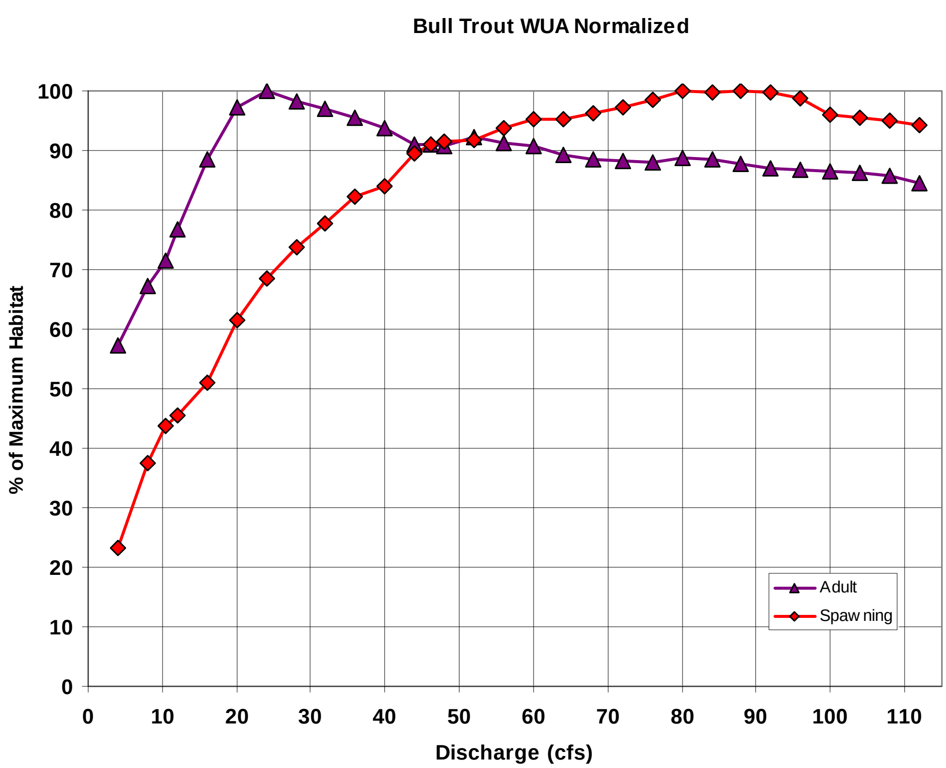

Figure 29. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Big Eightmile Creek, Reference Site.

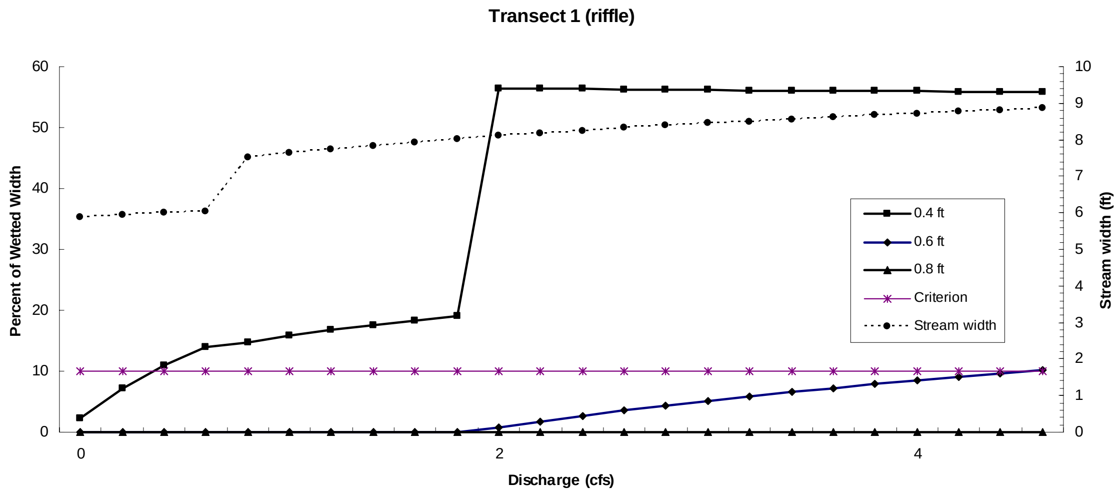

Figure 30. Contiguous widths at depths greater than passage criteria at a riffle transect on Big Eightmile Creek, Study Site 1.

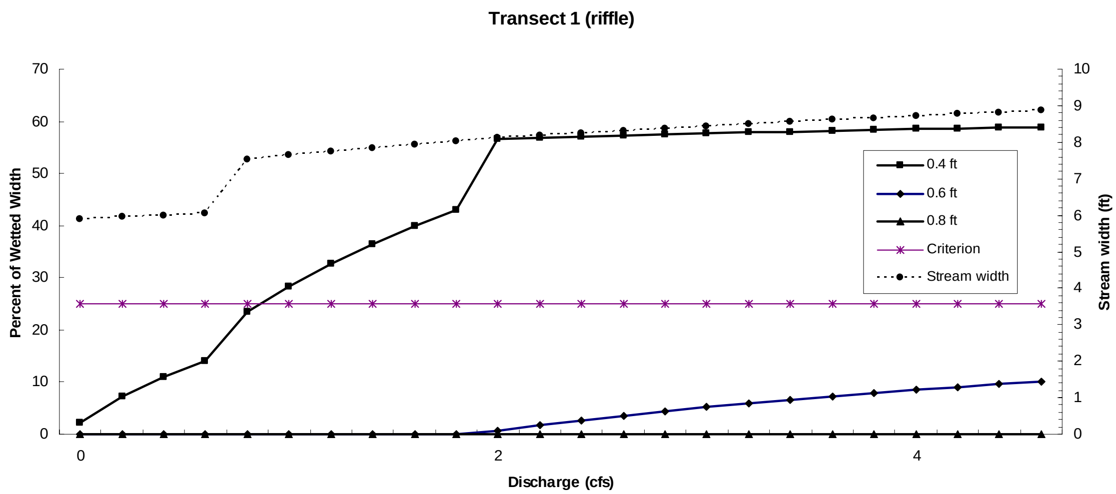

Figure 31. Total widths at depths greater than passage criteria at a riffle transect on Big Eightmile Creek, Study Site 1.

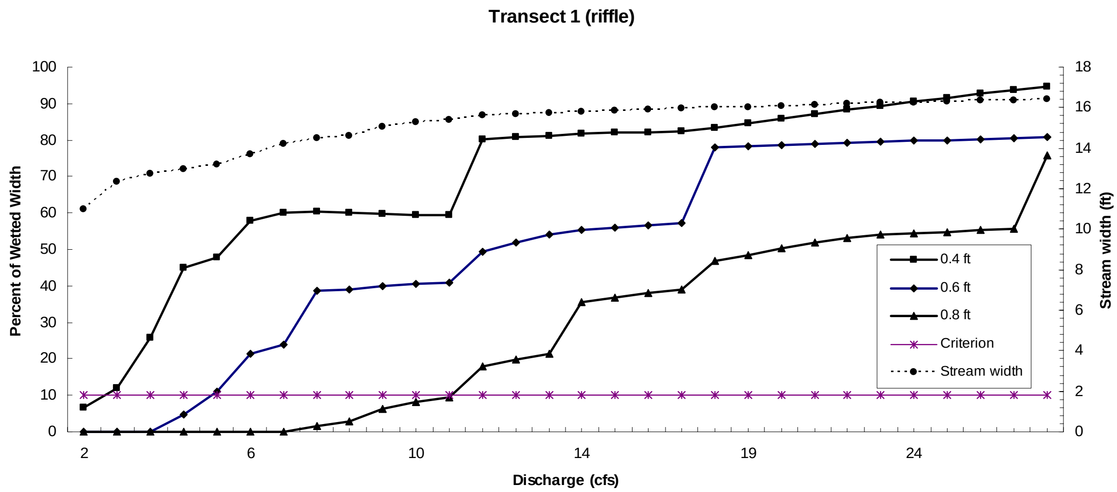

Figure 32. Contiguous widths at depths greater than passage criteria at a riffle transect on Big Eightmile Creek, Study Site 2.

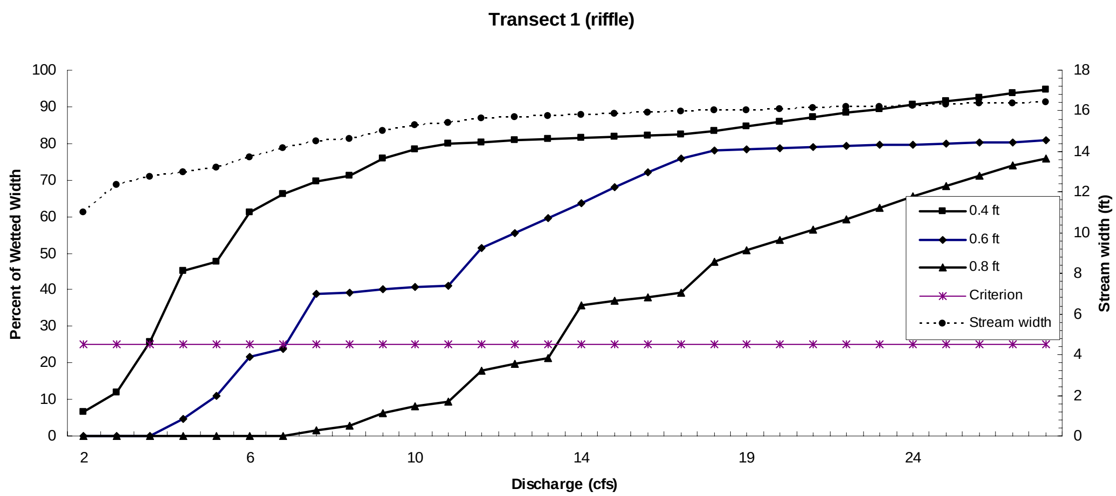

Figure 33. Total widths at depths greater than passage criteria at a riffle transect on Big Eightmile Creek, Study Site 2.

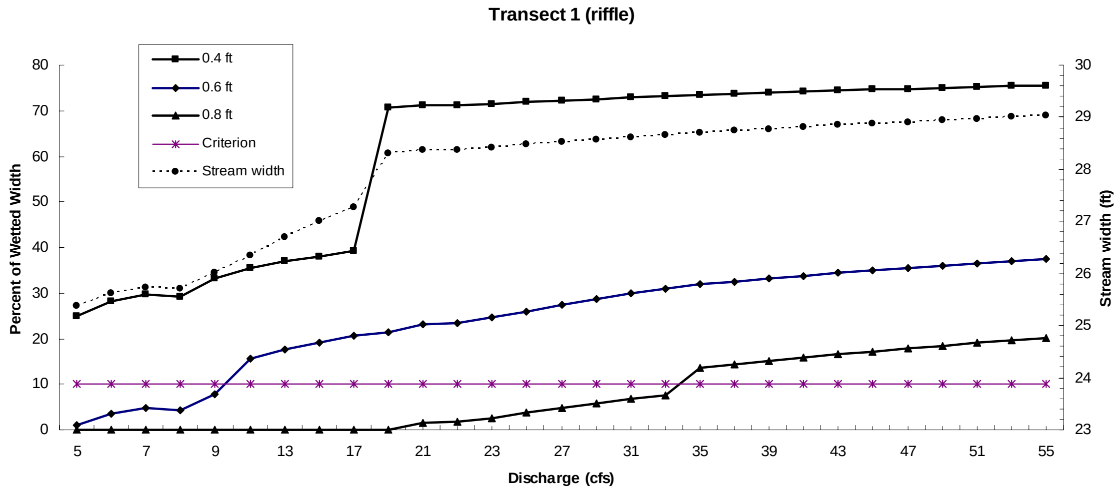

Figure 34. Contiguous widths at depths greater than passage criteria at a riffle transect on Big Eightmile Creek, Study Site 3.

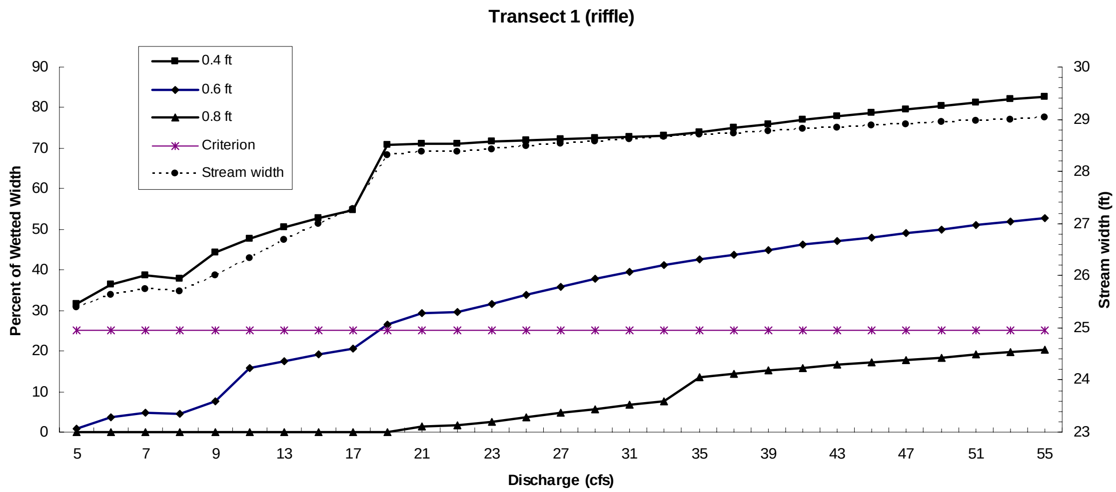

Figure 35. Total widths at depths greater than passage criteria at a riffle transect on Big Eightmile Creek, Study Site 3.

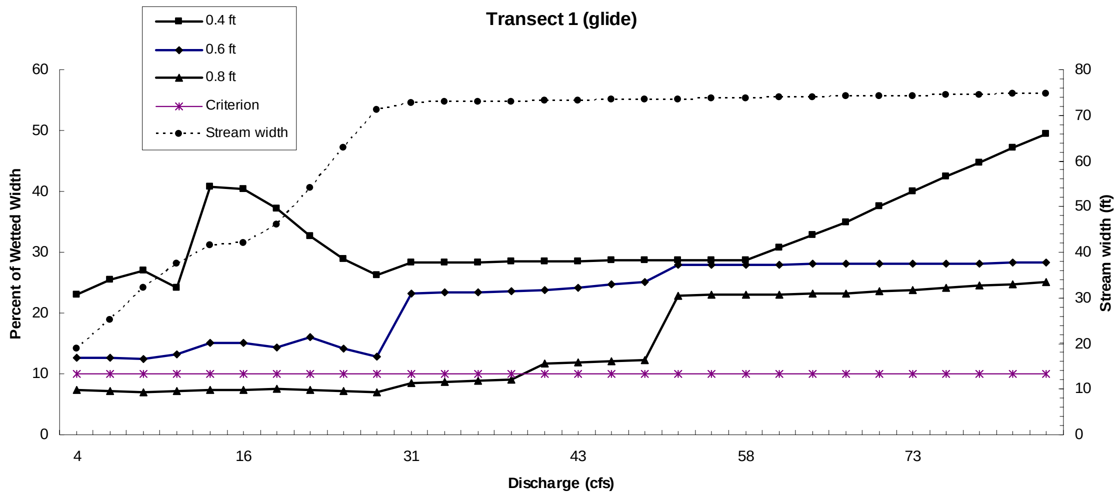

Figure 36. Contiguous widths at depths greater than passage criteria at a glide transect on Big Eightmile Creek, Study Site 4.

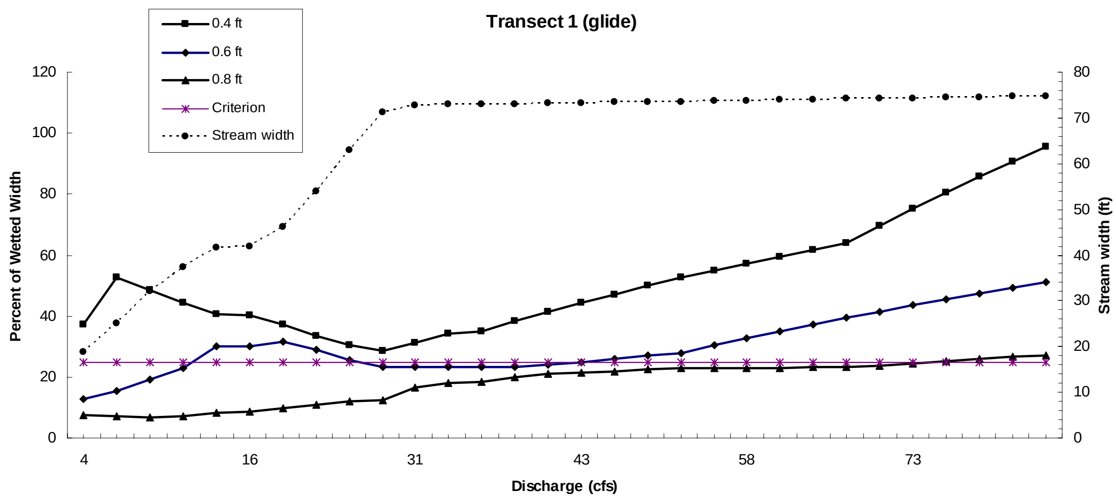

Figure 37. Total widths at depths greater than passage criteria at a glide transect on Big Eightmile Creek, Study Site 4.

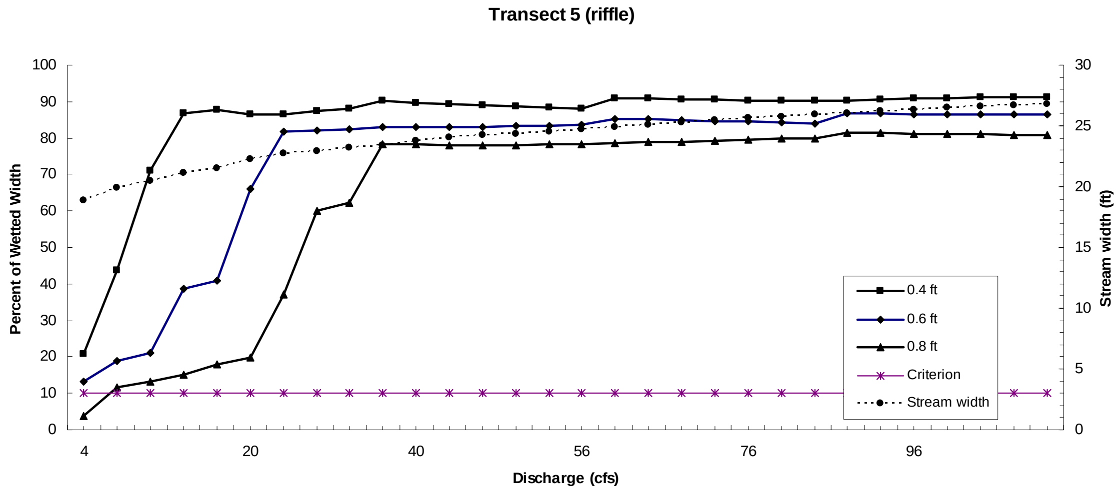

Figure 38. Contiguous widths at depths greater than passage criteria at a riffle transect on Big Eightmile Creek, Reference Site.

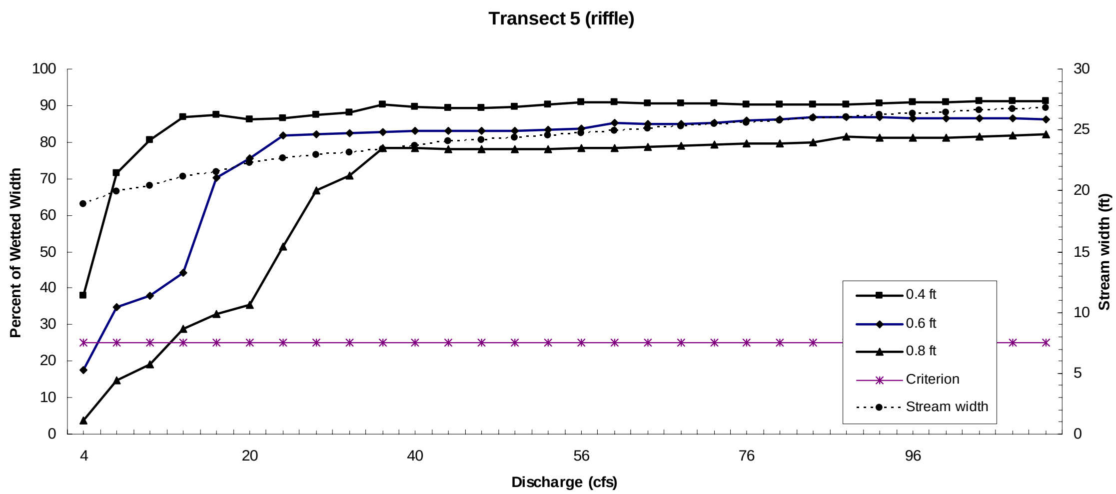

Figure 39. Total widths at depths greater than passage criteria at a riffle transect on Big Eightmile Creek, Reference Site.

Table 18. Habitat modeling summary on Big Eightmile 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
Study Site 1					
Spawning	>4.6	>4.6	>4.6	NA[2]	NA
Adult	>4.6	>4.6	>4.6	>5	5
Study Site 2					
Spawning	25	25	20	NA[2]	NA
Adult	23	23	12	7.5	5
Study Site 3					
Spawning	29	29	29	NA[2]	NA
Adult	27	27	11	19	11
Study Site 4					
Spawning	40	40	85	NA[2]	NA
Adult	82	82	85	14	<4
Study Site 5 (Reference)					
Spawning	104	104	88	NA[2]	NA
Adult	44	44	24	8	4

[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

5.2 Bohannon Creek

Measured discharges and dates of field surveys are summarized in Table 19. Attempts to measure low, medium, and high flows at most sites downstream from the reference site in Bohannon Creek were confounded by diversions. In most cases, only medium and low flows were measured. However, these conditions typically occur during the summer irrigation season with diversions. The maximum simulated flow at Study Site 4 was only 6 cfs because of fair high flow WSL calibration and suspect velocity simulations at higher flows.

Graphical representations of final normalized WUA versus discharge relationships are presented in Figures 40-54 for each site. Passage flow results for total and contiguous widths at depths greater than the passage criteria (Table 15) are illustrated in Figures 55-64. Summary results, including flows required for optimal WUAs and flows needed to meet the 0.6 feet deep passage criteria are presented in Table 20 and reflect differences in stream channel hydraulics among study sites.

Table 19. Discharges measured from highest to lowest at Bohannon Creek study sites during field surveys in 2004.

Stream Site	Discharge (cfs)	Survey Dates
Study Site 1	4.5	March 15 (2005)
	0.7	June 2
	0.2	April 30
Study Site 2	7.7	June 2
	1.8	September 14
	1.5	April 30
Study Site 3	17.2	June 2
	5.8	September 14
	3.9	April 30
Study Site 4	4.2	June 2
	1.6	September 14
	1.4	April 30
Study Site 5 (Reference)	17.4	June 2
	10.3	September 14
	3.7	April 30

Examination of cross-sectional profiles of study site transects (Appendix C) showed a narrower stream channel in the lower reaches (e.g., Study Sites 1 and 2) of Bohannon Creek than the upstream reaches (e.g., Study Site 5). At any given flow, more wetted area occurred at Study Site 5 than sites 1 and 2. For example, at about 10 cfs, 6,511 ft^2 of wetted area per linear 1,000 ft of stream occurred at Study Site 1. This compared with about 14,972 ft^2 of wetted area per 1,000 ft of stream at Study Site 5 (Appendix F). Thus, like Big Eightmile Creek, less flow with a smaller channel optimized habitat in the lower reaches than the upper reaches (Table 20). For example, at Study Site 2, 7.7 cfs provided optimal habitat for spawning bull trout (Table 20). This flow was less than optimal for spawning bull trout habitat (35.5 cfs) at Study Site 5 (Reference Site). Flows that met the 0.6 depth adult passage criteria ranged from 6 cfs at Study Site 1 to 19 cfs at Study Site 3.

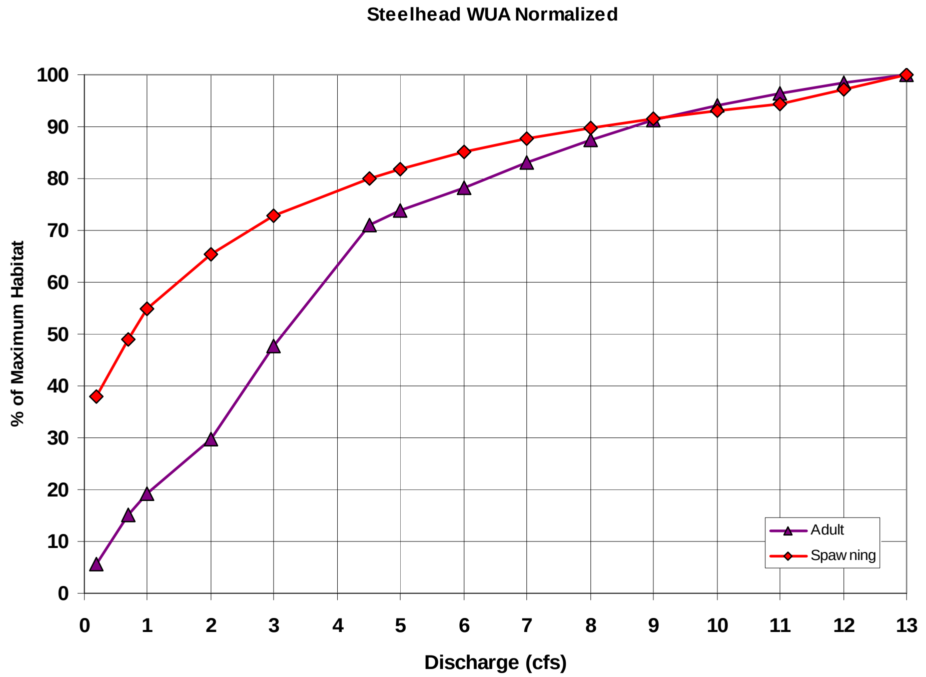

Figure 40. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Bohannon Creek, Study Site 1.

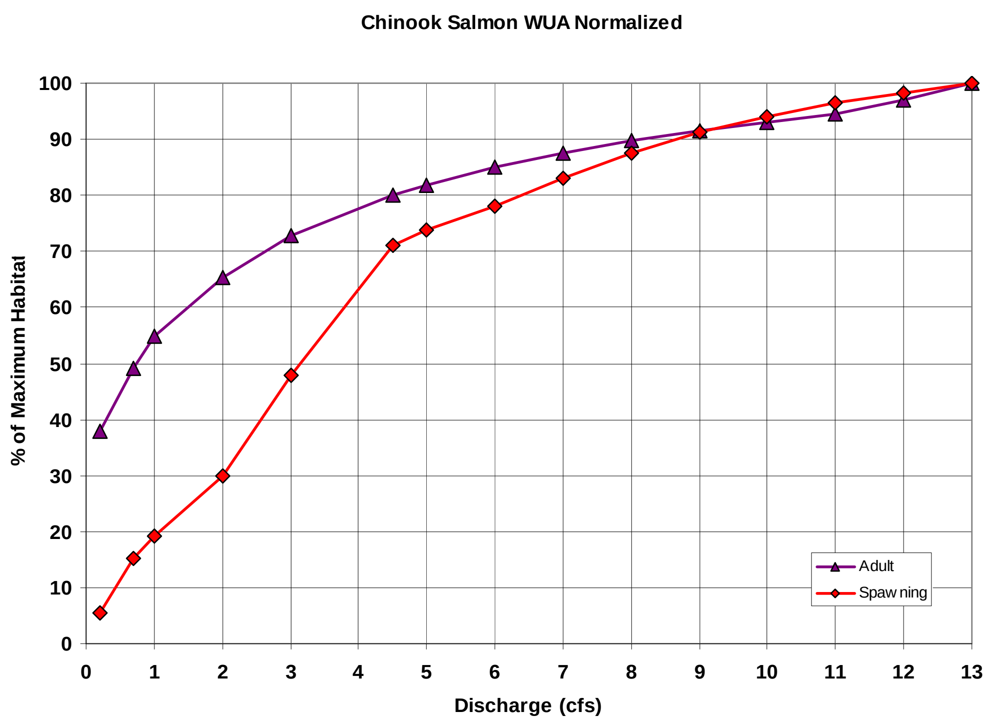

Figure 41. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Bohannon Creek, Study Site 1.

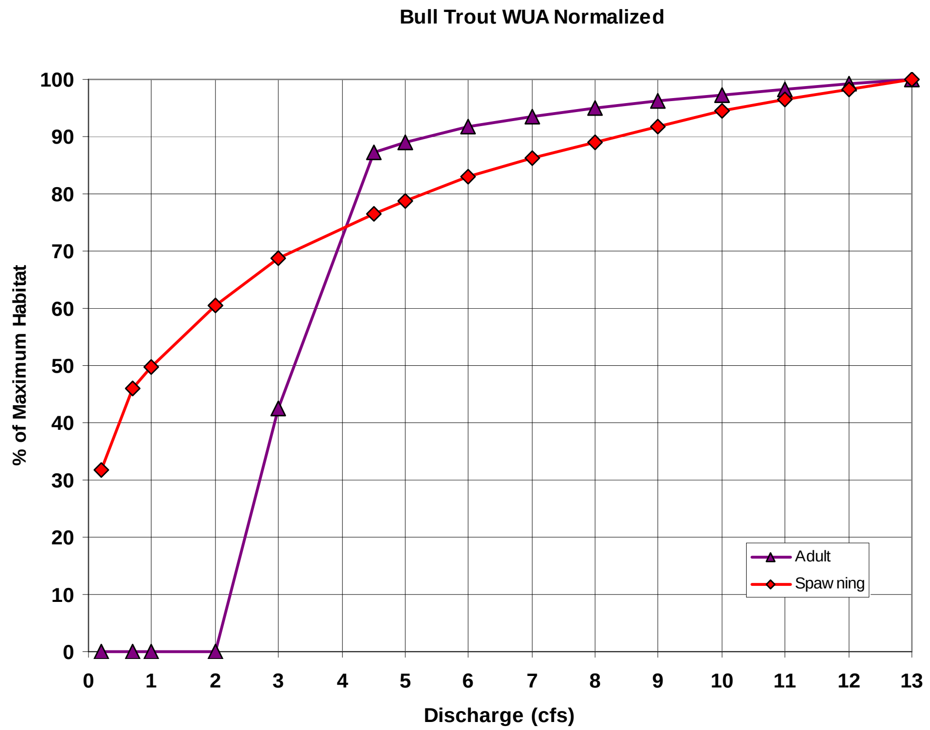

Figure 42. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Bohannon Creek, Study Site 1.

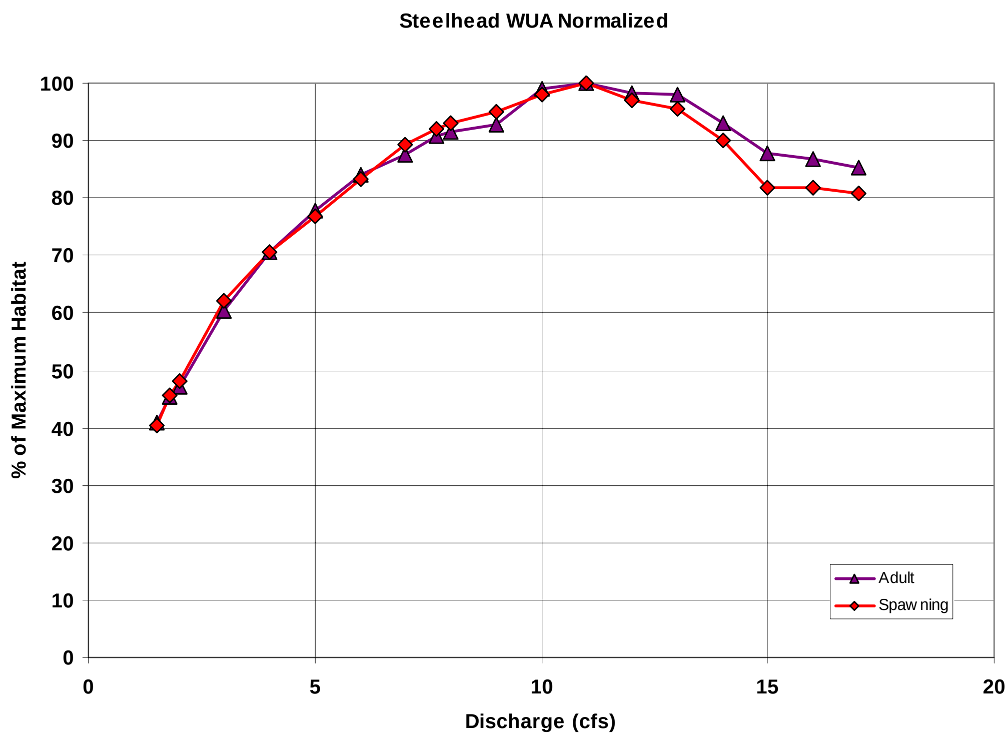

Figure 43. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Bohannon Creek, Study Site 2.

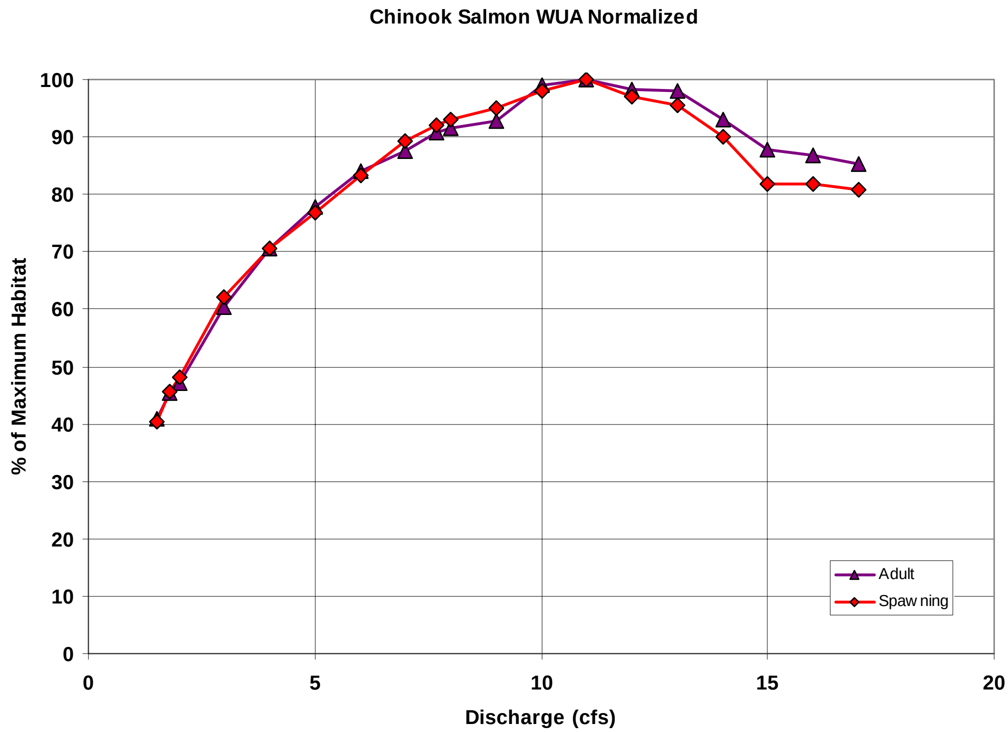

Figure 44. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Bohannon Creek, Study Site 2.

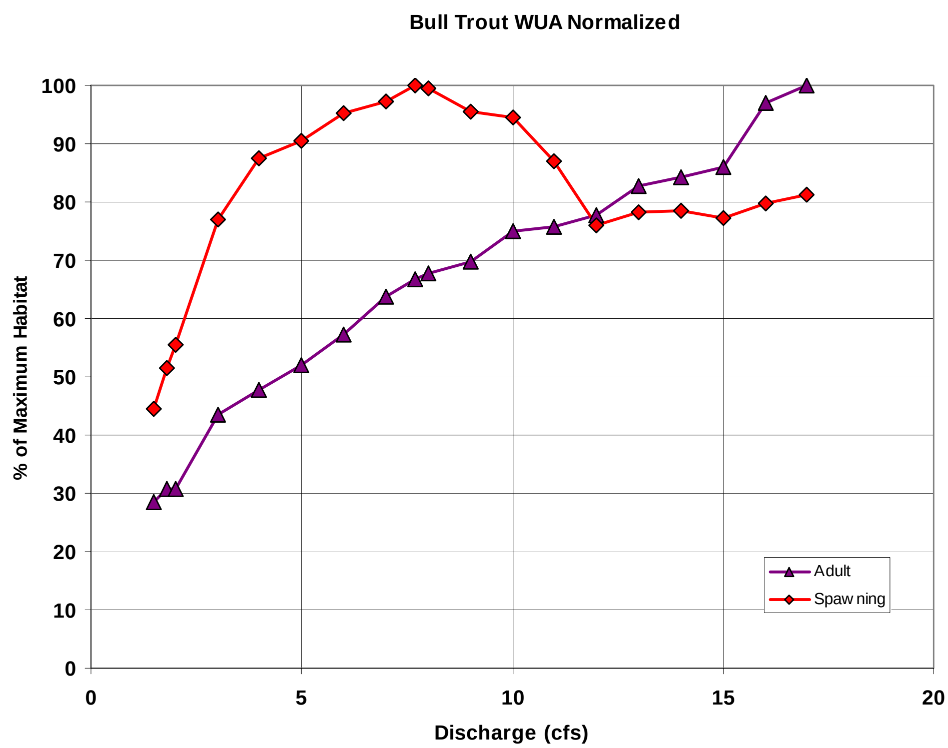

Figure 45. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Bohannon Creek, Study Site 2.

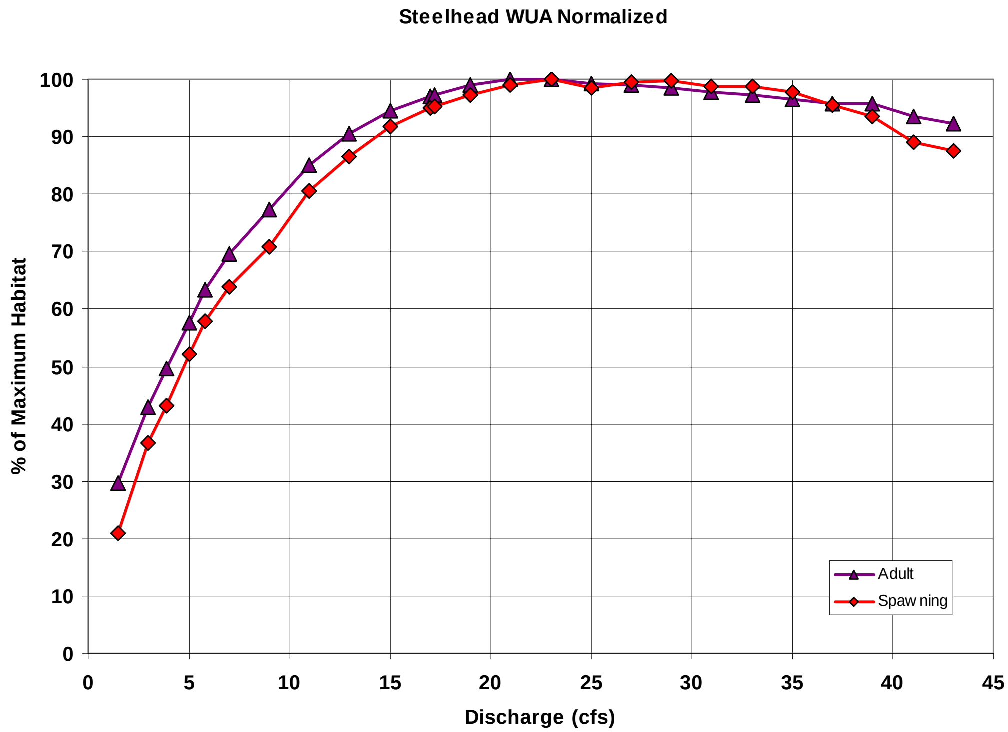

Figure 46. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Bohannon Creek, Study Site 3.

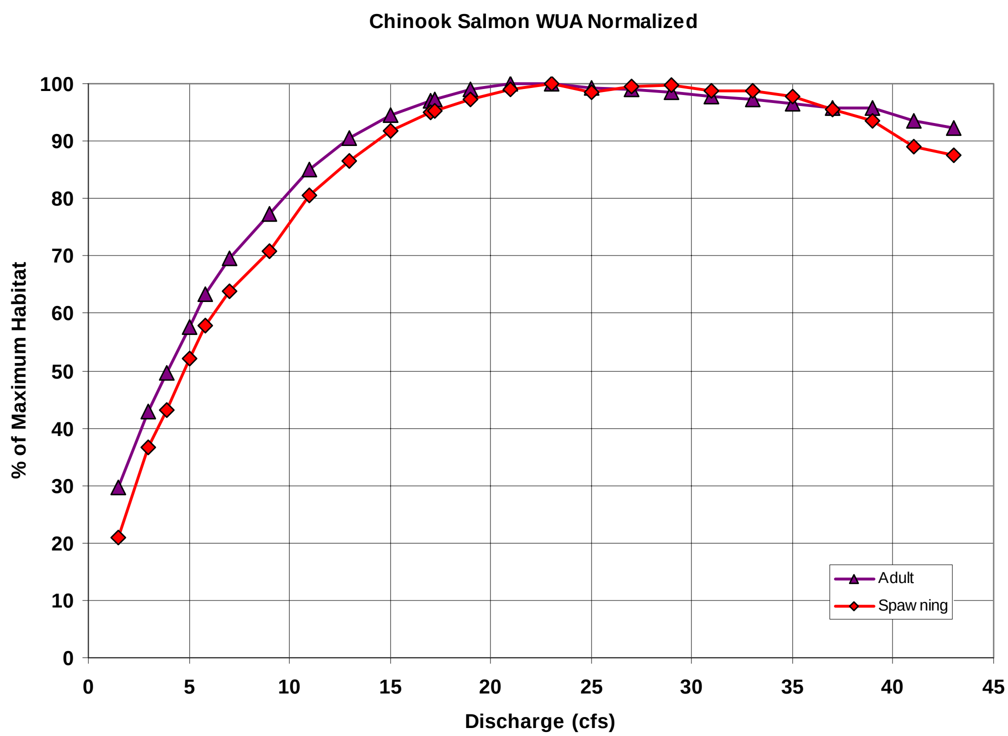

Figure 47. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Bohannon Creek, Study Site 3.

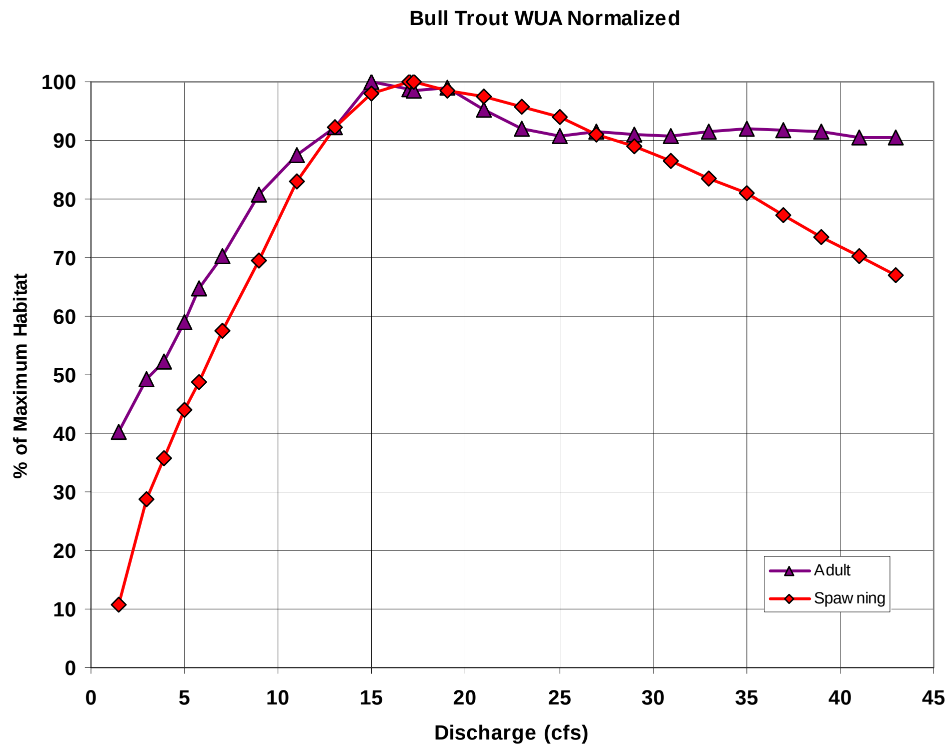

Figure 48. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Bohannon Creek, Study Site 3.

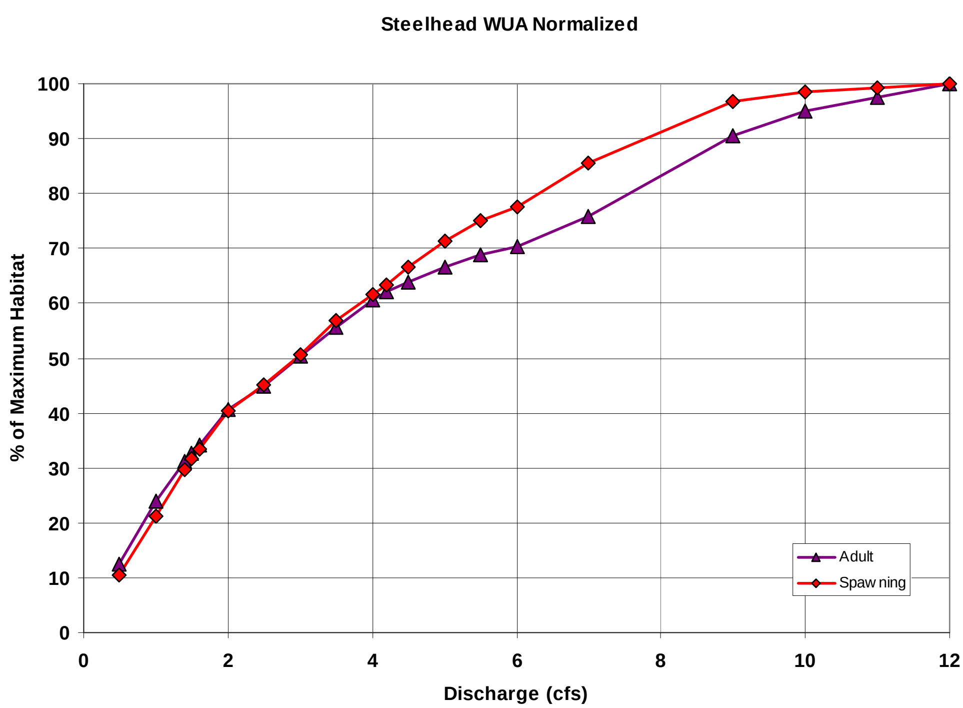

Figure 49. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Bohannon Creek, Study Site 4.

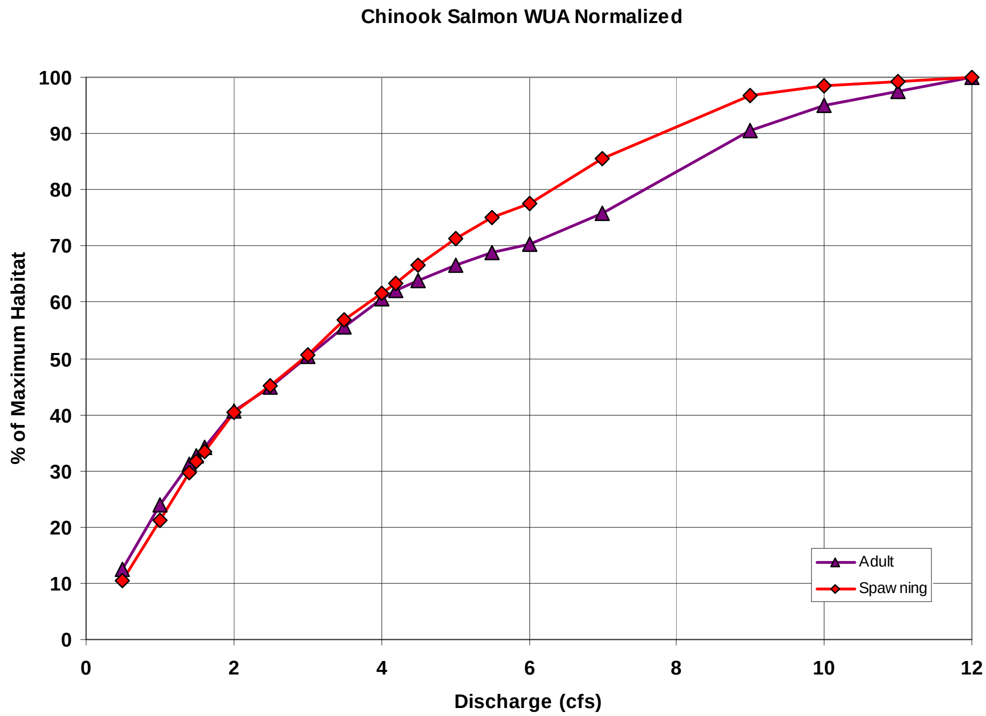

Figure 50. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Bohannon Creek, Study Site 4.

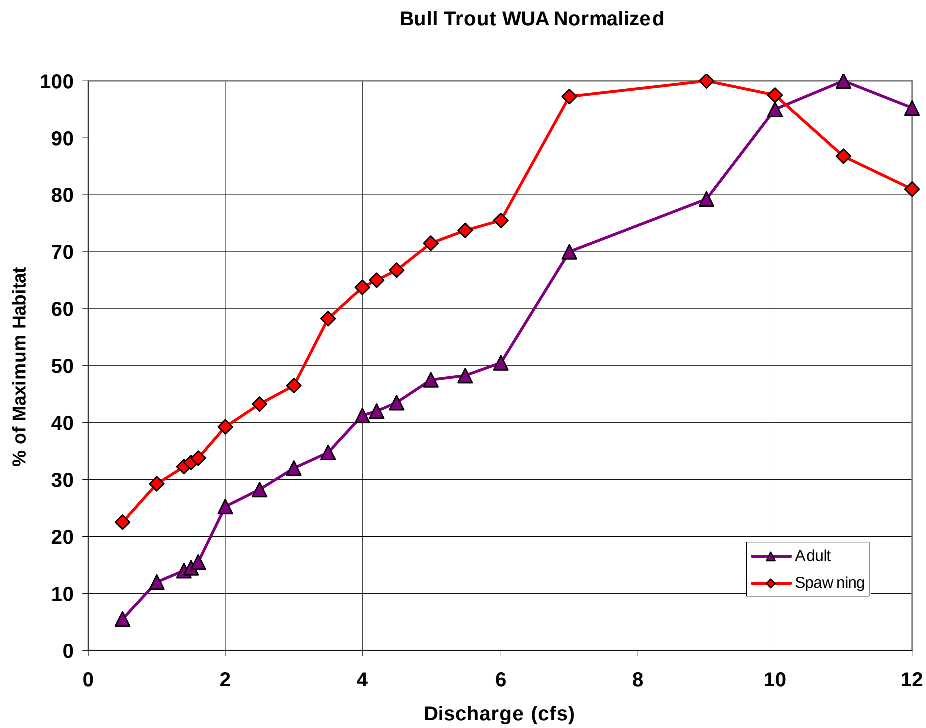

Figure 51. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Bohannon Creek, Study Site 4.

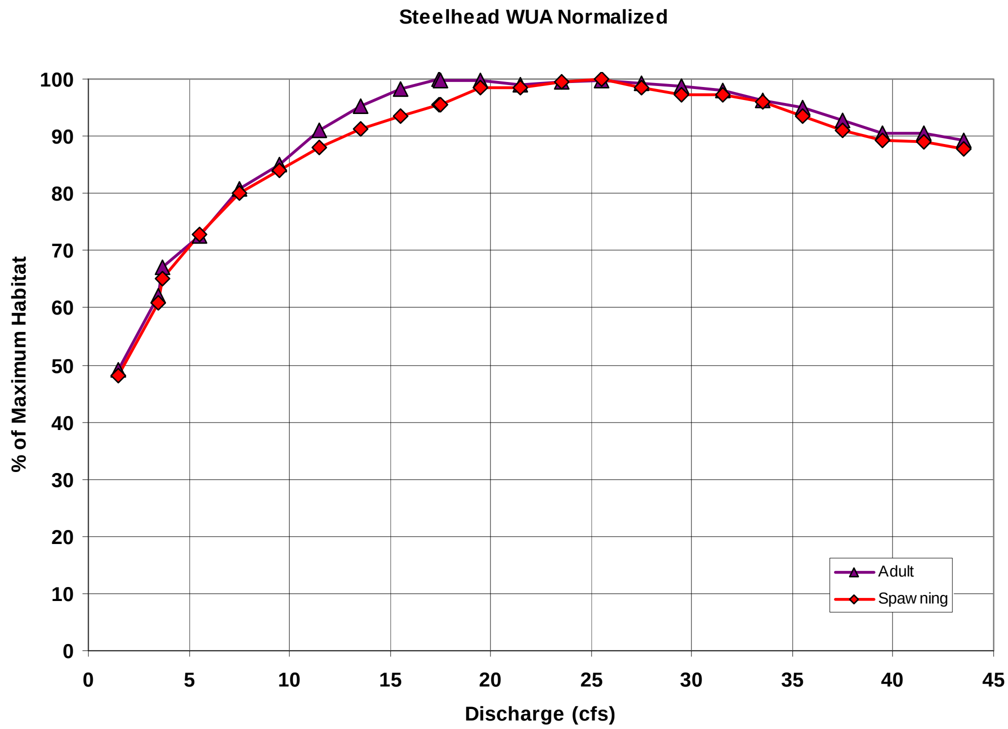

Figure 52. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Bohannon Creek, Reference Site.

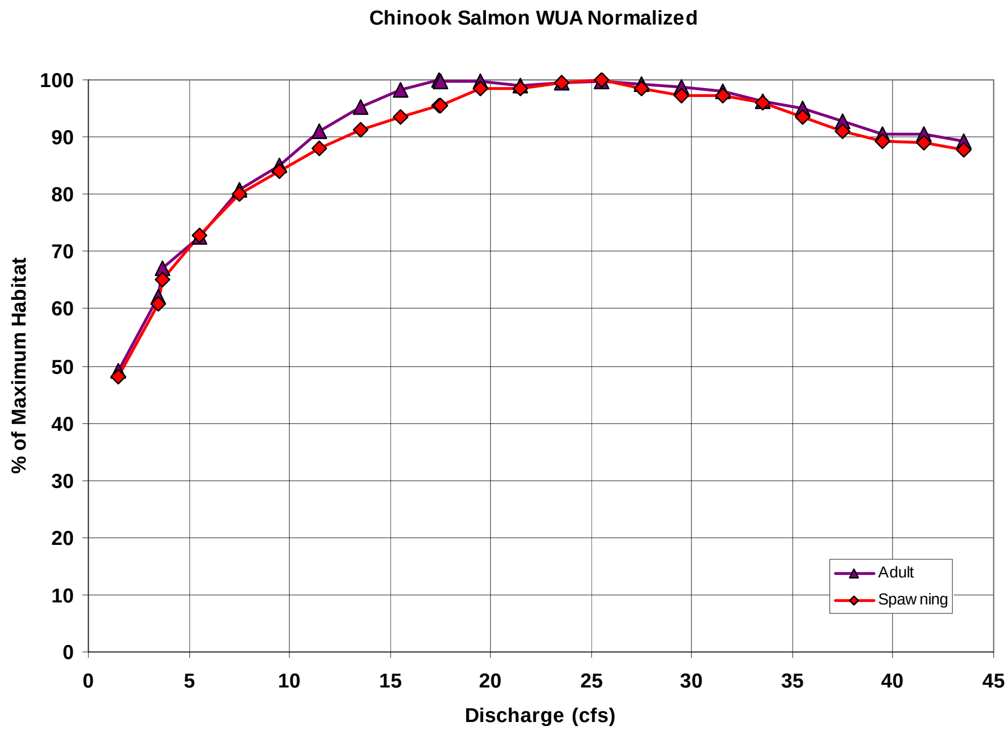

Figure 53. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Bohannon Creek, Reference Site.

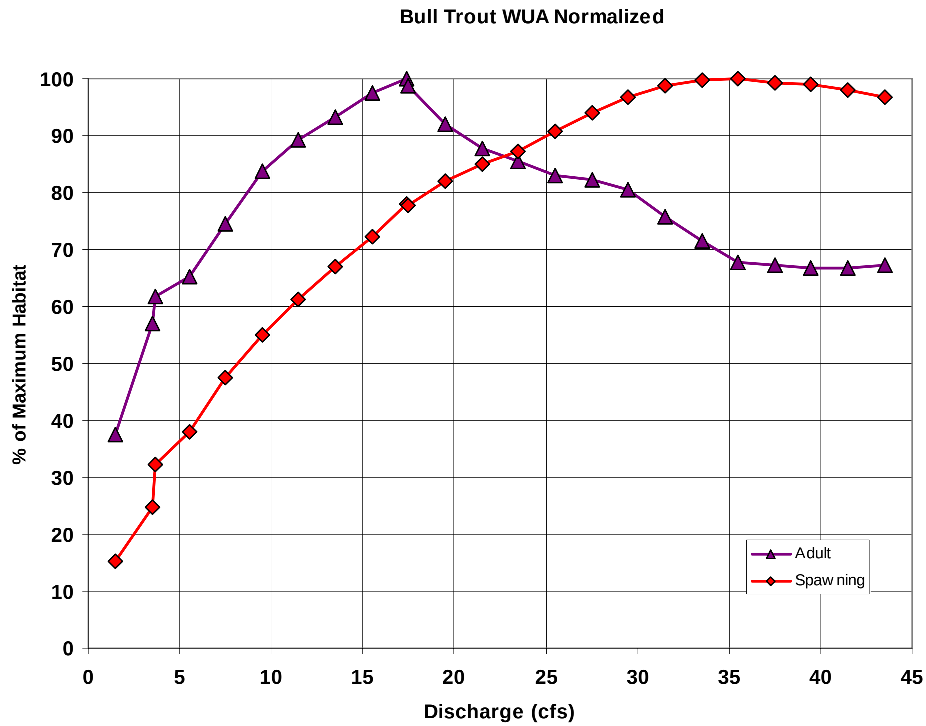

Figure 54. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Bohannon Creek, Reference Site.

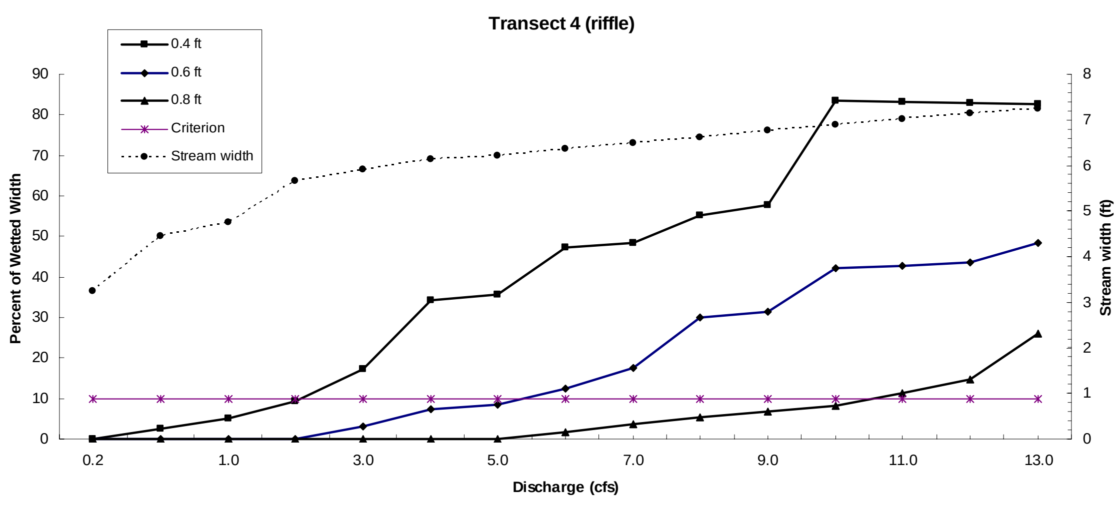

Figure 55. Contiguous widths at depths greater than passage criteria at a riffle transect on Bohannon Creek, Study Site 1.

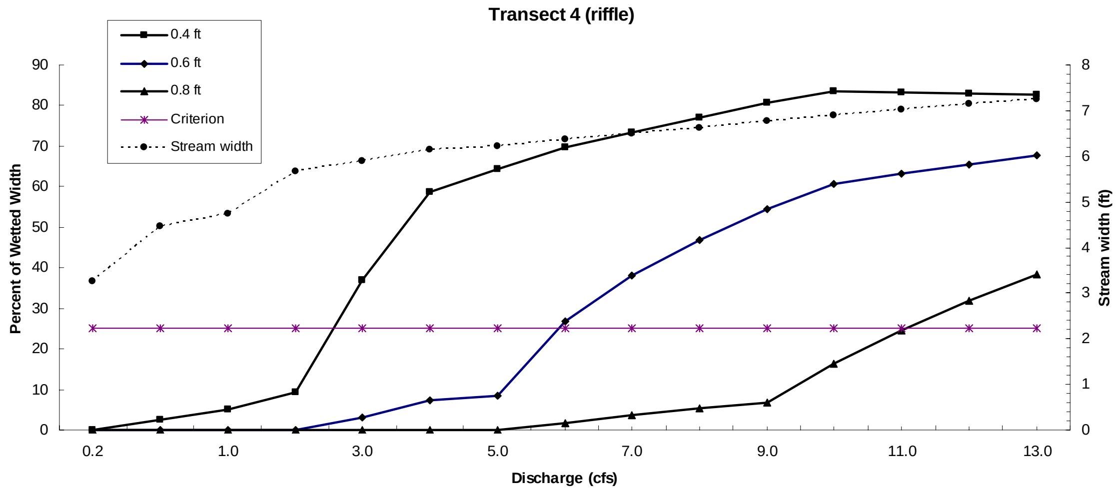

Figure 56. Total widths at depths greater than passage criteria at a riffle transect on Bohannon Creek, Study Site 1.

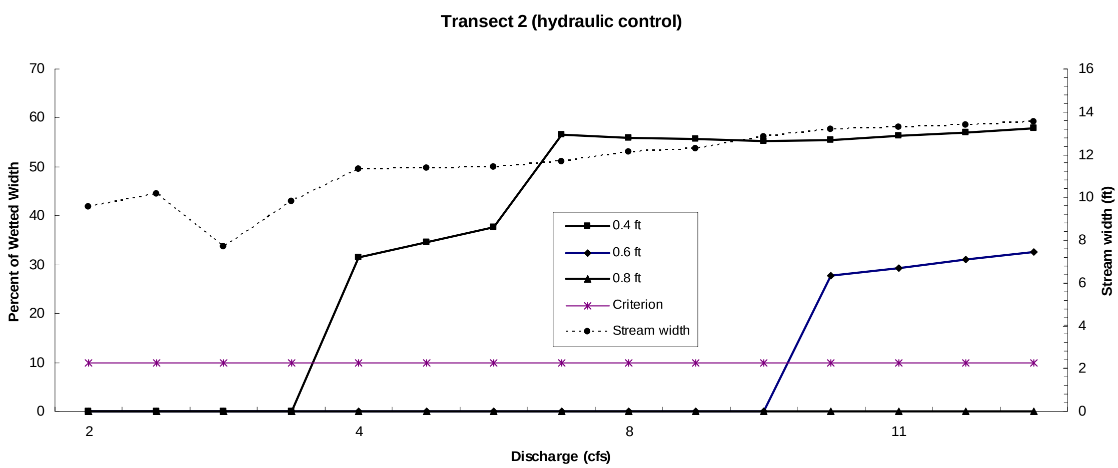

Figure 57. Contiguous widths at depths greater than passage criteria at a shallow transect on Bohannon Creek, Study Site 2.

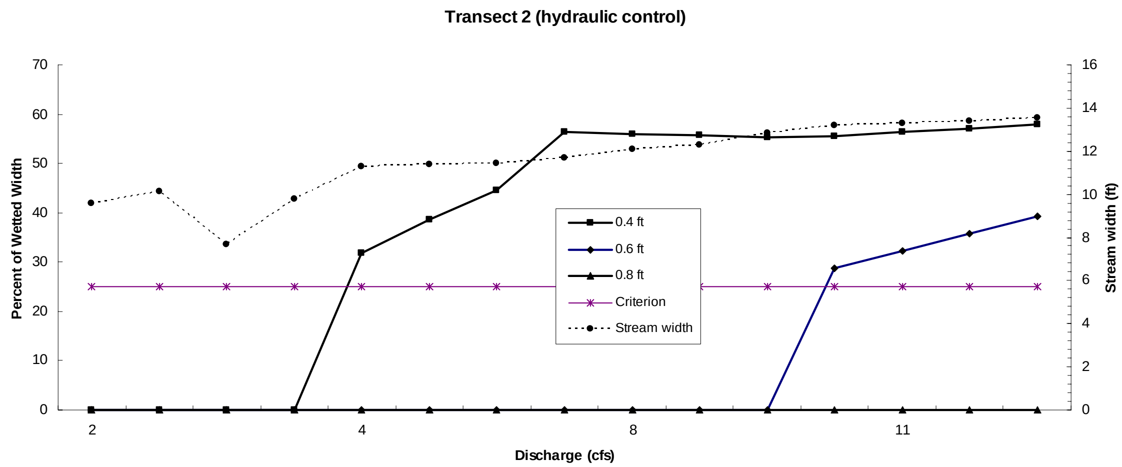

Figure 58. Total widths at depths greater than passage criteria at a shallow transect on Bohannon Creek, Study Site 2.

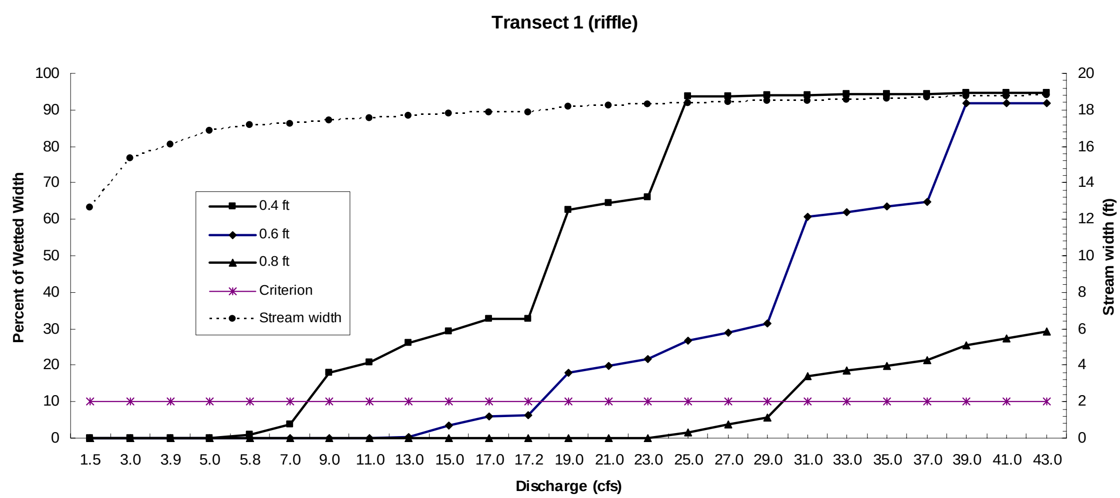

Figure 59. Contiguous widths at depths greater than passage criteria at a riffle transect on Bohannon Creek, Study Site 3.

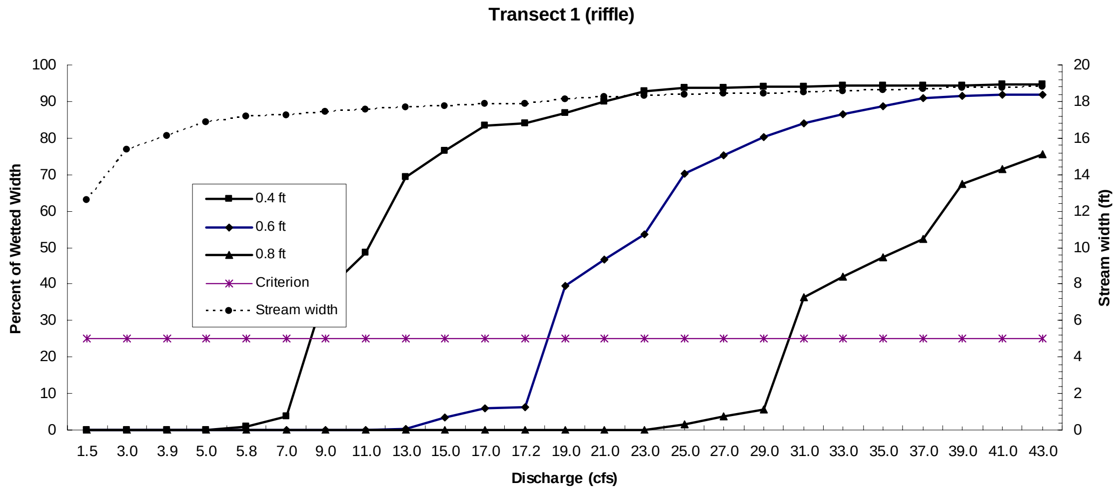

Figure 60. Total widths at depths greater than passage criteria at a riffle transect on Bohannon Creek, Study Site 3.

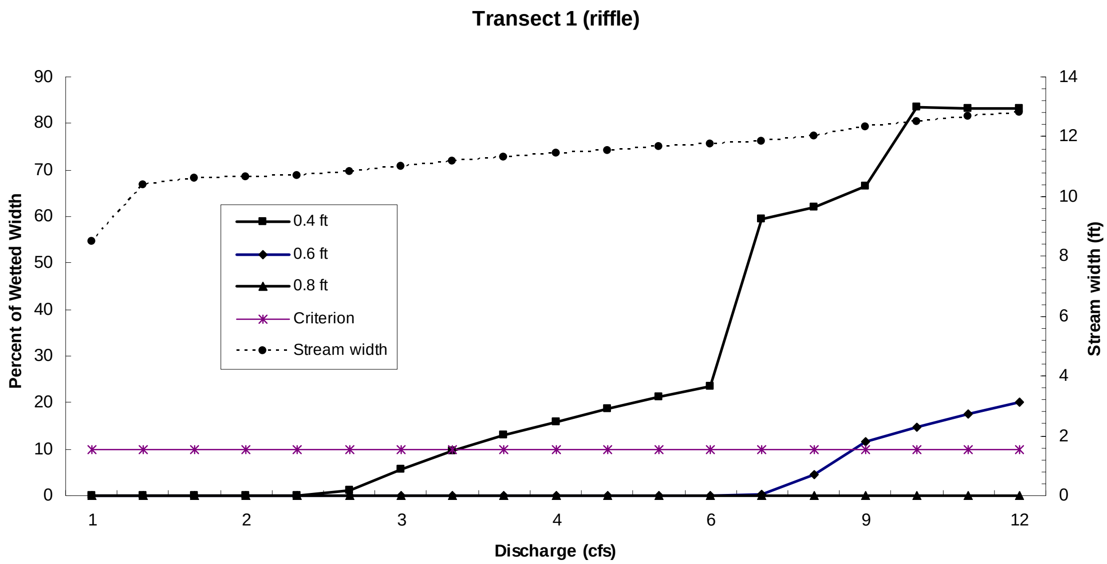

Figure 61. Contiguous widths at depths greater than passage criteria at a riffle transect on Bohannon Creek, Study Site 4.

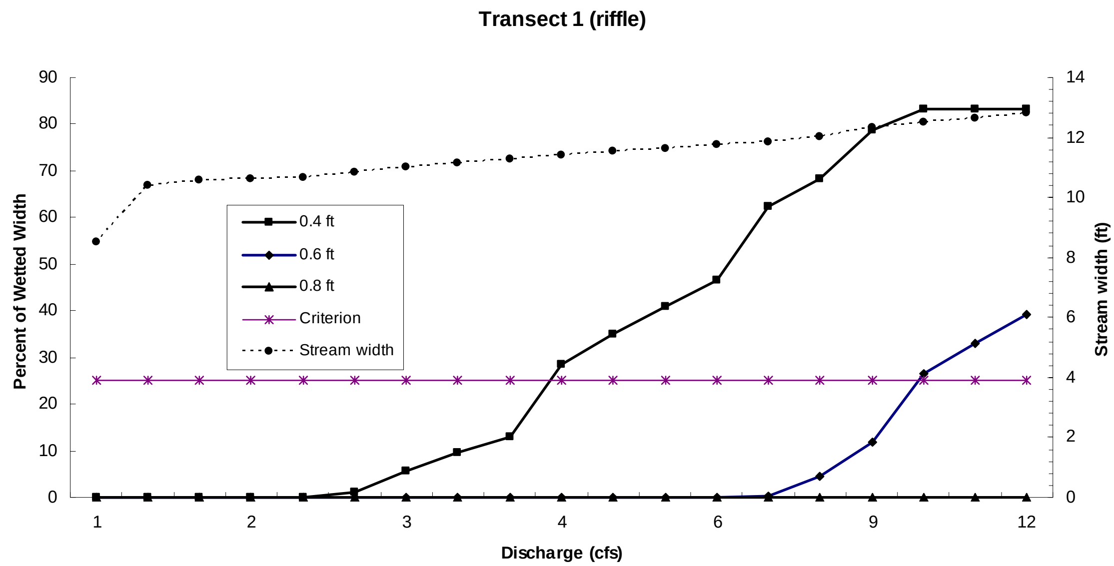

Figure 62. Total widths at depths greater than passage criteria at a riffle transect on Bohannon Creek, Study Site 4.

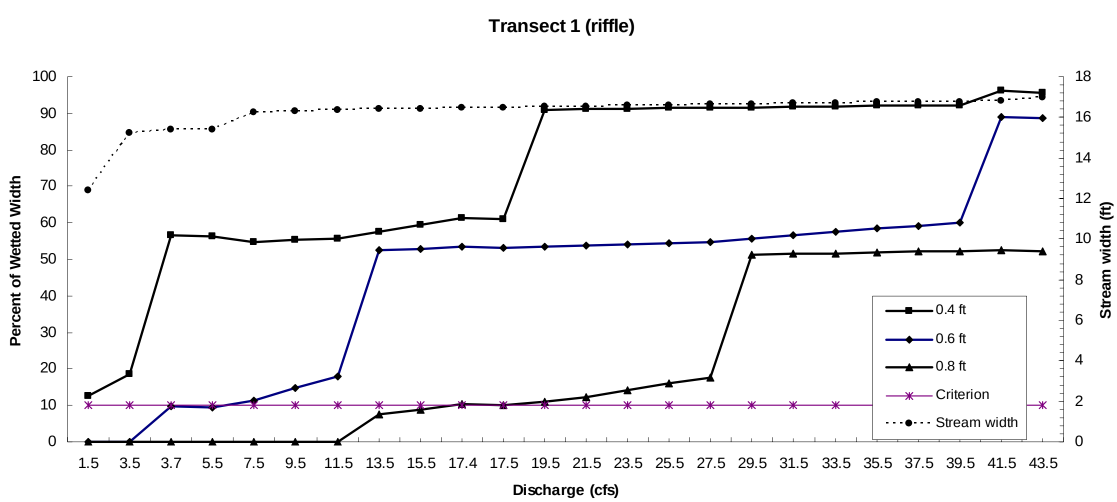

Figure 63. Contiguous widths at depths greater than passage criteria at a riffle transect on Bohannon Creek, Reference Site.

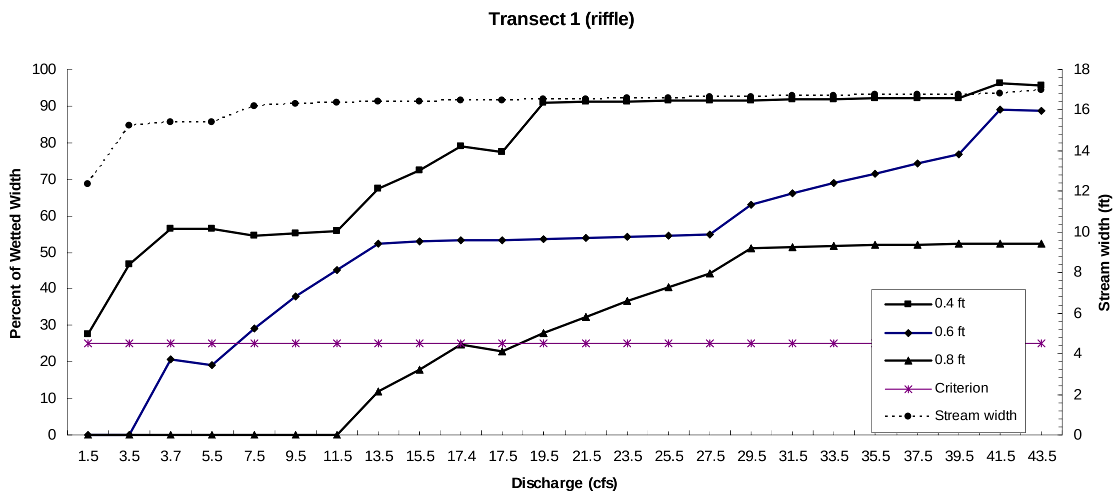

Figure 64. Total widths at depths greater than passage criteria at a riffle transect on Bohannon Creek, Reference Site.

Table 20. Habitat modeling summary on Bohannon 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
Study Site 1					
Spawning	>13	>13	>13	NA[2]	NA
Adult	>13	>13	>13	6	6
Study Site 2					
Spawning	11	11	7.7	NA[2]	NA
Adult	11	11	>17	10	10
Study Site 3					
Spawning	23	23	17	NA[2]	NA
Adult	21	21	15	19	19
Study Site 4					
Spawning	>12	>12	9	NA	NA
Adult	>12	>12	11	10	9
Study Site 5 (Reference)					
Spawning	25.5	25.5	35.5	NA	NA
Adult	17.4	17.4	17.4	7.5	7.5

[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

5.3 Hayden Creek

Measured discharges and dates of field surveys are summarized in Table 21. Unlike Big Eightmile and Bohannon Creeks, surveys were completed at low, medium, and high flows at all study sites.

Table 21. Discharges measured from highest to lowest at Hayden Creek study sites during field surveys in 2004.

Stream Site	Discharge (cfs)	Survey Dates
Study Site 1	127.7	June 4
	69.2	May 4
	23.3	September 16
Study Site 2	165.0	June 4
	92.2	May 4
	36.9	September 16
Study Site 3 (Reference)	184.5	June 4
	101.2	May 4
	37.5	September 16

Graphical representations of final normalized WUA versus discharge relationships are presented in Figures 65-73 for each site. A minimal amount of bull trout spawning habitat occurs in only one cell at Study Site 1 at flows greater than 140 cfs. That is the reason for the suspect shape of the WUA curve in Figure 67. Passage flow results for total and contiguous widths at depths greater than the passage criteria (Table 15) are illustrated in Figures 74-79.

Summary results, including flows required for optimal WUAs and flows needed to meet the 0.6 feet deep passage criteria are presented in Table 22. Summary results reflected differences in stream channel hydraulics among study sites.

Weighted Usable Area (WUA) estimates from a previous unpublished study conducted by EA Engineering on Hayden Creek downstream from the confluence of Basin Creek were compared to our results at Study Site 1 (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 1 because this was the only stream segment located downstream from Basin Creek where the stream channel hydraulics and hydrology were similar between studies. Appendix F includes graphical comparisons of the habitat modeling results between this study and the less intensive EA Engineering study. Although study results show similarities for some life stages (e.g., adult steelhead and Chinook salmon), reasons for differences between WUA estimates for other life stages are unknown. The results of this study are not easily transferable to other drainages unless hydrology, hydraulics, and limiting factors (e.g., temperature, passage) are similar among streams.

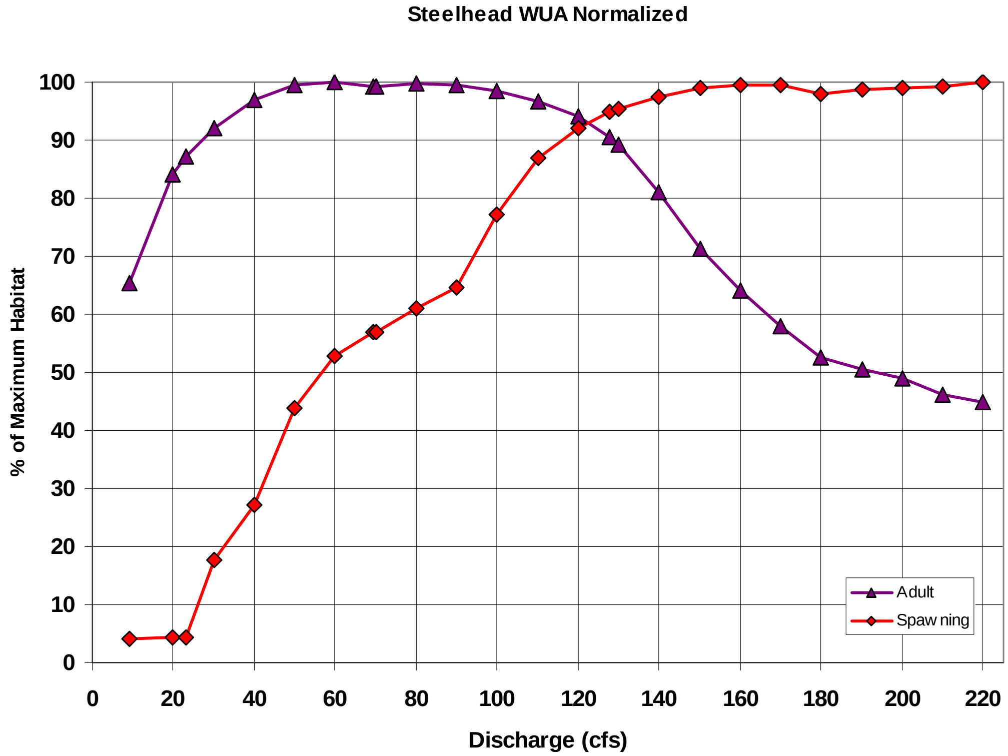

Figure 65. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Hayden Creek, Study Site 1.

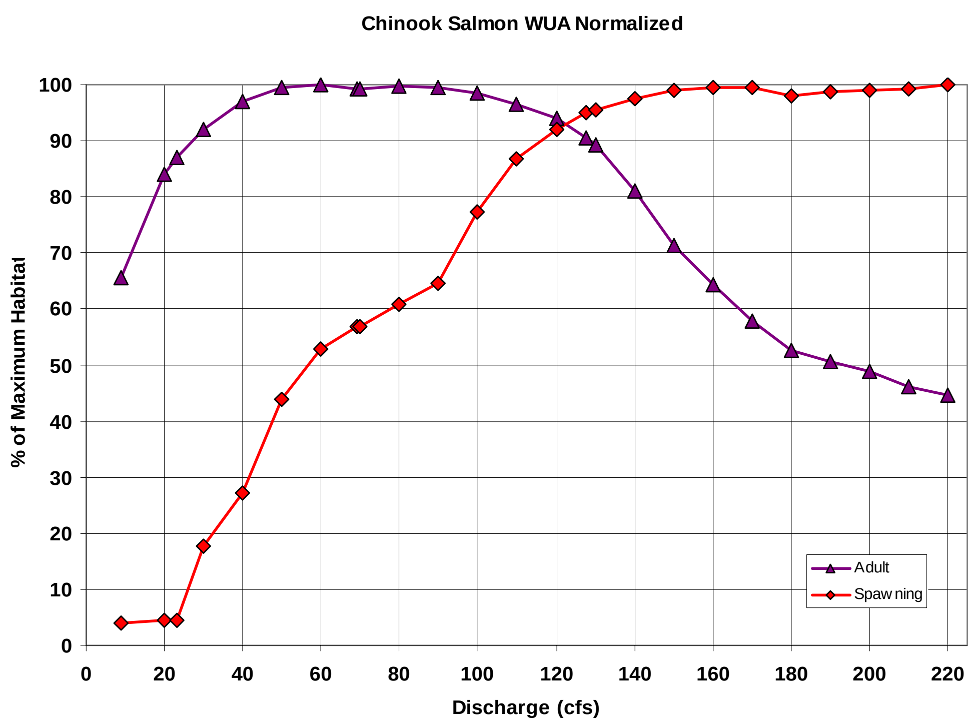

Figure 66. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Hayden Creek, Study Site 1.

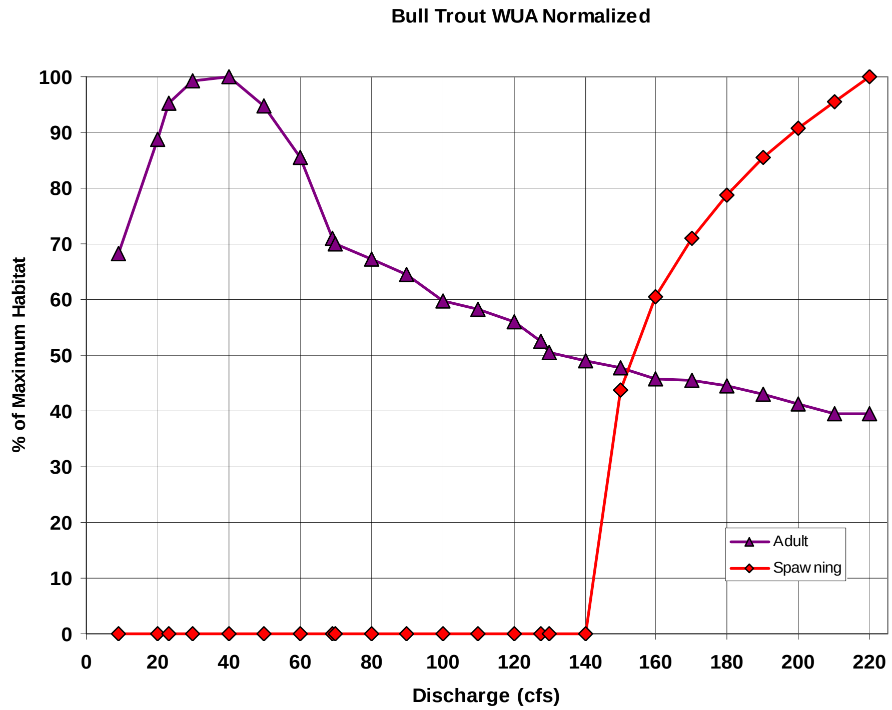

Figure 67. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Hayden Creek, Study Site 1.

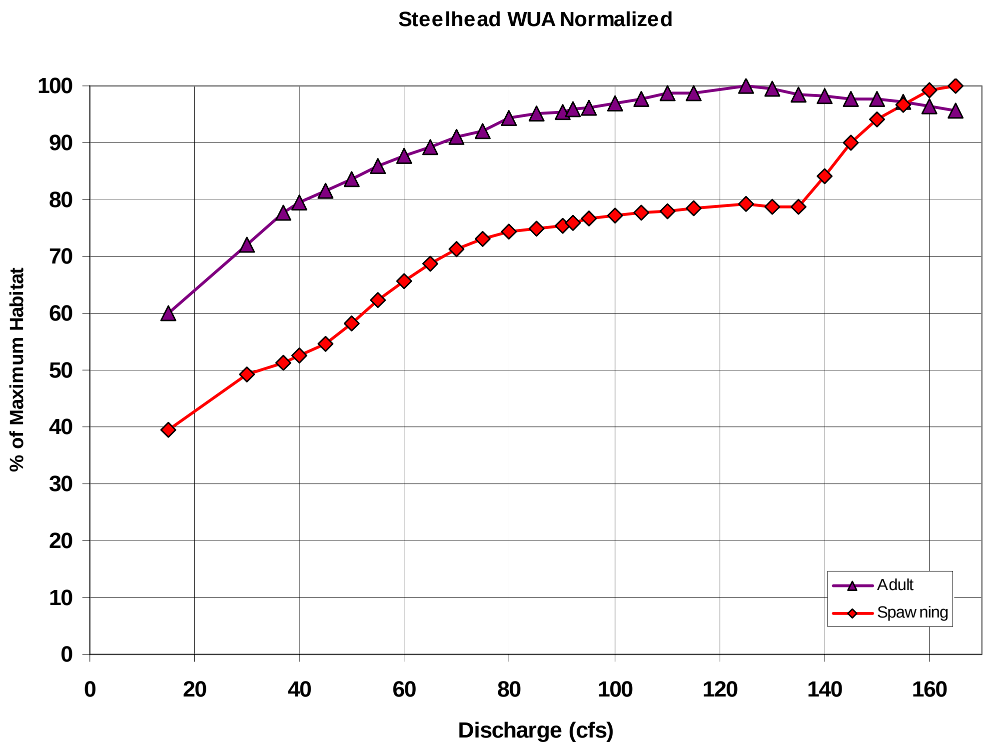

Figure 68. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Hayden Creek, Study Site 2.

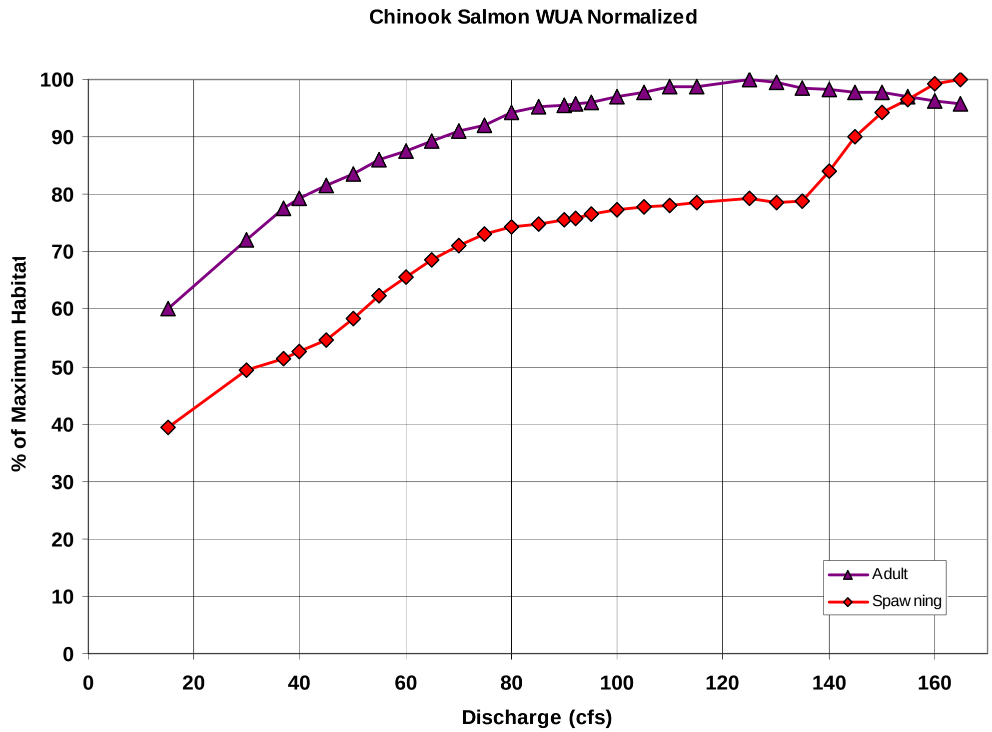

Figure 69. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Hayden Creek, Study Site 2.

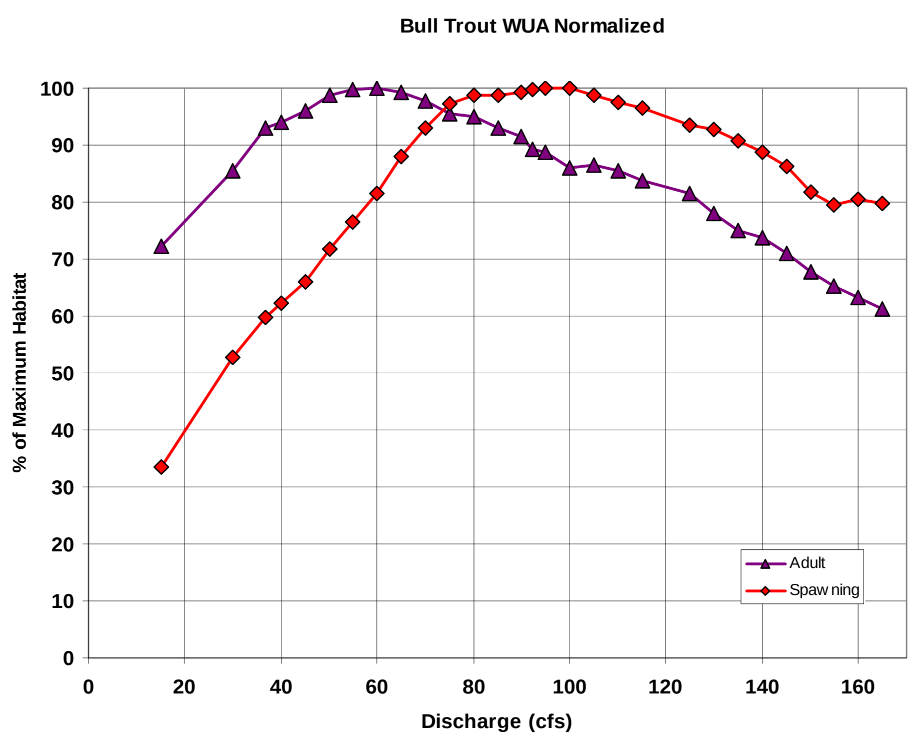

Figure 70. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Hayden Creek, Study Site 2.

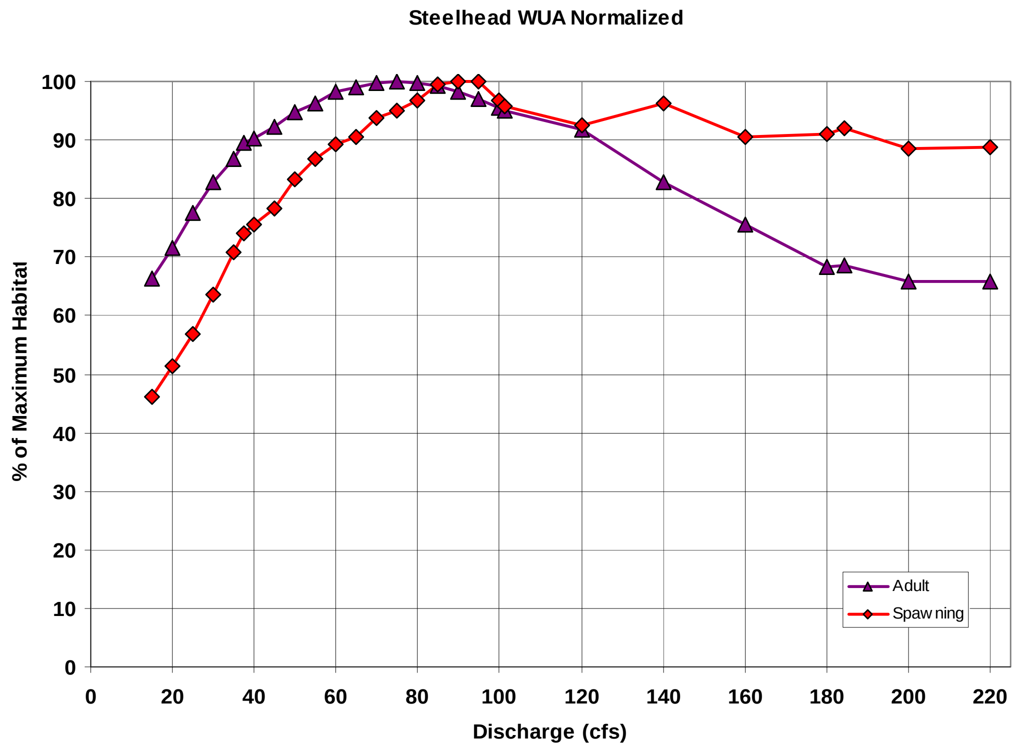

Figure 71. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for steelhead in Hayden Creek, Study Site 3.

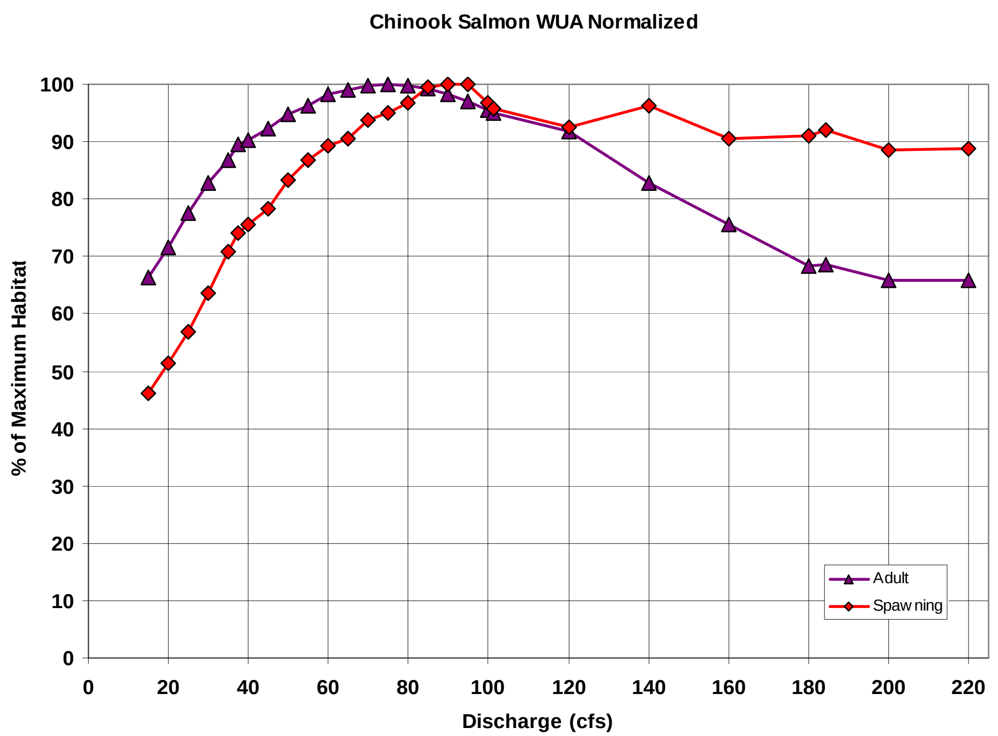

Figure 72. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for Chinook salmon in Hayden Creek, Study Site 3.

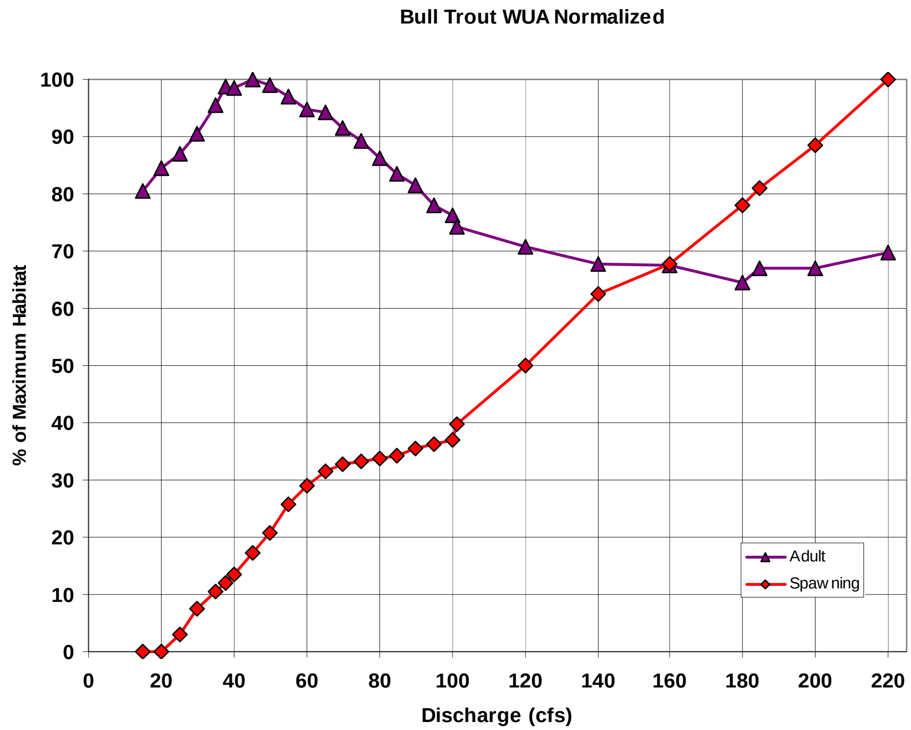

Figure 73. Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for bull trout in Hayden Creek, Study Site 3.

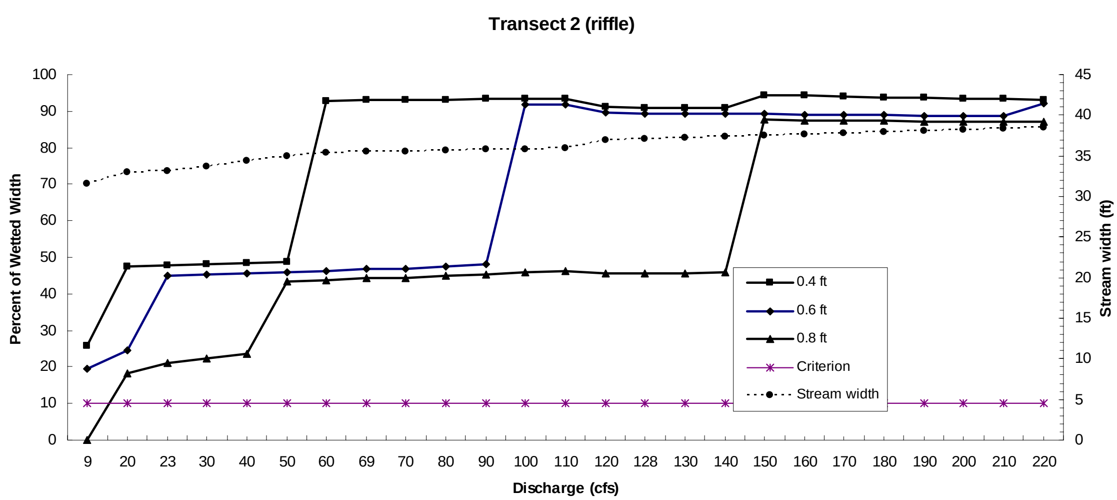

Figure 74. Contiguous widths at depths greater than passage criteria at a riffle transect on Hayden Creek, Study Site 1.

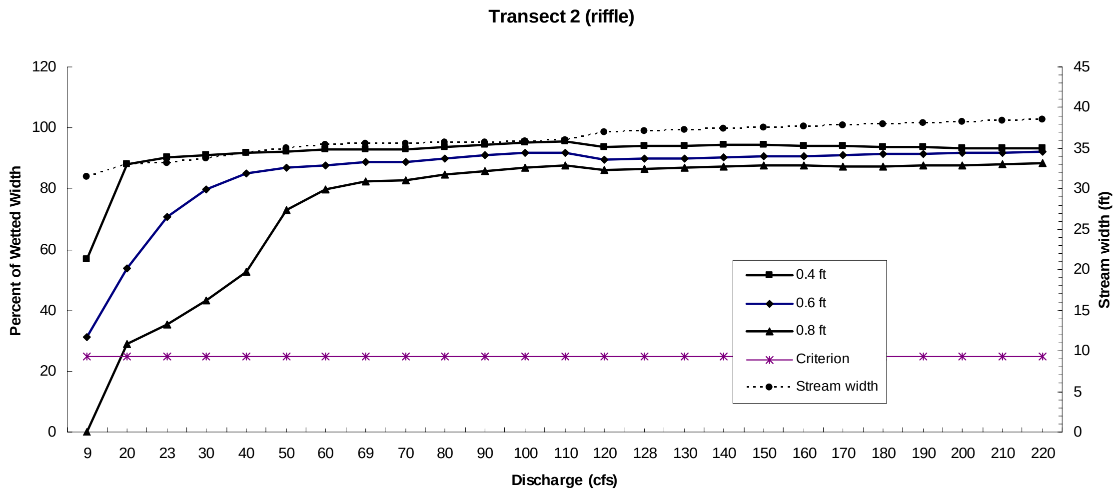

Figure 75. Total widths at depths greater than passage criteria at a riffle transect on Hayden Creek, Study Site 1.

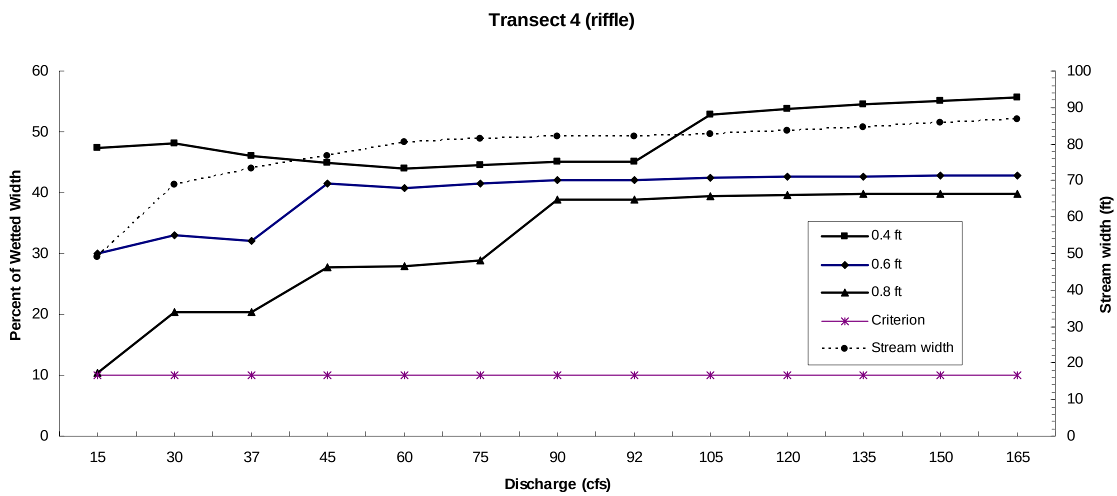

Figure 76. Contiguous widths at depths greater than passage criteria at a riffle transect on Hayden Creek, Study Site 2.

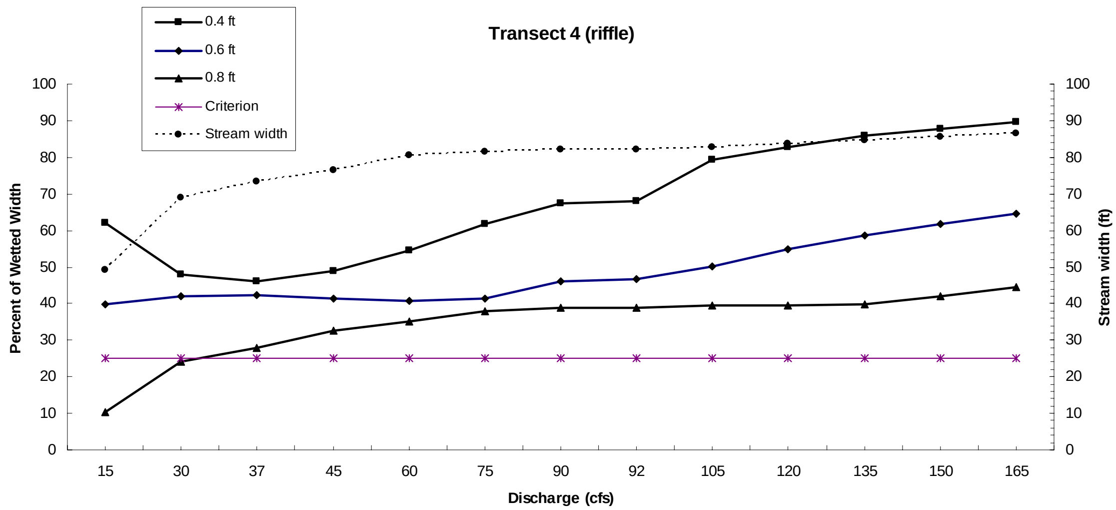

Figure 77. Total widths at depths greater than passage criteria at a riffle transect on Hayden Creek, Study Site 2.

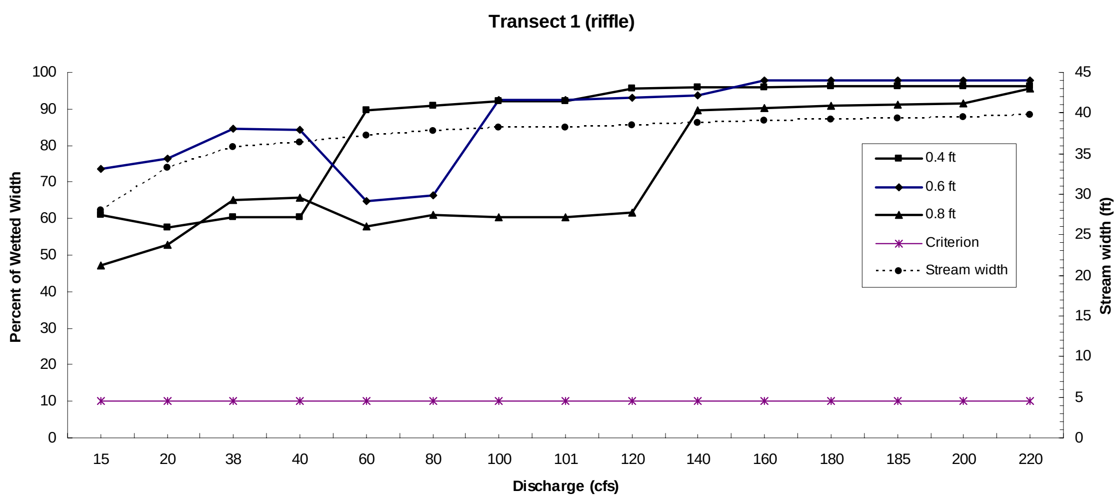

Figure 78. Contiguous widths at depths greater than passage criteria at a riffle transect on Hayden Creek, Study Site 3.

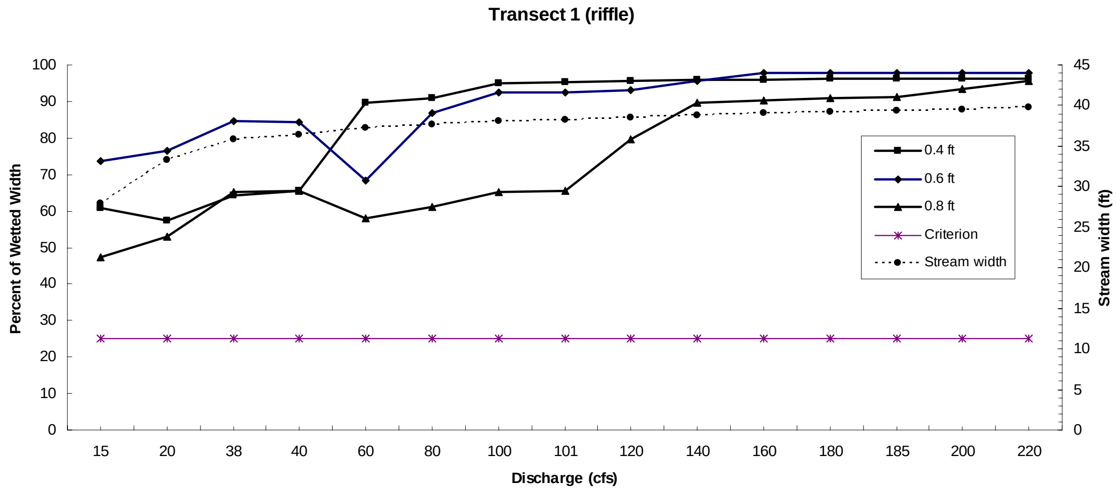

Figure 79. Total widths at depths greater than passage criteria at a riffle transect on Hayden Creek, Study Site 3.

Table 22. Habitat modeling summary on Hayden 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
Study Site 1					
Spawning	>220	>220	>220	NA[2]	NA
Adult	60	60	40	<9	<9
Study Site 2					
Spawning	>165	>165	95	NA[2]	NA
Adult	125	125	60	<15	<15
Study Site 3					
Spawning	90	90	>220	NA[2]	NA
Adult	75	75	45	<15	<15

[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

5.4 Guidelines for Using Study Results

The results presented in this report summarize the hydrology, habitat, and temperature characteristics of Big Eightmile, Bohannon and Hayden Creeks during summer, 2004. PHABSIM analysis of the data collected and compiled for this study resulted in a series of graphs that illustrate relations between a dimensionless value (expressed as percent of maximum) called weighted usable area (WUA) and discharge (Figures 15-29, 40-54 and 65-73). The highest point on each curve represents the discharge at which habitat is optimized for adult or spawning life stages for the fish species analyzed in this study (salmon, steelhead, and bull trout). These optimized values, summarized in Tables 18, 20, and 22, rarely coincide among life stages for any one species. Furthermore, adult and spawning life stages for salmon, steelhead, and bull trout occur at different times of the year. These results imply that the optimum amount of water needed for adult and spawning 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 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.

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, juvenile life stage will not be included in this study.

The selection of target flows 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 16 provides some general guidelines for which life stage to assess. For small tributary streams of the Lemhi River sub-basin, one possible 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.

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 seems reasonable that providing connectivity to the Lemhi River by providing enough water for adult fish passage would be a management priority (Table 16). Water depths are an additional consideration for the adult life stage. Choice of target flows should not be reduced to the point that stream depth is reduced below the level needed for fish passage (Tables 18, 20, and 22), depending on available water supply.

The actual habitat experienced by fish in any river depends on the flow regime of the river. The development of habitat conditions over a period of time is an integral part of the comparison of flow regimes and developing flow recommendations. Habitat time series analysis involves interfacing a time series of streamflow data with the functional relationship between streamflow and habitat (WUA) (Bovee et al. 1998). This computational process is done for each flow regime alternative and life stage. Flow and habitat duration statistics are developed that allow a direct comparison of the changes that occur in both flow and habitat under a range of conditions. The amount of WUA available, in terms of lost or gained, can be determined by comparing WUA for a flow alternative to a reference or unregulated stream flow condition. The decision point in PHABSIM is a comparison of flow regimes. In streams with more than one species of interest, the results should be reviewed to ensure recommended flows balance the needs of all species.

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 et al. (2001) 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. 2001).

6.0 ACKNOWLEDGMENTS

We thank the numerous representatives from various organizations and private landowners who contributed to the success of this project. Al Simpson of Reclamation provided valuable assistance in obtaining landowner permission on private land. We also thank landowners who allowed access to their property. 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, Jon Hortness, Joseph Bunt, and Alvin Sablan assisted with obtaining valuable hydrology data. Patrick Murphy of IDFG provided recently collected fishery data for Big Eightmile and Bohannon Creeks. Representatives on the Interagency Technical Workgroup organized by Reclamation also provided guidance, including Cynthia Robertson (IDFG), Jim Morrow (NOAA Fisheries), Jana Brimmer (FWS), and Jude Trapani (BLM). A draft version of this report was peer-reviewed by Al Simpson of Reclamation and Terry Maret, Jon Hortness, and Douglas Ott of USGS.

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APPENDIX A – REACH AND STUDY SITE DESCRIPTIONS AND PHOTOS

Big Eightmile Creek, Reach 1: This reach was the most downstream segment of the study site, and was dewatered much of the year due to diversions above (LBEC-02). It was characterized mainly by riffles and glides. Riparian vegetation was sparce at this study site.

<u>Study Site 1 – Most downstream study site (N44.73826 W113.46152)</u>

Transect 1 – riffle (downstream transect)
Transect 2 – run (upstream transect)

Big Eightmile Creek, Reach 2: This study site was located on private property, just downstream from a major diversion (LBEC-07). The diversion downstream emptied the channel of most of the discharge. It primarily consisted of riffles and glides.

Study Site 2 – (N44.697853 W113.481394)

Transect 1 – riffle
Transect 2 – glide
Transect 3 – riffle
Transect 4 – glide

Big Eightmile Creek, Reach 3: This reach was located between two major diversions (LBEC-07 and LBEC-11) that defined the upstream and downstream boundaries of reaches 2 and 4, respectively. The study site was located on private property, and was a mixture of riffle, pool, glide habitat types.

<u>Study Site 3 – (N44.673450 W113.495593)</u>
Transect 1 – hydraulic control/ passage riffle
Transect 2 – pool
Transect 3 – pool
Transect 4 – glide
Transect 5 – riffle

Big Eightmile Creek, Reach 4: This study site for this reach is located on private property and represents a mixture of riffle and run habitat types. The upper and lower boundaries of this reach are two large diversions (LBEC-11 and LBEC-15), separating reaches 3 and 5, respectively. Riparian vegetation is thick in areas, with willows and cottonwood trees.

Study Site 4 – (N44.655989 W113.506397)

Transect 1 – glide
Transect 2 – glide
Transect 3 – riffle
Transect 4 – riffle

Big Eightmile Creek, Reference Site (Reach 5): This reach was located on Forest Service land, upstream of a large diversion (LBEC-15), and downstream of a small tributary (Devils Canyon). This study site was representative of Bohannon Creek undisturbed by diversion structures. The study site represented natural flow conditions immediately upstream from the major diversions on Bohannon Creek.

<u>Study Site 5 (reference site) – (N44.644681 W113.528209)</u>

Transect 1 – hydraulic control
Transect 2 – pool
Transect 3 – glide
Transect 4 – riffle
Transect 5 – riffle

Bohannon Creek, Reach 1: This reach extended from the confluence with the Lemhi River upstream to the first major diversion (BC-03). The stream channel was very narrow, consisting of primarily glides and riffles.

<u>Study Site 1 – Most downstream site (N45.11245 W113.74531)</u>

Transect 1 – riffle-passage issue (most downstream transect)
Transect 2 – glide
Transect 3 – riffle
Transect 4 – riffle (passage)
Transect 5 – glide (most upstream transect)

Bohannon Creek, Reach 2: This reach was located between the last major diversion downstream (BC-03), to the next major diversion upstream (BC-05). The discharge in this reach depended heavily upon water taken from the upper diversion.

Study Site 2 – Next study site upstream from Reach 1 (N45.123300 W113.731923)

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

Bohannon Creek, Reach 3: This was the third reach of Bohannon Creek, having major diversions at the downstream (BC-05) and upstream (BC-06) end of the reach.

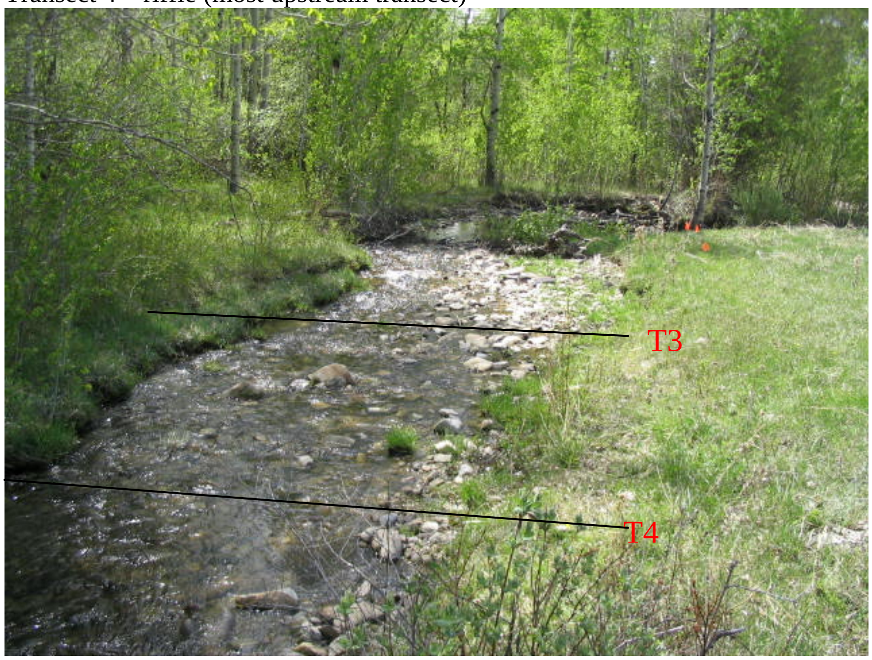
Study Site 3 – (N45.137167 W113716639)

Transect 1 – riffle-passage issue (most downstream transect)
Transect 2 – riffle
Transect 3 – riffle
Transect 4 – glide
Transect 5 – hydraulic control
Transect 6 – pool
Transect 7 – glide (most upstream transect)

Bohannon Creek, Reach 4: This reach represented the stream between the next two major diversions (BC-06 and BC-07). This reach had excellent riparian vegetation, and good quality of woody debris in and around the transects. The riparian vegetation was dominated by cottonwood trees and willows.

Study Site 4 – (N45.166290 W113.710615)

Transect 1 – riffle-passage issue (most downstream transect)
Transect 2 – glide
Transect 3 – riffle
Transect 4 – riffle (most upstream transect)



Bohannon Creek, Reach 5 (reference site): This study site represented the natural flow conditions immediately upstream from the major diversion (BC-13). This represented Bohannon Creek as most likely undisturbed by diversion structures.

<u>Study Site 5 (Reference Site) – (N45.191728 W113.689640)</u>

Transect 1 – riffle/hydraulic control (most downstream transect)
Transect 2 – pool
Transect 3 – riffle
Transect 4 – riffle
Transect 5 – glide
Transect 6 – riffle/hydraulic control (most upstream transect)

Hayden Creek, Reach 1: This reach extended from the confluence with the Lemhi River upstream to the first major diversion (LHC-01). The stream channel was widest at this reach compared to the upstream reaches.

<u>Study Site 1 – Most downstream study site (N44.867460 W113.627563)</u>

Transect 1 – glide (most downstream transect)
Transect 2 – riffle
Transect 3 – hydraulic control
Transect 4 – pool
Transect 5 – glide (most upstream transect)

Hayden Creek, Reach 2: This reach extended from the private property boundary to the major diversion upstream, LHC-10. This reach was characterized by a mixture of a pool, riffles and glides. All riparian vegetation had been burnt by the 2003 forest fire.

Study Site 2 (N44.798752 W113.696469)

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

Hayden Creek, Reach 3: This reach extended from the LHC-10 diversion upstream into private property. This was the most upstream reach for Hayden Creek, representing the least impacted stretches of stream. This reach of the stream was the narrowest of the three study sites. Again, most riparian vegetation was burnt by the 2003 forest fire.

<u>Study Site 3 – Most upstream study site (N44.796708 W113.697623)</u>

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

APPENDIX B – HABITAT MAPPING PROPORTIONS

Big Eightmile Creek

	Distance Mapped (feet)	Proportions (%)
Study Site 1		
Riffle	376	53.4
Glide	296	42.0
Pool	32	4.5
Total	707	100
Study Sites 2 &3		
Riffle	2047	56.9
Glide	1390	38.6
Pool	162	4.5
Total	3599	100
Study Site 4		
Riffle	3270	59.5
Glide	1860	33.8
Pool	367	6.7
Total	5497	100
Study Site 5		
Riffle	120	58.8
Glide	67	32.8
Pool	17	8.3
Total	204	100

Bohannon Creek

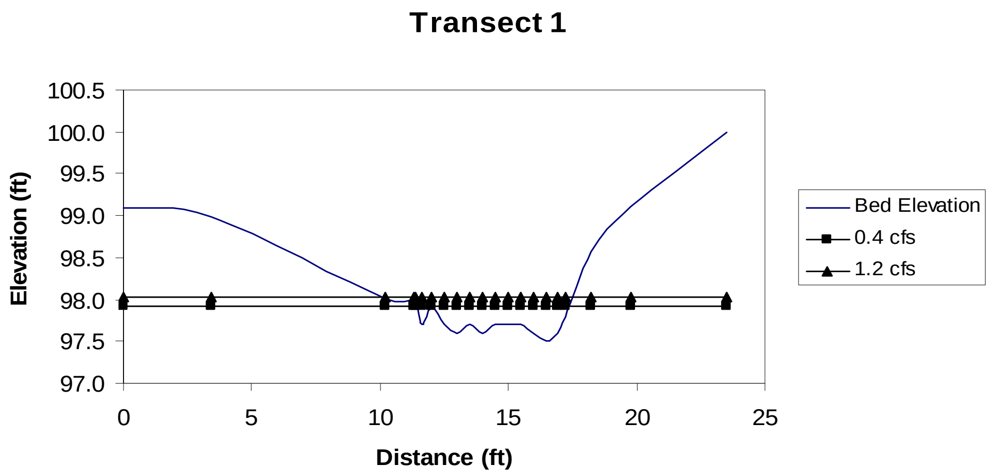
	Distance Mapped (feet)	Proportions (%)
Study Site 1		
Riffle	95	39.6
Glide	139	57.9
Pool	6	2.5
Total	240	100
Study Site 2		
Riffle	279	42.3
Glide	339	51.4
Pool	41	6.2
Total	659	100
Study Site 3		
Riffle	1414	57.8
Glide	800	32.7
Pool	233	9.5
Total	2447	100
Study Site 4		
Riffle	2223	80.2
Glide	456	16.4
Pool	94	3.4
Total	2773	100
Study Site 5		
Riffle	396	69.4
Glide	132	23.2
Pool	42	7.4
Total	570	100

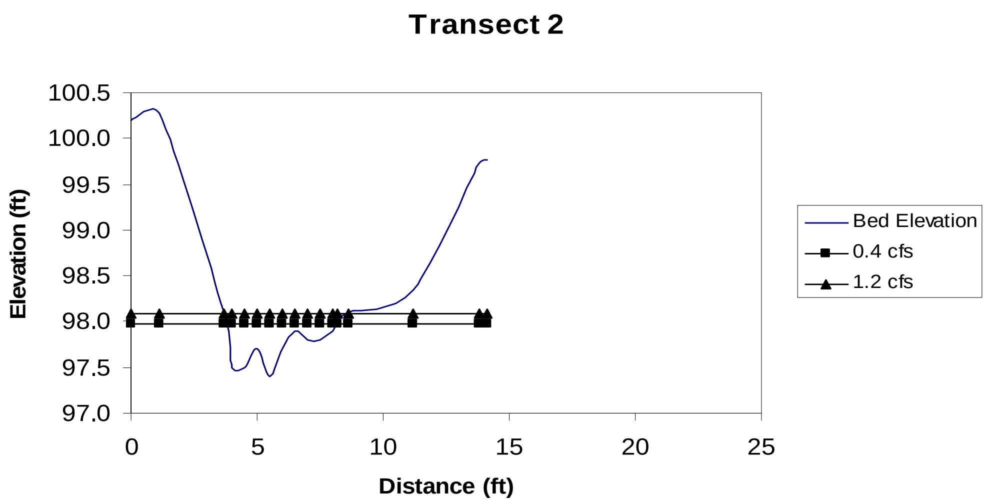
Hayden Creek

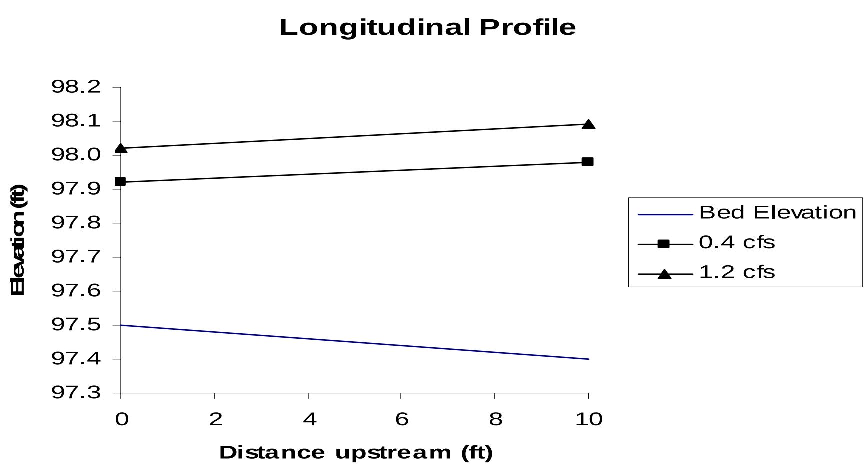
	Distance Mapped (feet)	Proportions (%)
Study Site 1		
Riffle	567	50.8
Glide	499	44.7
Pool	50	4.5
Total	1116	100
Study Site 2		
Riffle	472	41.3
Glide	612	53.6
Pool	58	5.1
Total	1142	100
Study Site 3		
Riffle	428	67.3
Glide	166	26.1
Pool	42	6.6
Total	636	100

APPENDIX C – CROSS-SECTIONAL PROFILES AND MEASURED WATER SURFACE ELEVATIONS

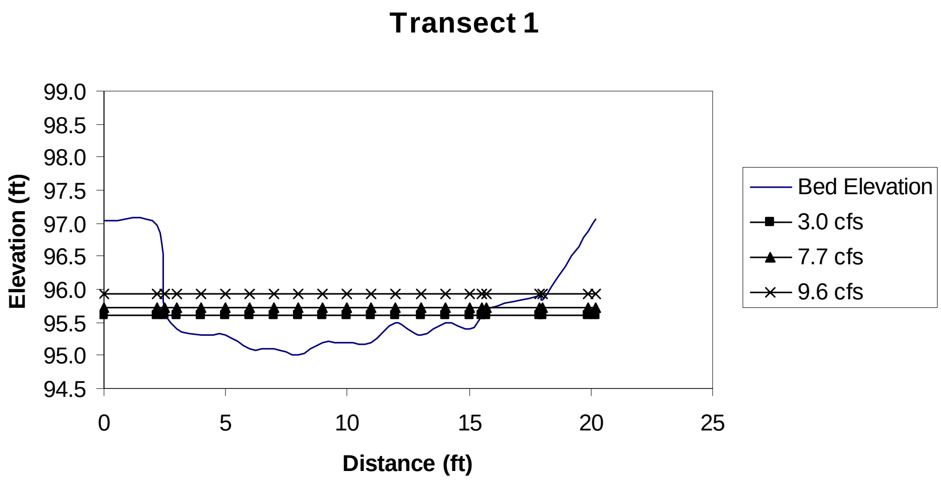
Big Eightmile, Site 1

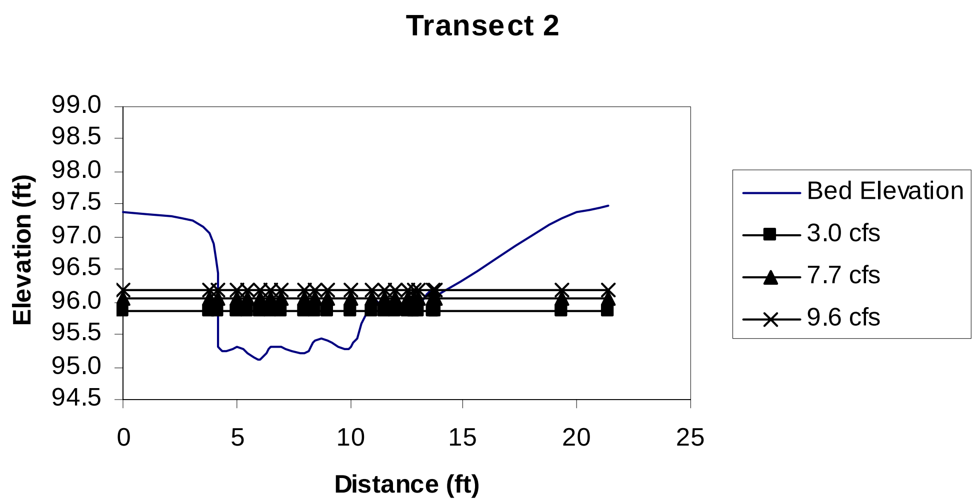


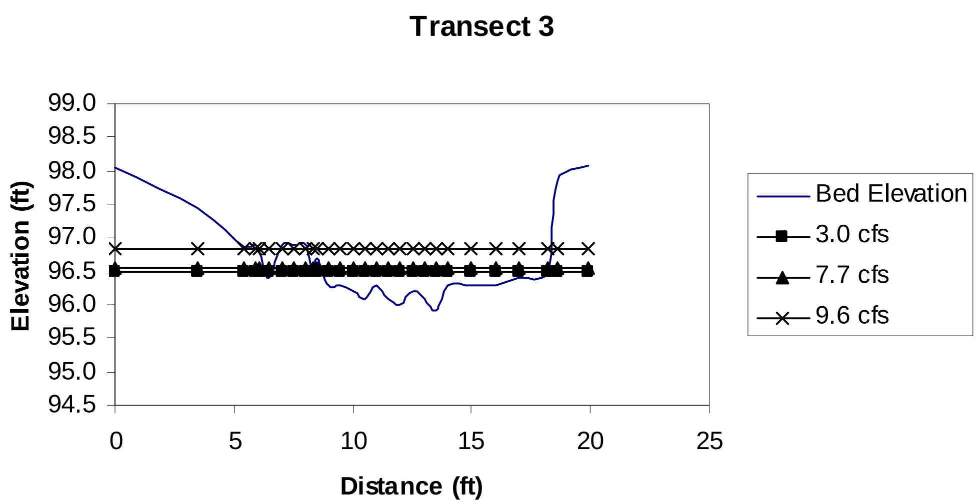


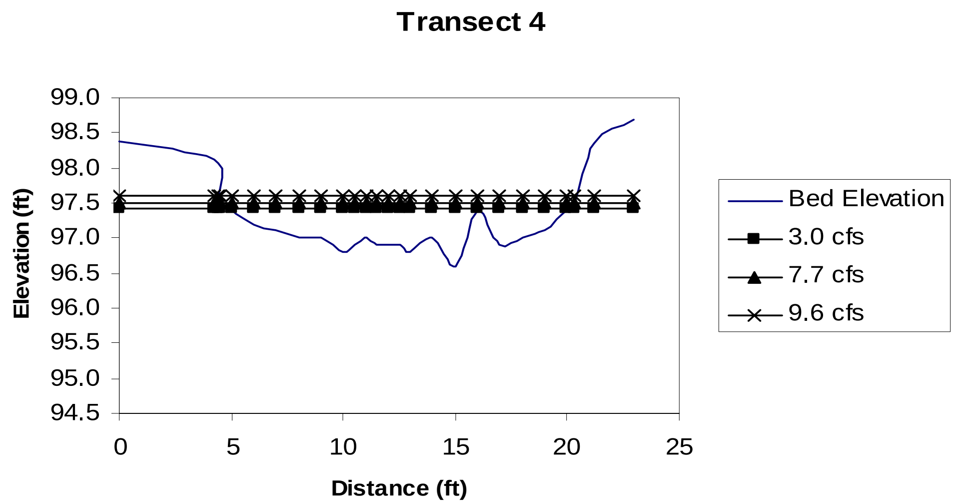


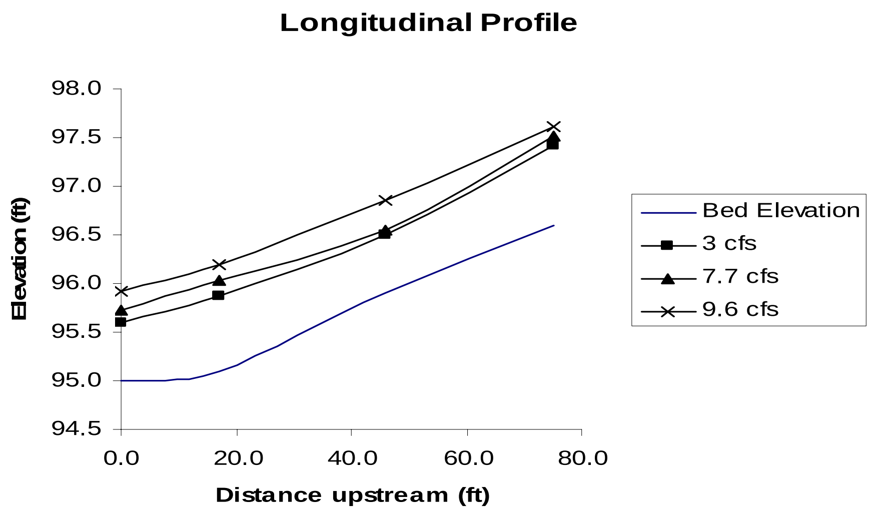
Big Eightmile Creek, Site 2



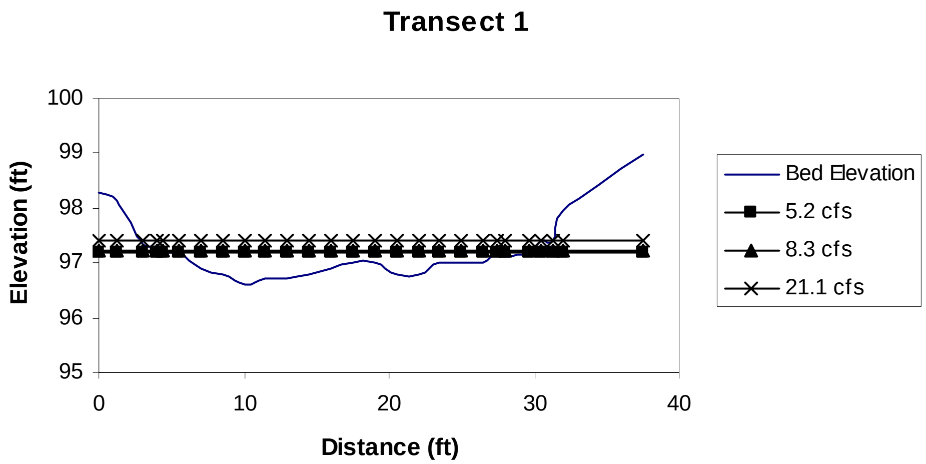




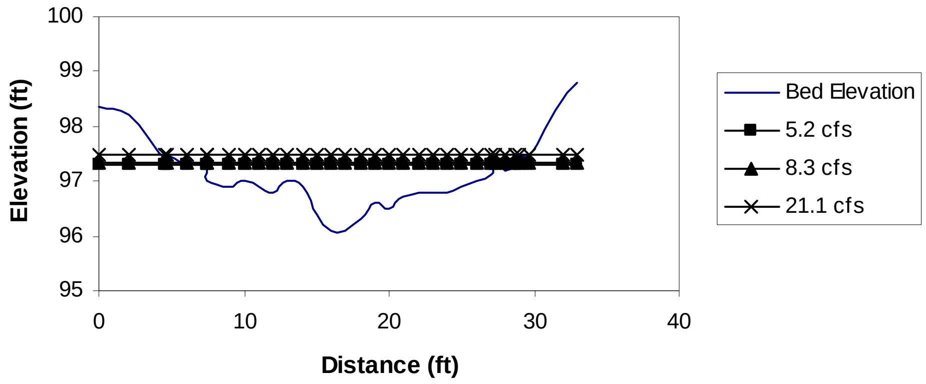




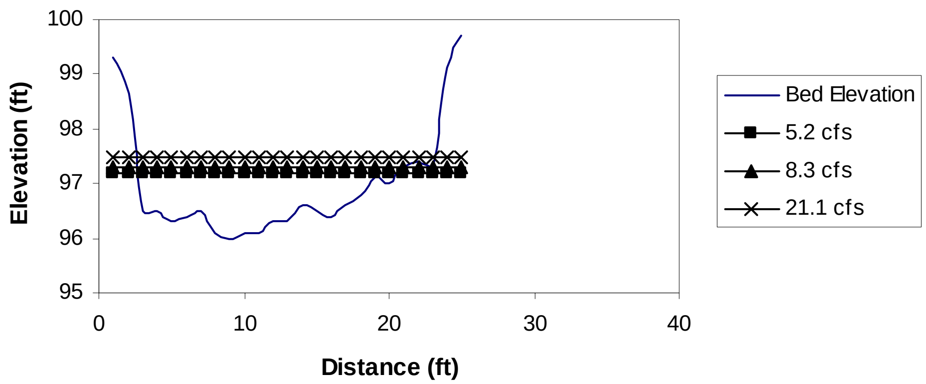
Big Eightmile Creek, Site 3



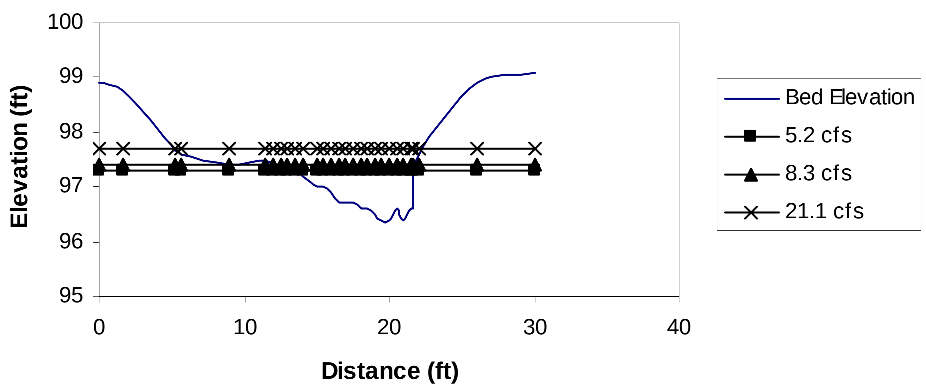
Transect 2

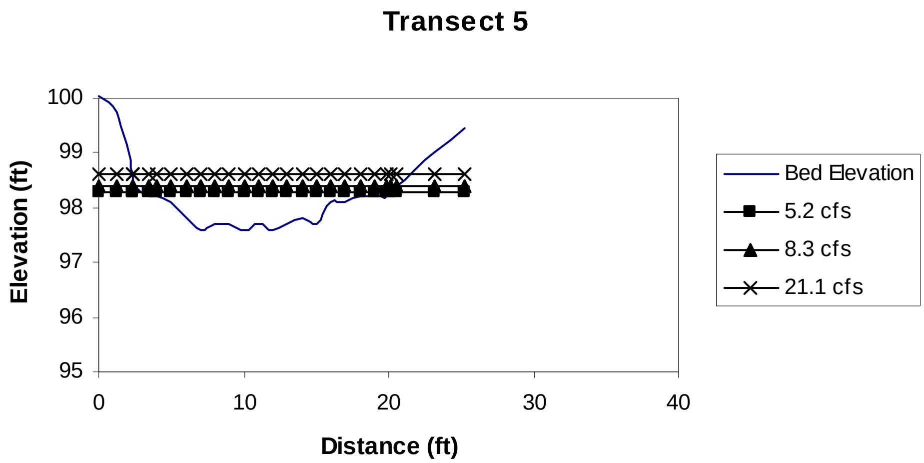


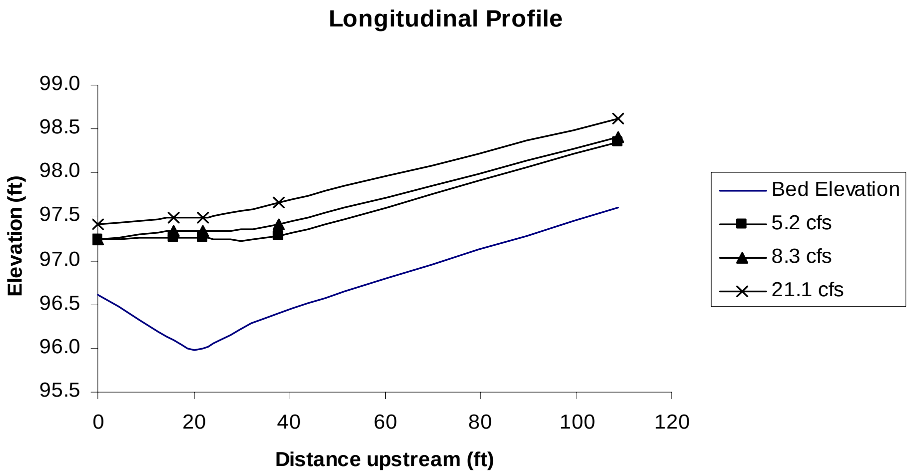
Transect 3



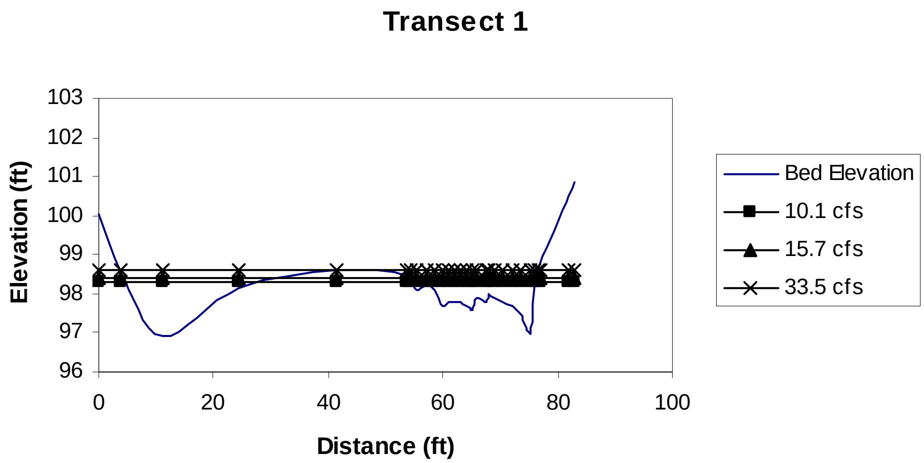
Transect 4

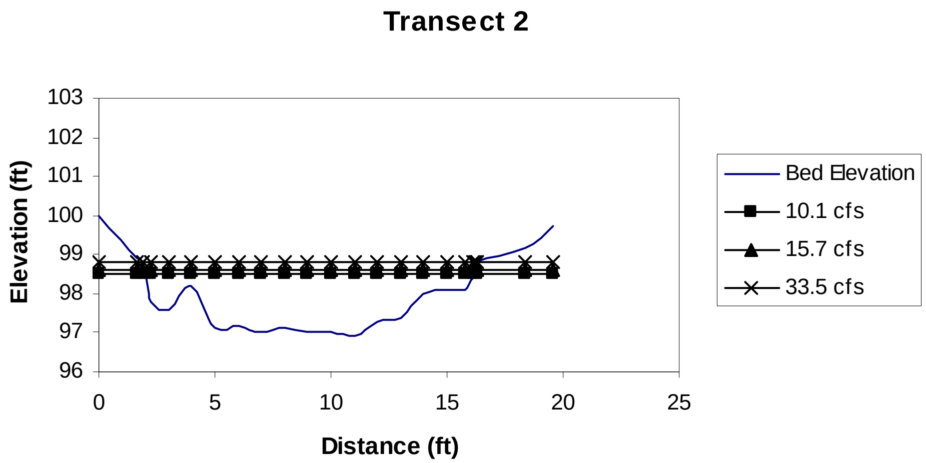




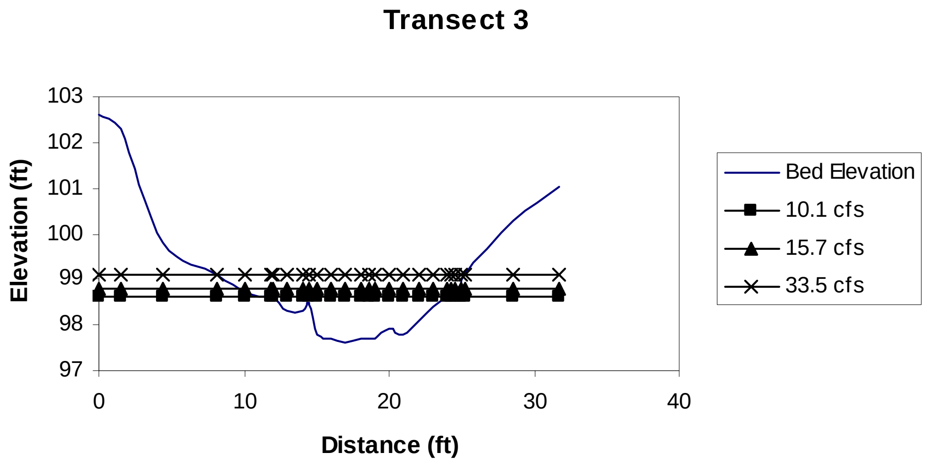


Big Eightmile Creek, Site 4

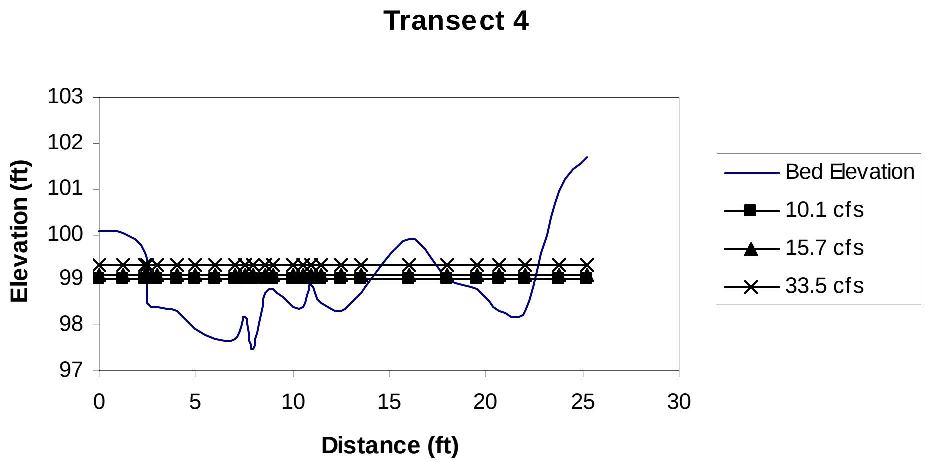




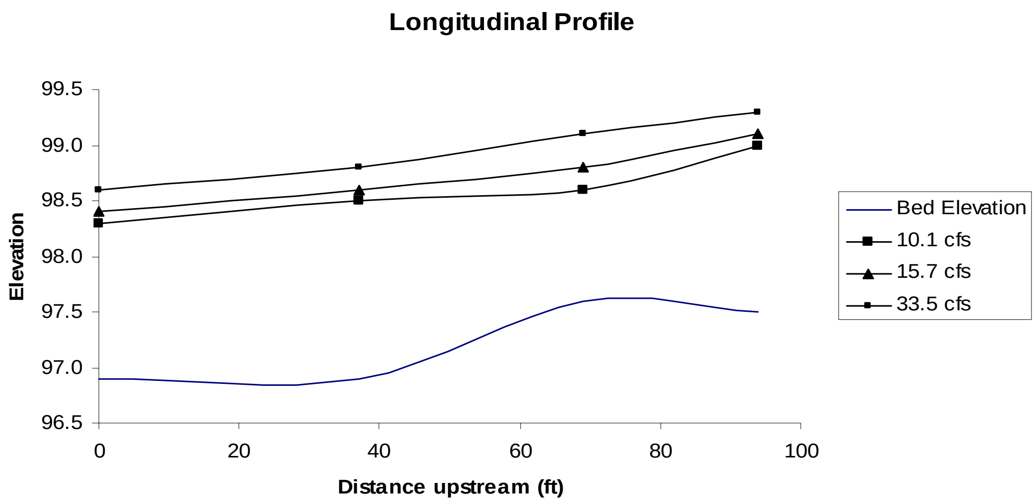
Transect 2
Elevation (ft)
Distance (ft)
103
102
101
100
99
98
97
96
0
5
10
15
20
25
Bed Elevation
10.1 cfs
15.7 cfs
33.5 cfs



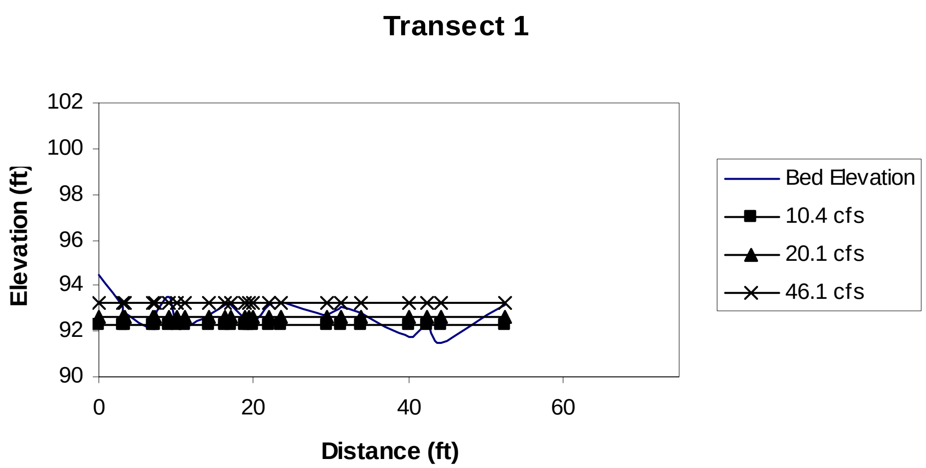
Transect 3
Elevation (ft)
Distance (ft)
103
102
101
100
99
98
97
0
10
20
30
40
Bed Elevation
10.1 cfs
15.7 cfs
33.5 cfs

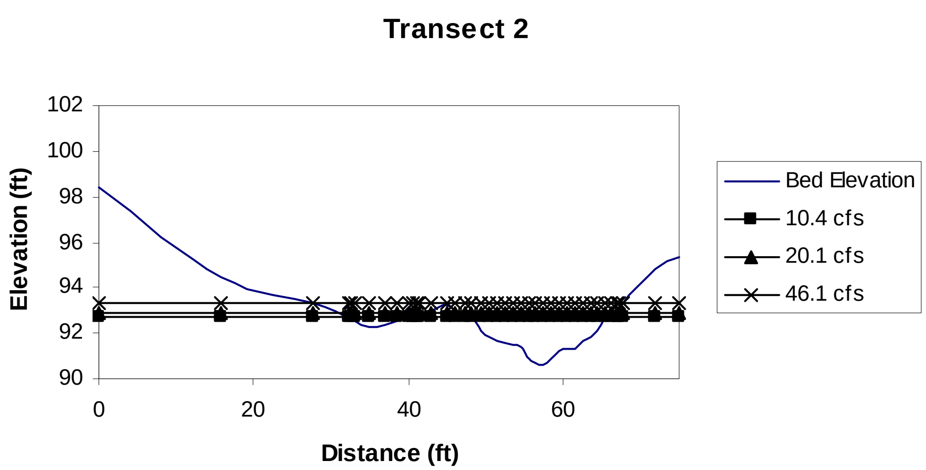


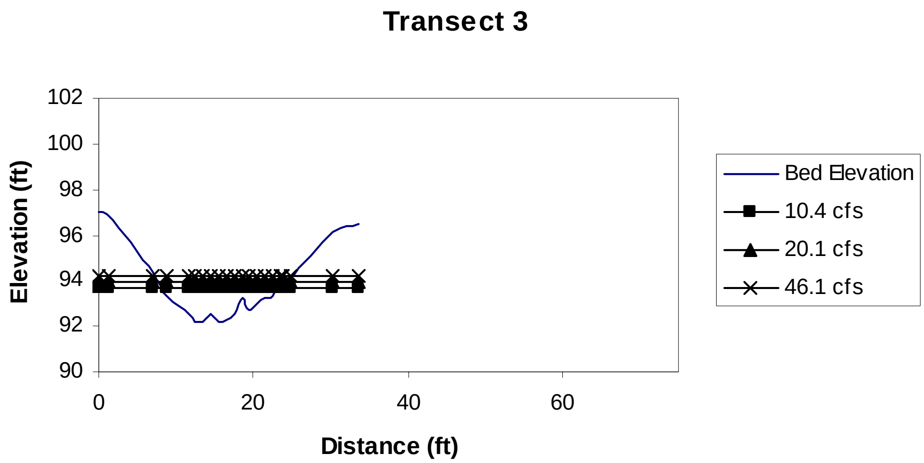
Transect 4
Elevation (ft)
Distance (ft)
103
102
101
100
99
98
97
0
5
10
15
20
25
30
Bed Elevation
10.1 cfs
15.7 cfs
33.5 cfs

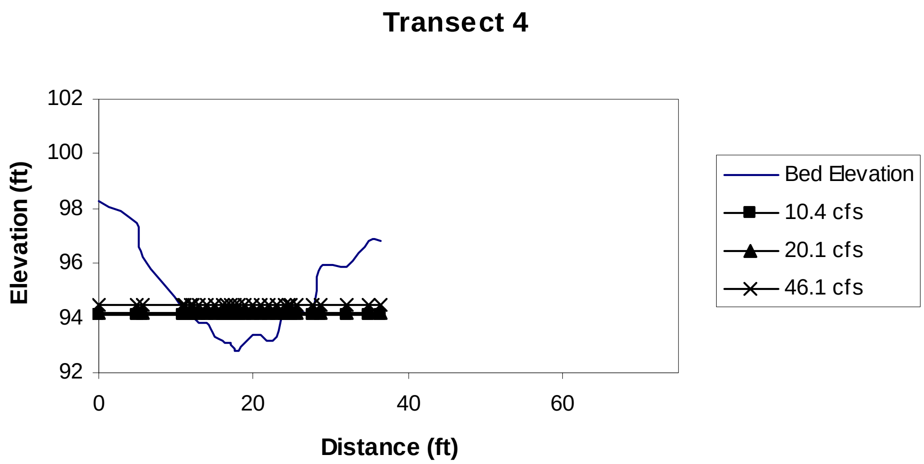


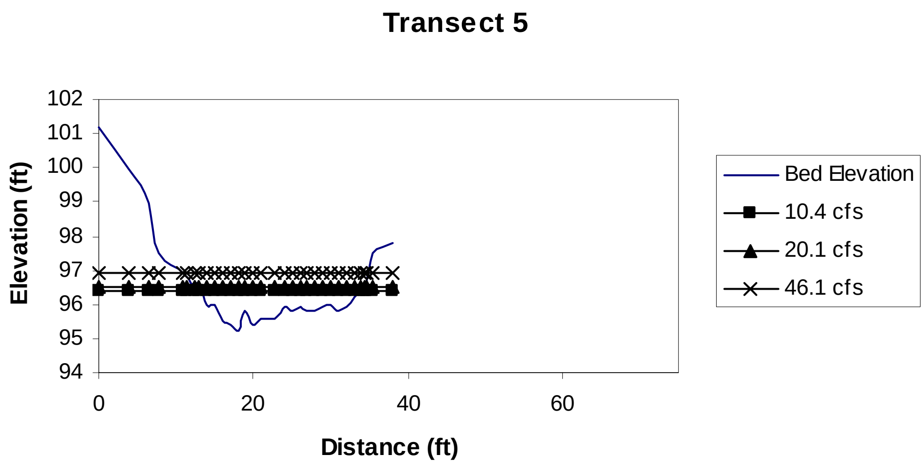
Big Eightmile Creek, Site 5 (Reference Site)

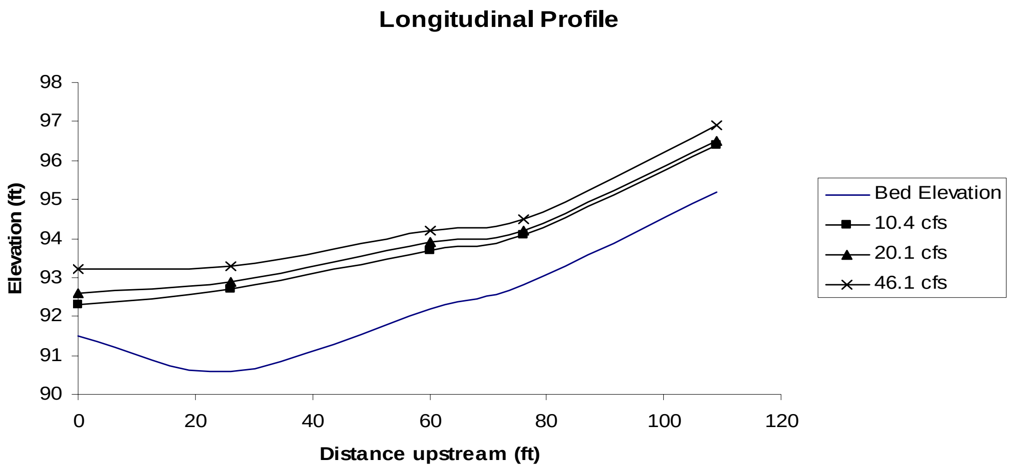




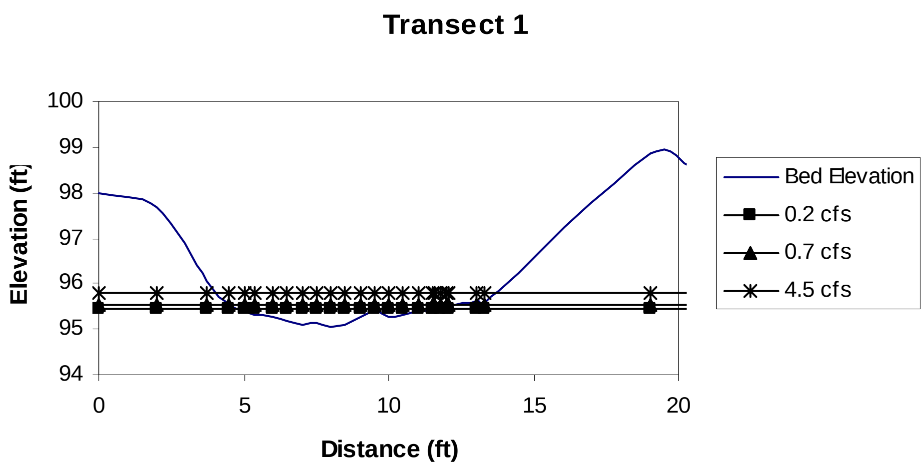

Transect 3
Elevation (ft)
102
100
98
96
94
92
90
0
20
40
60
Distance (ft)
Bed Elevation
10.4 cfs
20.1 cfs
46.1 cfs

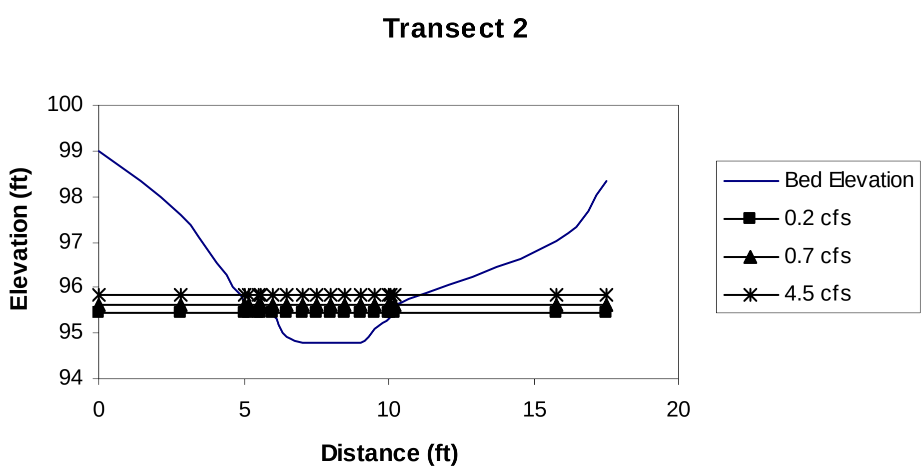

Transect 4
Elevation (ft)
102
100
98
96
94
92
0
20
40
60
Distance (ft)
Bed Elevation
10.4 cfs
20.1 cfs
46.1 cfs

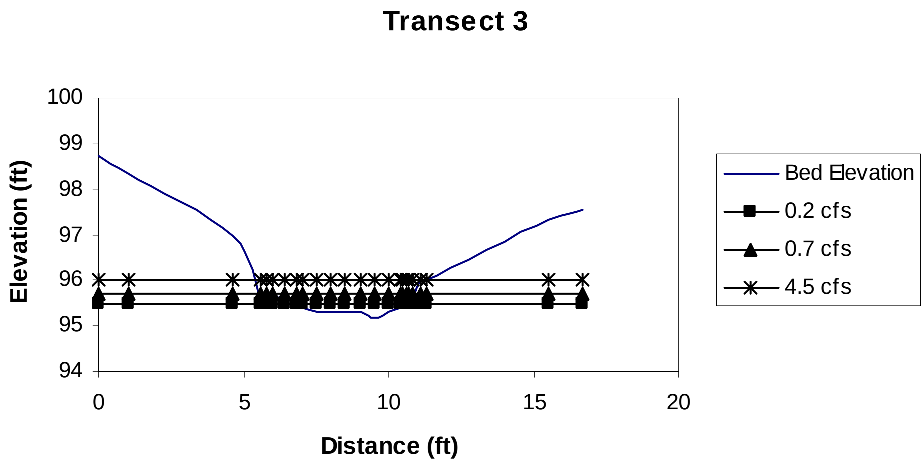

Transect 5
Elevation (ft)
102
101
100
99
98
97
96
95
94
0
20
40
60
Distance (ft)
Bed Elevation
10.4 cfs
20.1 cfs
46.1 cfs

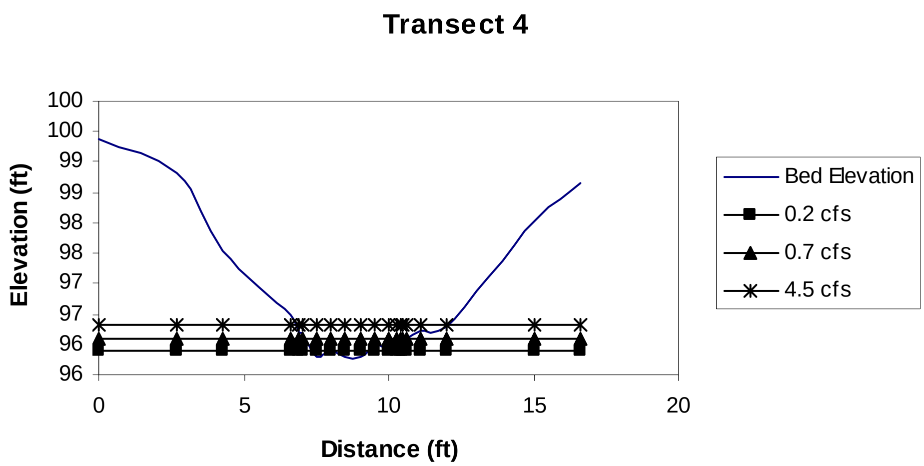


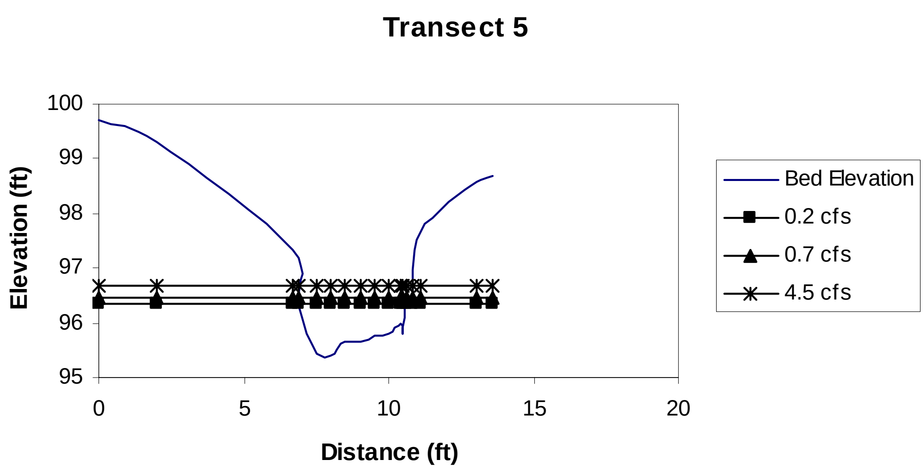
Bohannon Creek, Site 1

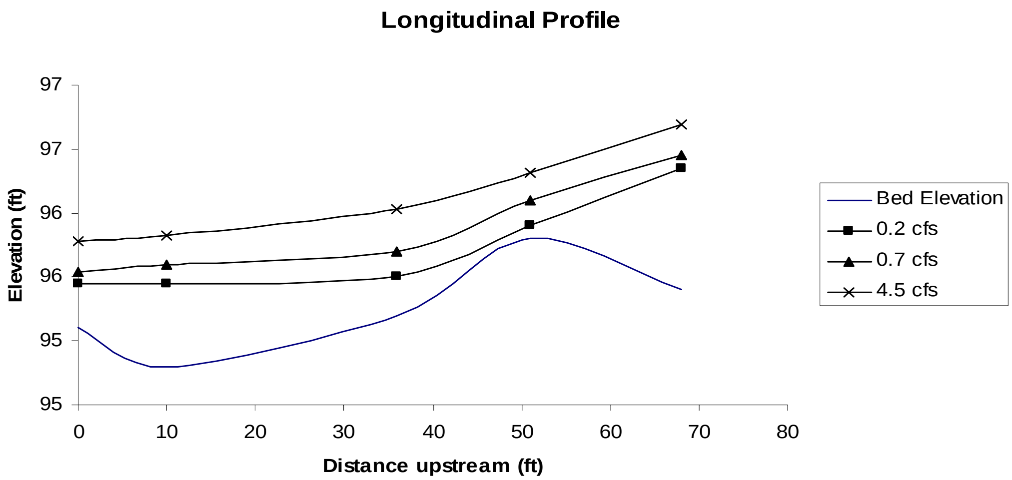




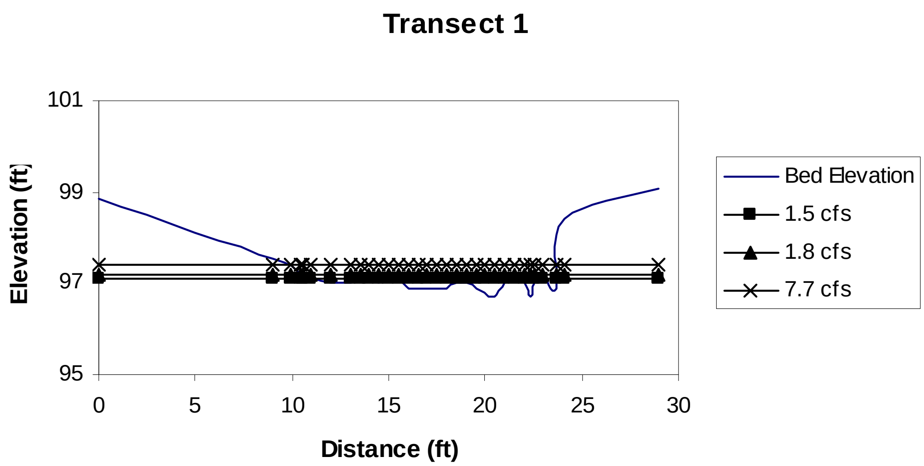

Transect 3
100
99
98
97
96
95
94
Elevation (ft)
0
5
10
15
20
Distance (ft)
Bed Elevation
0.2 cfs
0.7 cfs
4.5 cfs

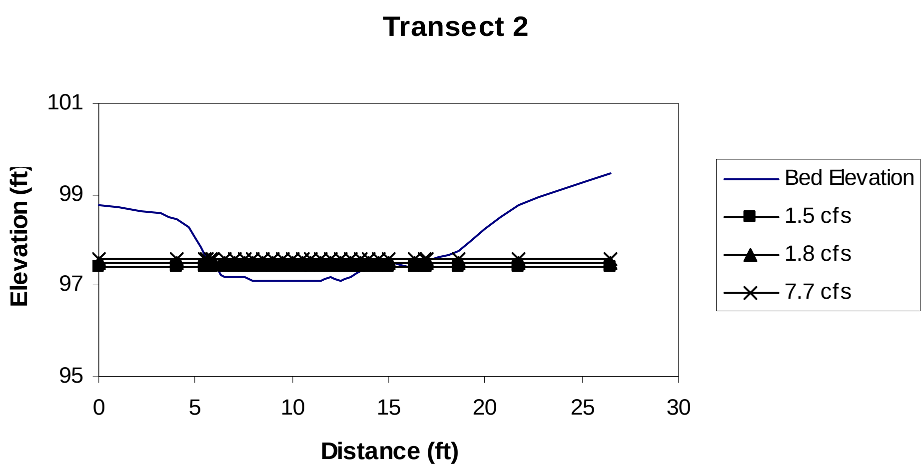

Transect 4
100
100
99
99
98
98
97
97
96
96
Elevation (ft)
0
5
10
15
20
Distance (ft)
Bed Elevation
0.2 cfs
0.7 cfs
4.5 cfs

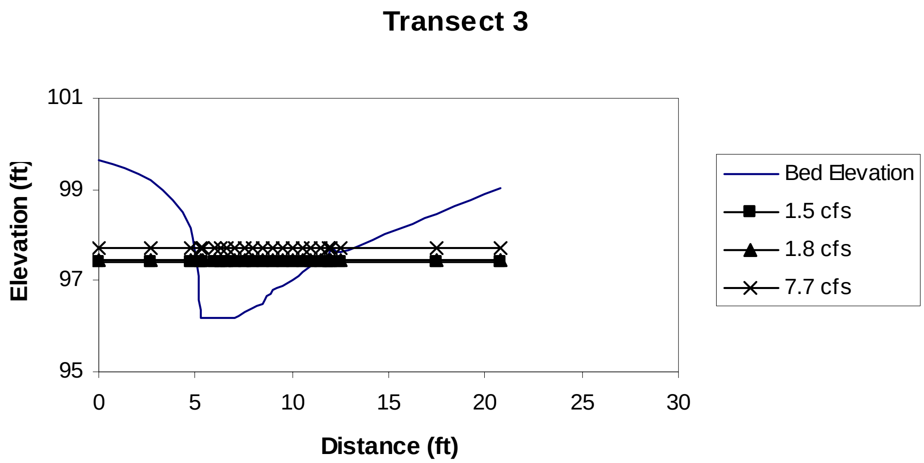

Transect 5
100
99
98
97
96
95
Elevation (ft)
0
5
10
15
20
Distance (ft)
Bed Elevation
0.2 cfs
0.7 cfs
4.5 cfs

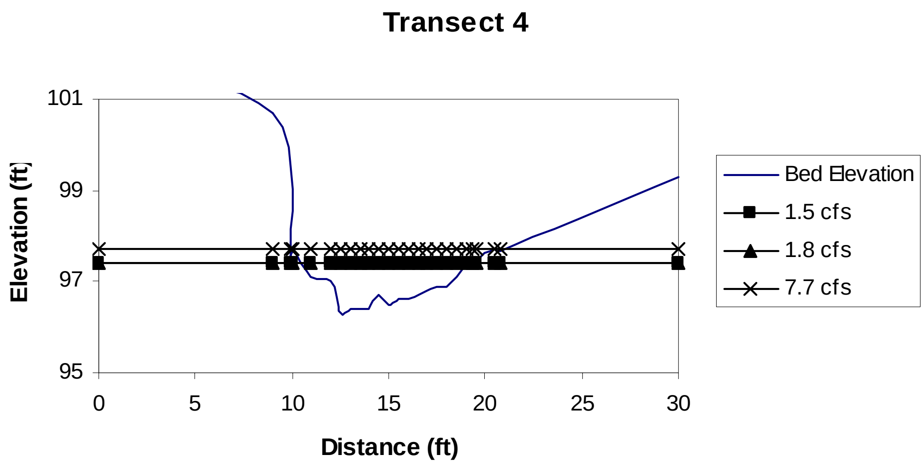


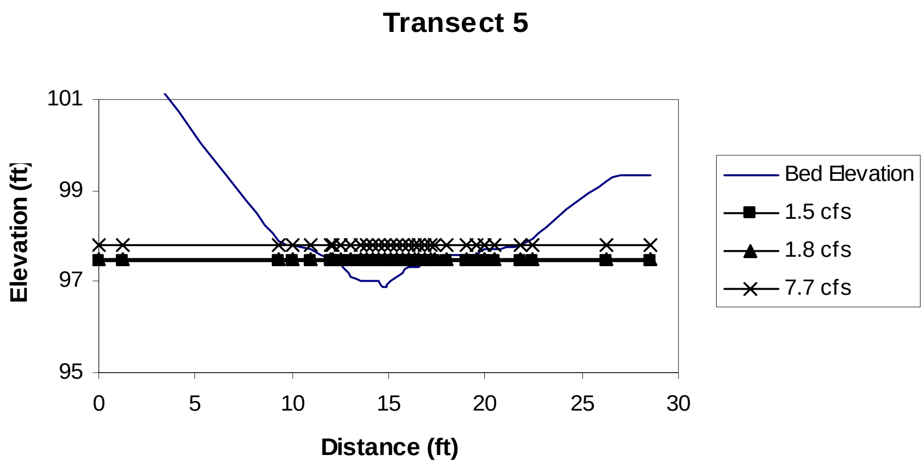
Bohannon Creek, Site 2



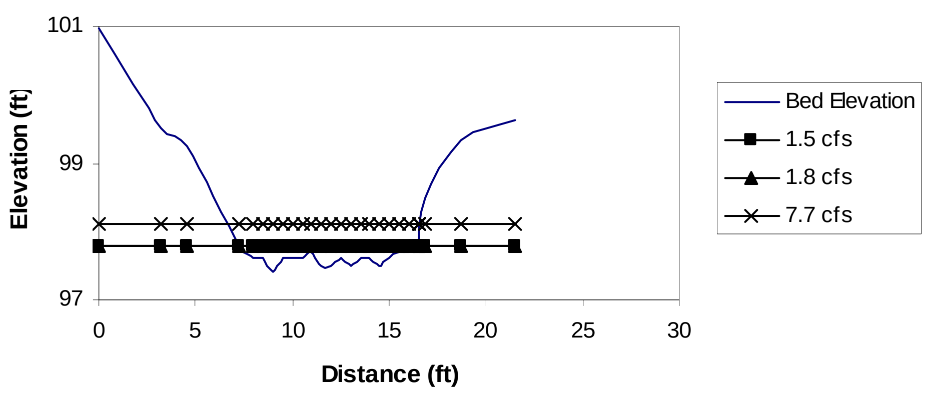



Transect 3
Elevation (ft)
101
99
97
95
0
5
10
15
20
25
30
Distance (ft)
Bed Elevation
1.5 cfs
1.8 cfs
7.7 cfs

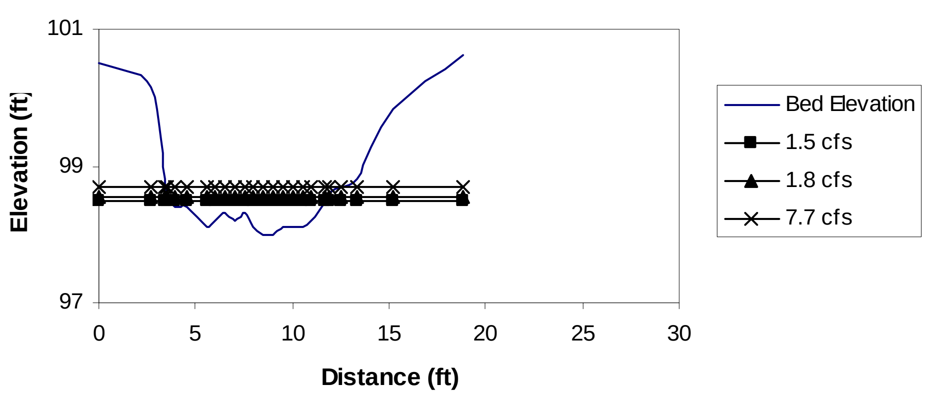

Transect 4
Elevation (ft)
101
99
97
95
0
5
10
15
20
25
30
Distance (ft)
Bed Elevation
1.5 cfs
1.8 cfs
7.7 cfs


Transect 5
Elevation (ft)
101
99
97
95
0
5
10
15
20
25
30
Distance (ft)
Bed Elevation
1.5 cfs
1.8 cfs
7.7 cfs

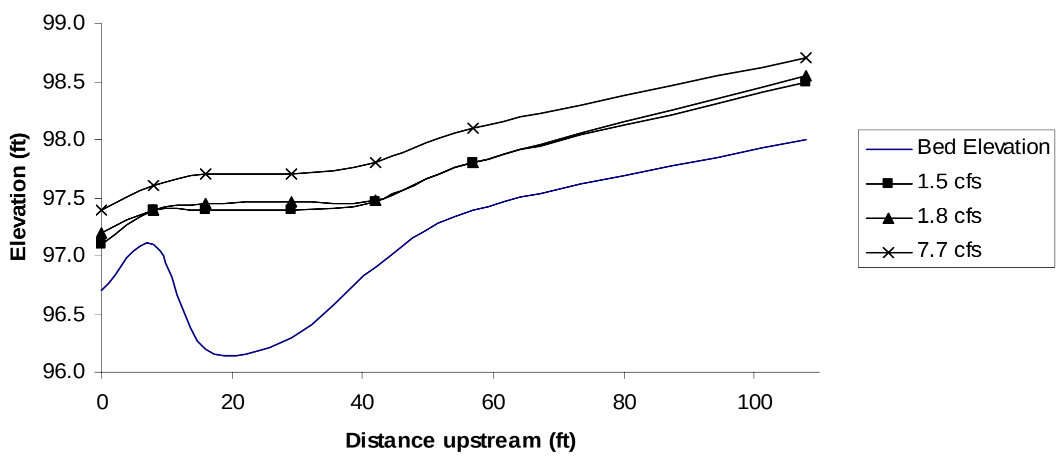
Transect 6



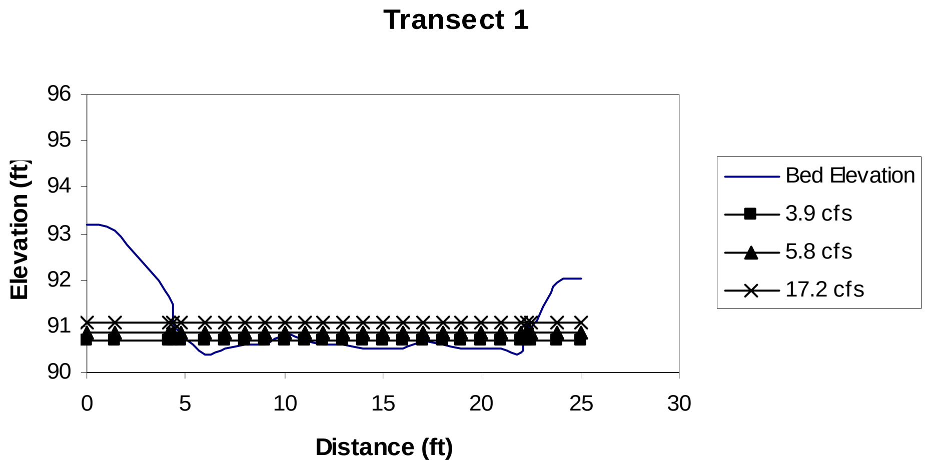
Transect 7

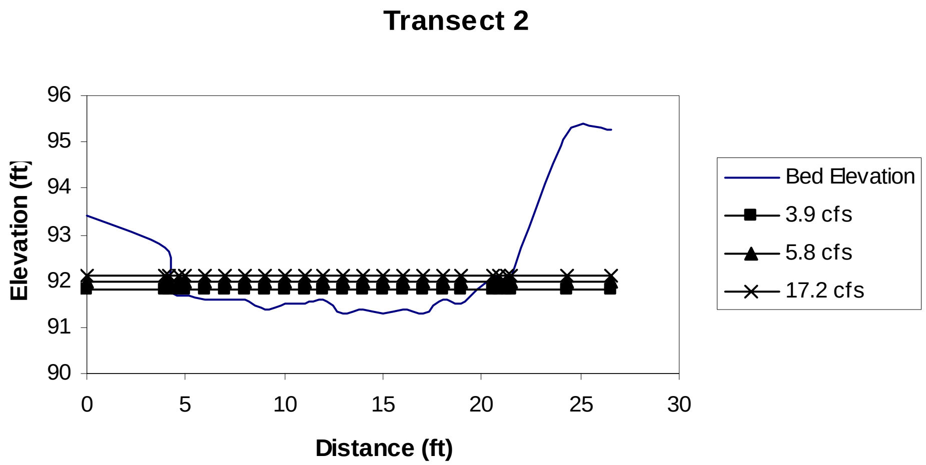


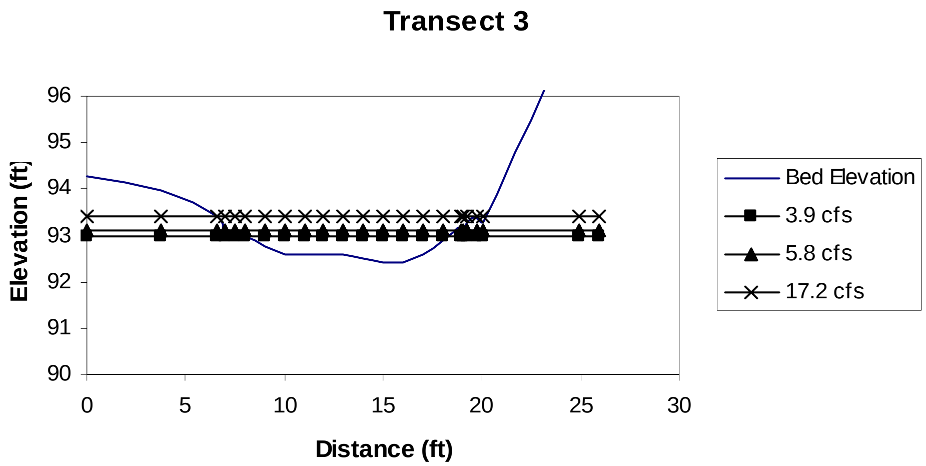
Longitudinal Profile



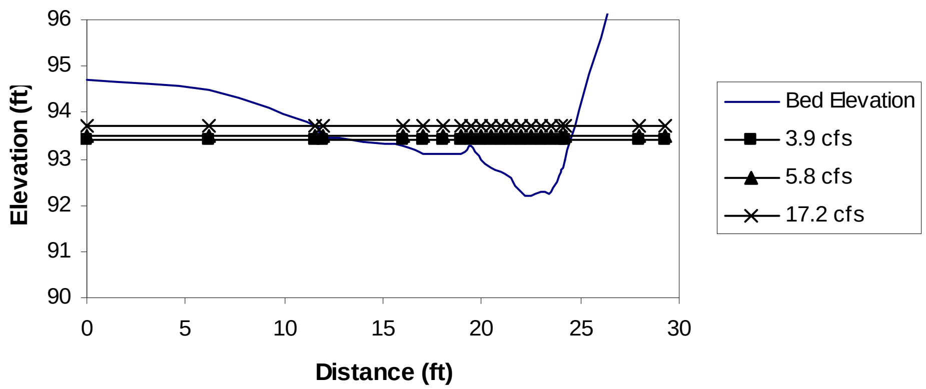
Bohannon Creek, Site 3



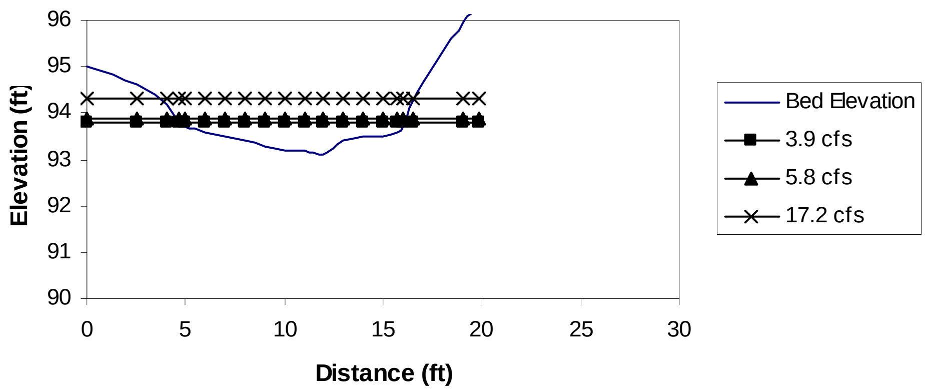




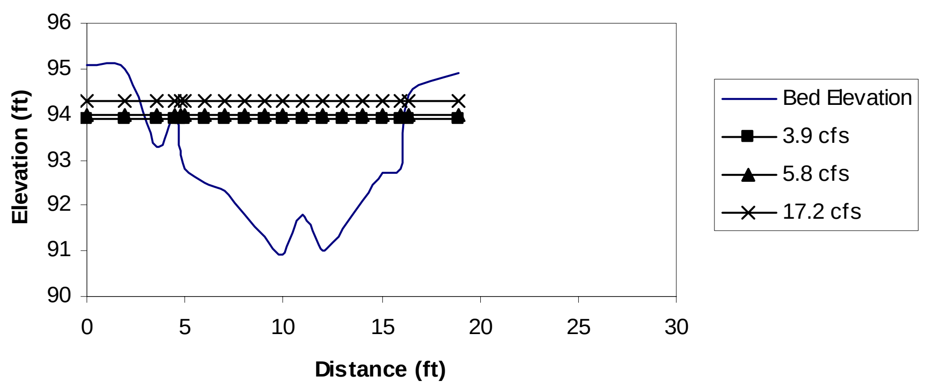
Transect 4



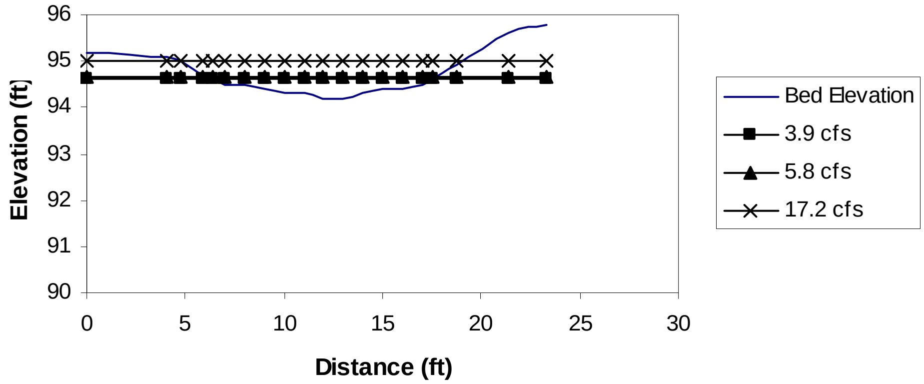
Transect 5



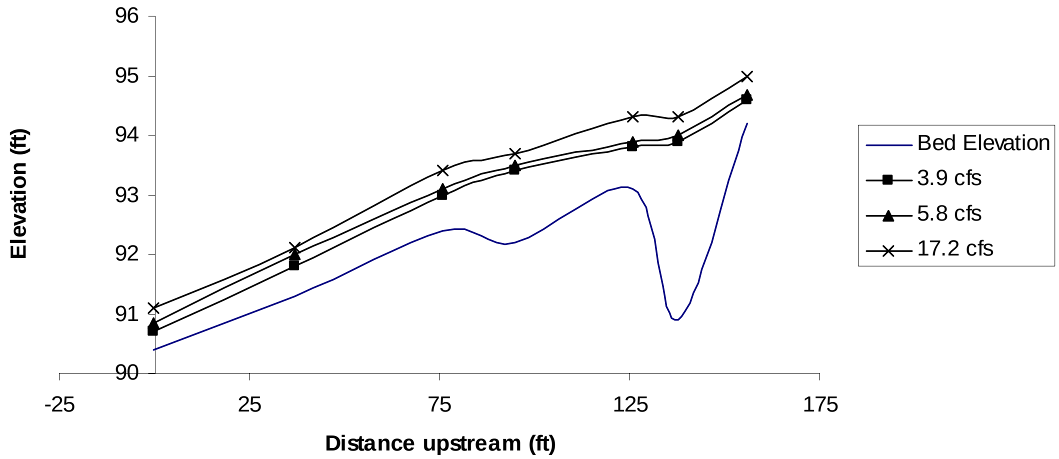
Transect 6



Transect 7

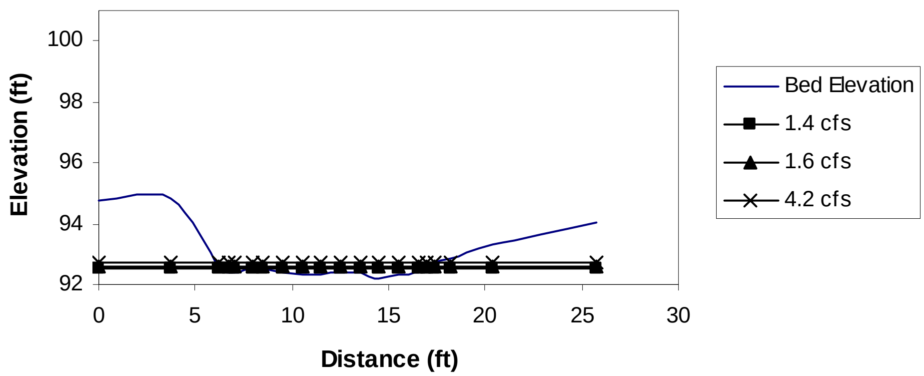


Longitudinal Profile

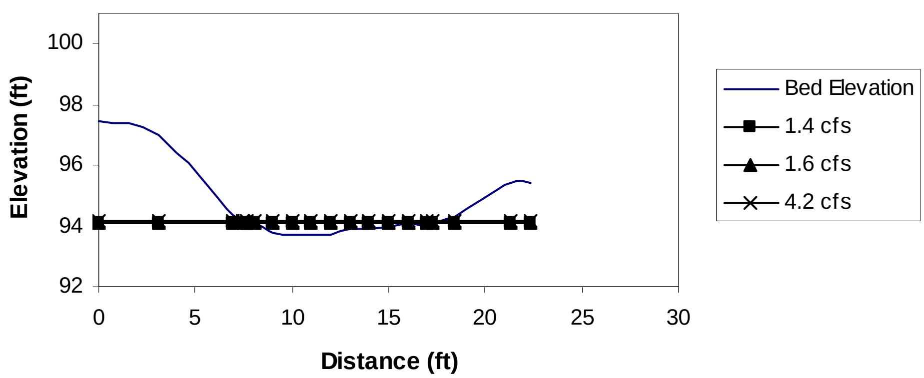


Bohannon Creek, Site 4

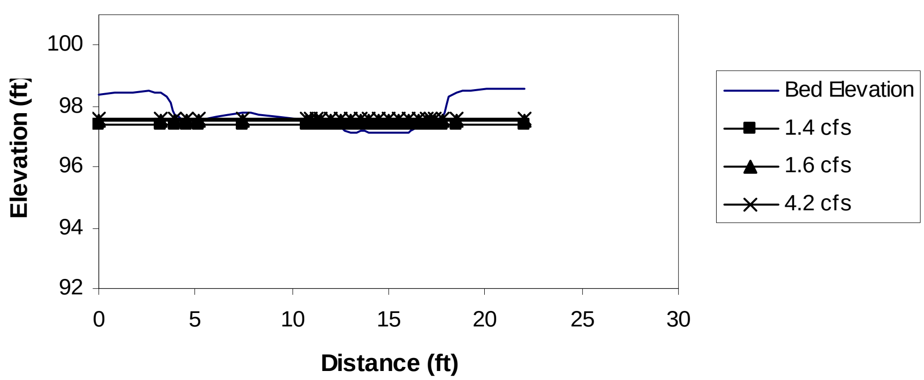
Transect 1

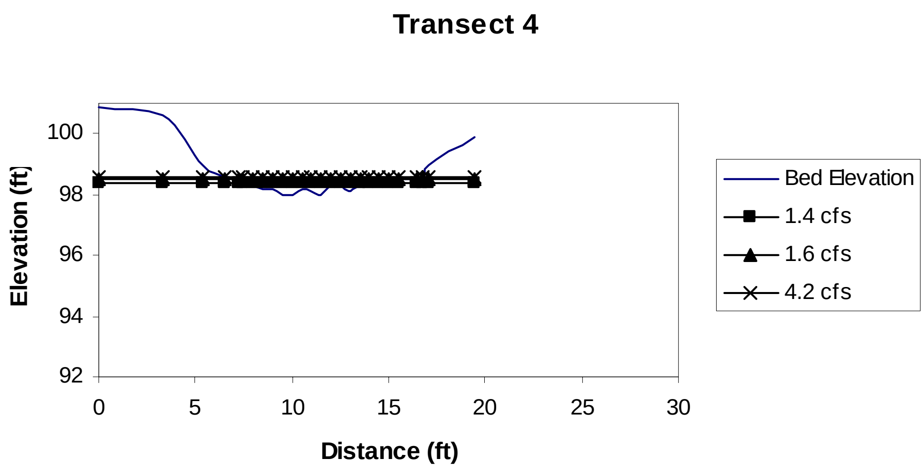


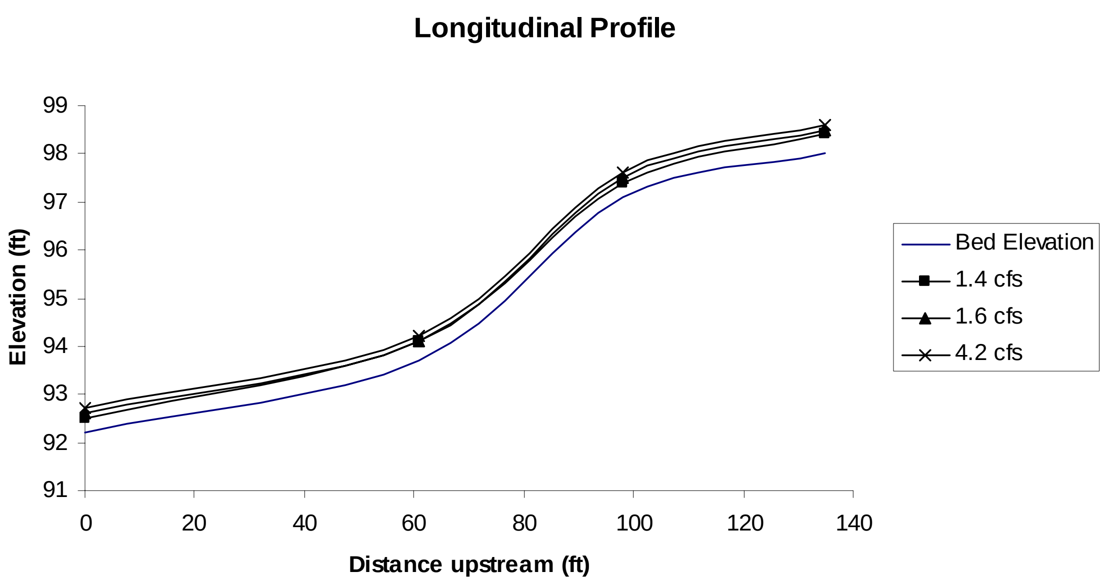
Transect 2



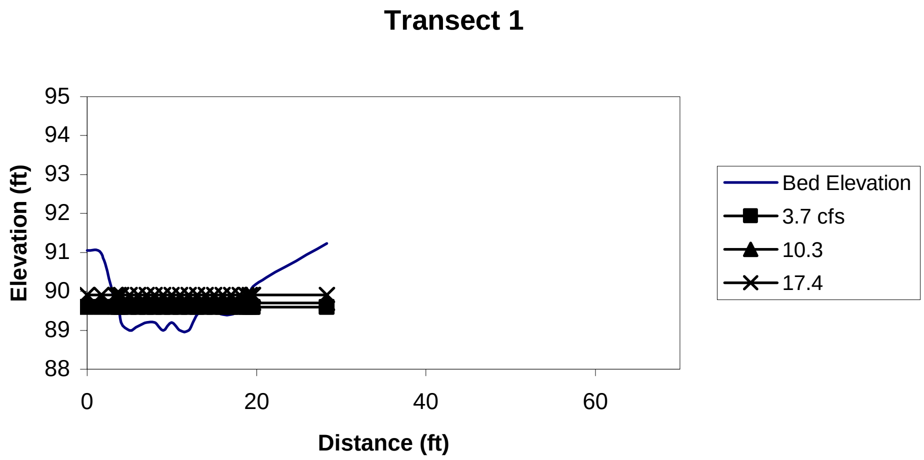
Transect 3

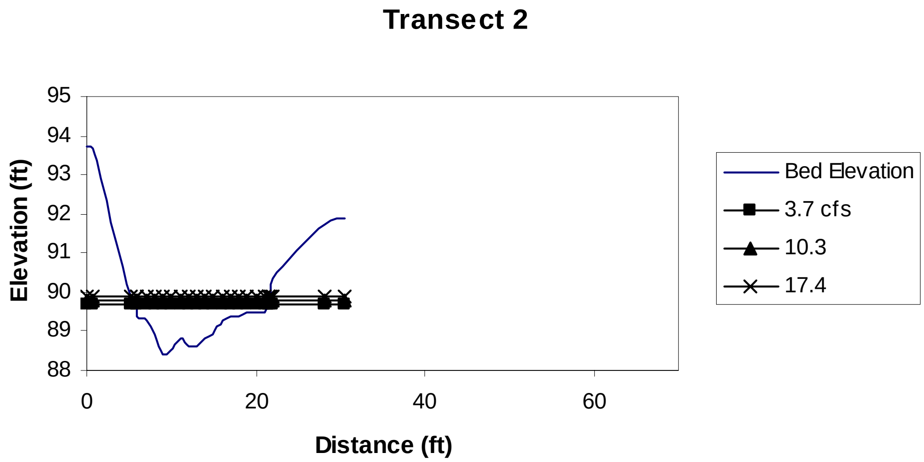


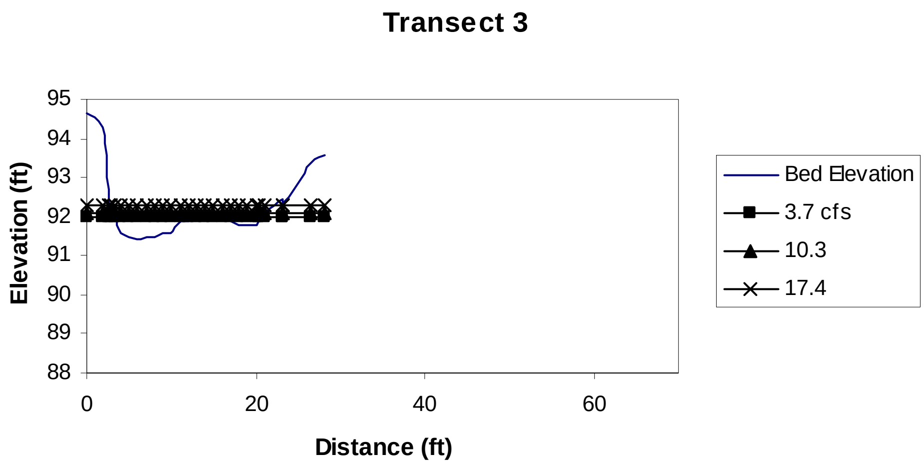

Transect 4
Elevation (ft)
100
98
96
94
92
0
5
10
15
20
25
30
Distance (ft)
Bed Elevation
1.4 cfs
1.6 cfs
4.2 cfs

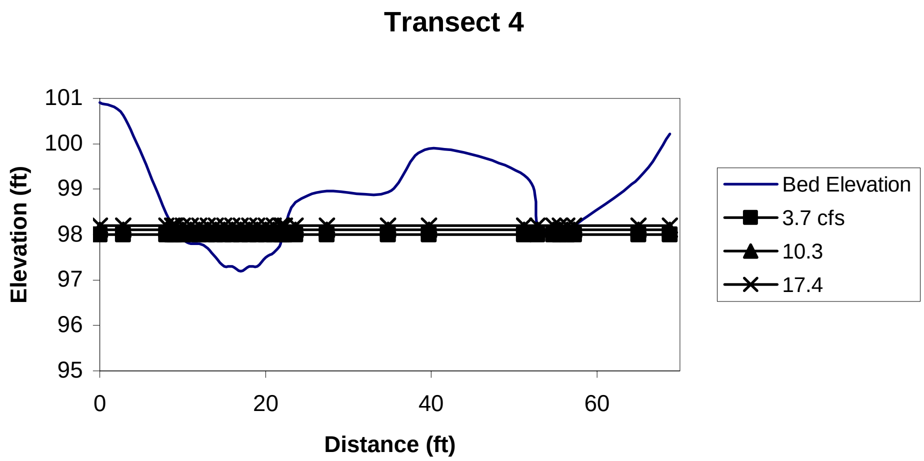

Longitudinal Profile
Elevation (ft)
99
98
97
96
95
94
93
92
91
0
20
40
60
80
100
120
140
Distance upstream (ft)
Bed Elevation
1.4 cfs
1.6 cfs
4.2 cfs

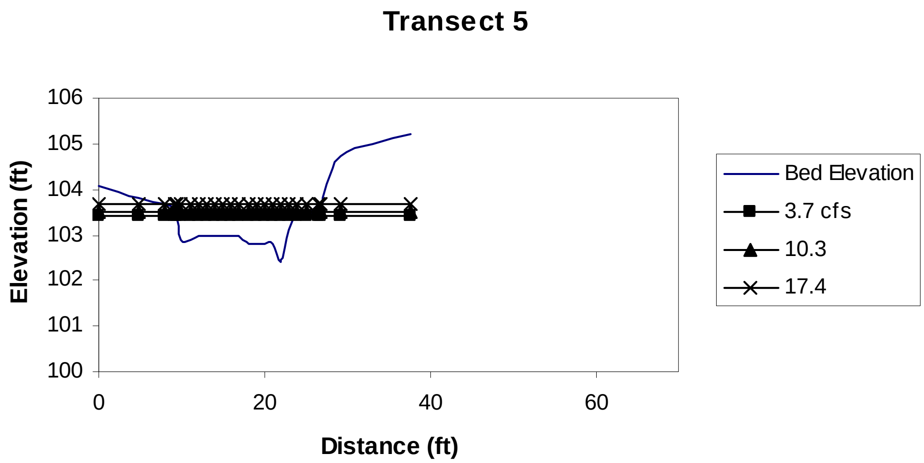
Bohannon Creek, Site 5 (Reference Site)

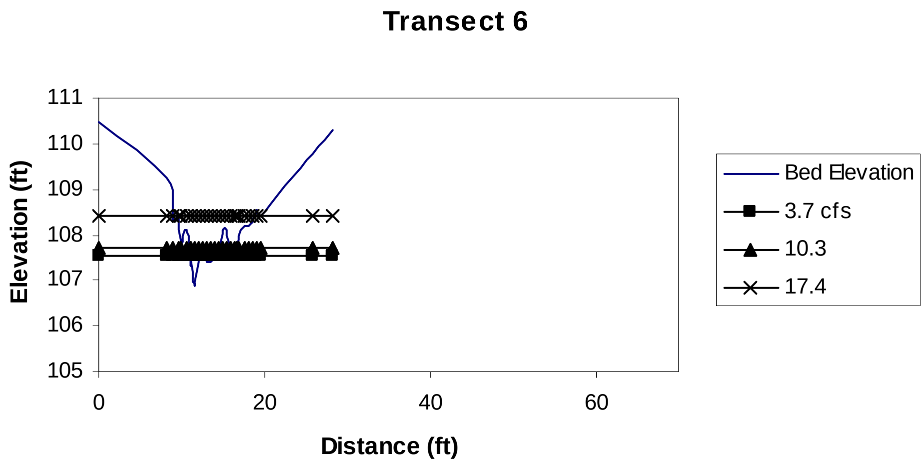


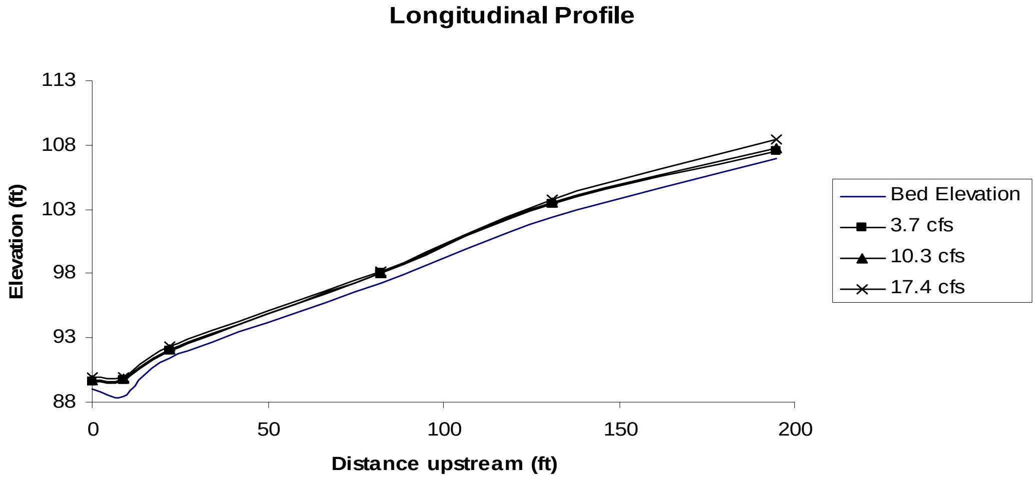




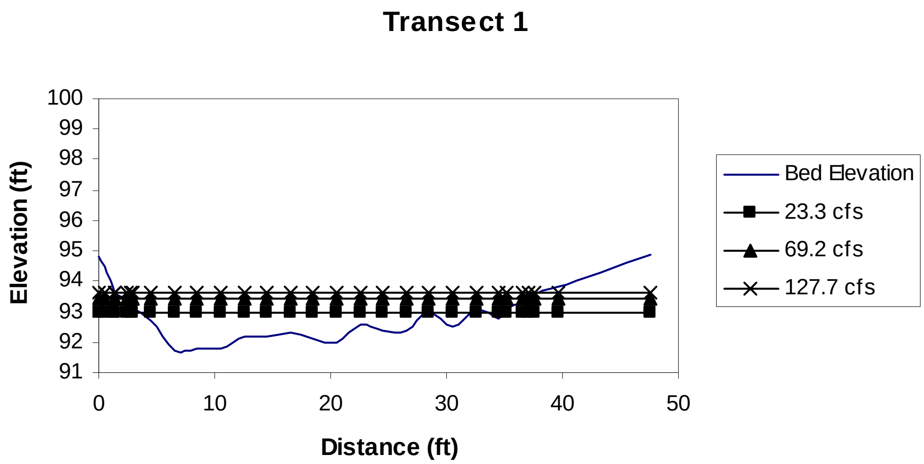

Transect 4
101
100
99
98
97
96
95
Elevation (ft)
0
20
40
60
Distance (ft)
Bed Elevation
3.7 cfs
10.3
17.4

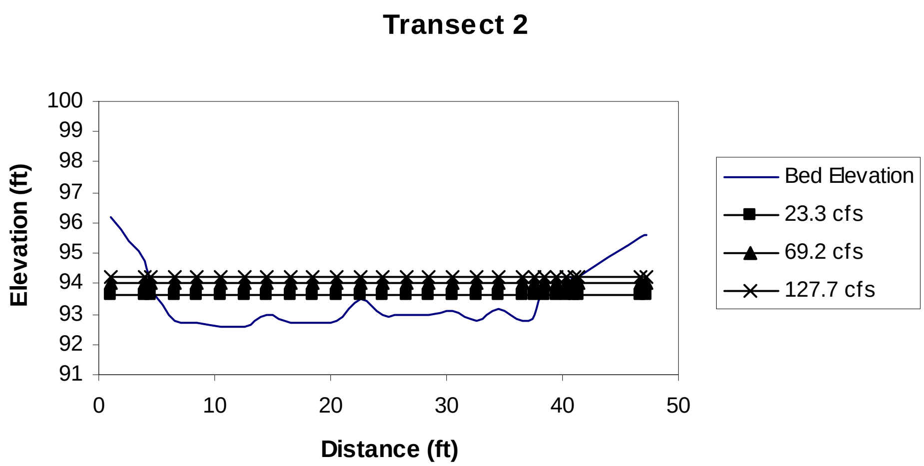

Transect 5
106
105
104
103
102
101
100
Elevation (ft)
0
20
40
60
Distance (ft)
Bed Elevation
3.7 cfs
10.3
17.4

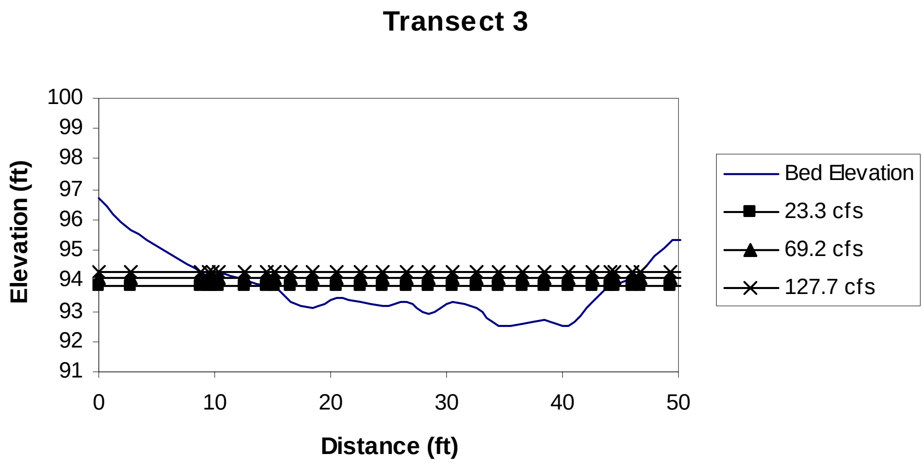

Transect 6
111
110
109
108
107
106
105
Elevation (ft)
0
20
40
60
Distance (ft)
Bed Elevation
3.7 cfs
10.3
17.4

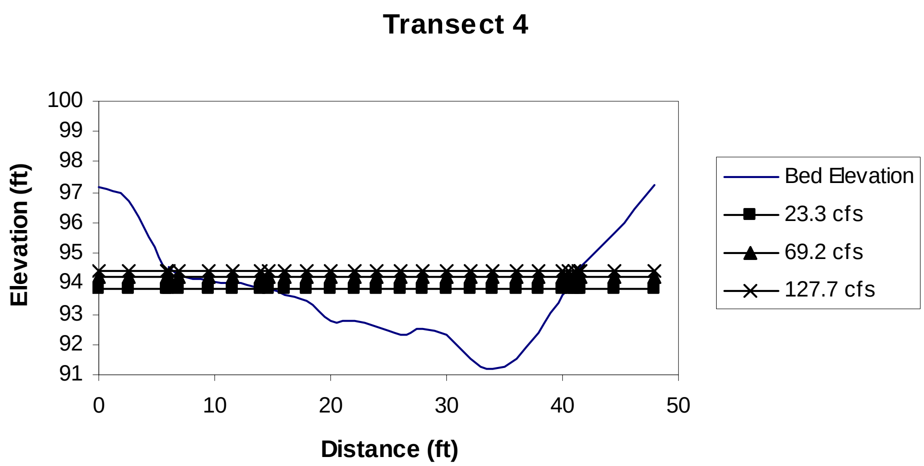


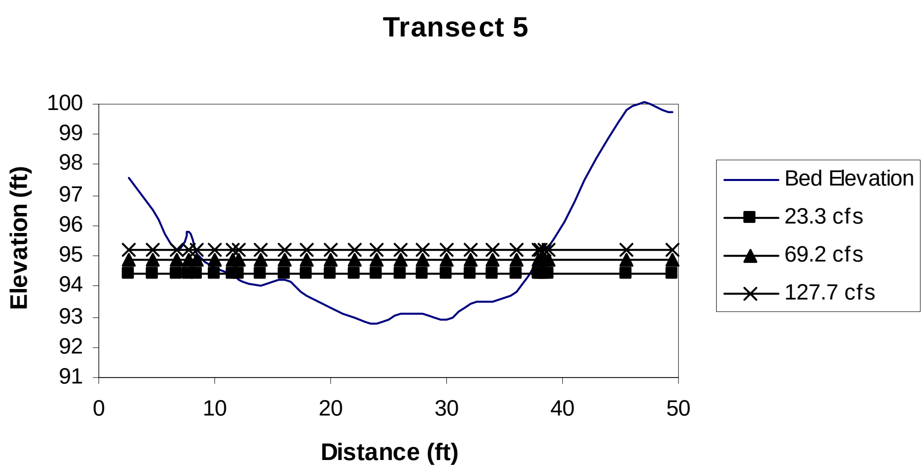
Hayden Creek, Site 1

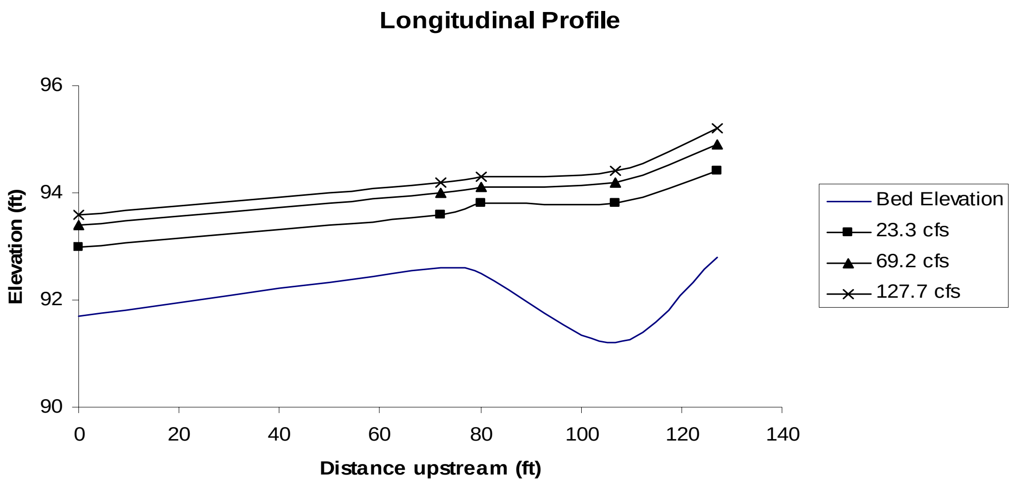




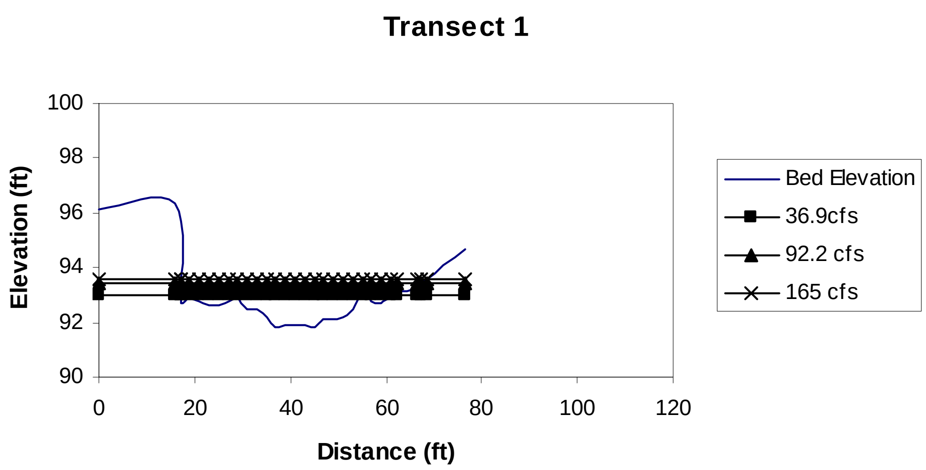

Transect 3
100
99
98
97
96
95
94
93
92
91
Elevation (ft)
0
10
20
30
40
50
Distance (ft)
Bed Elevation
23.3 cfs
69.2 cfs
127.7 cfs

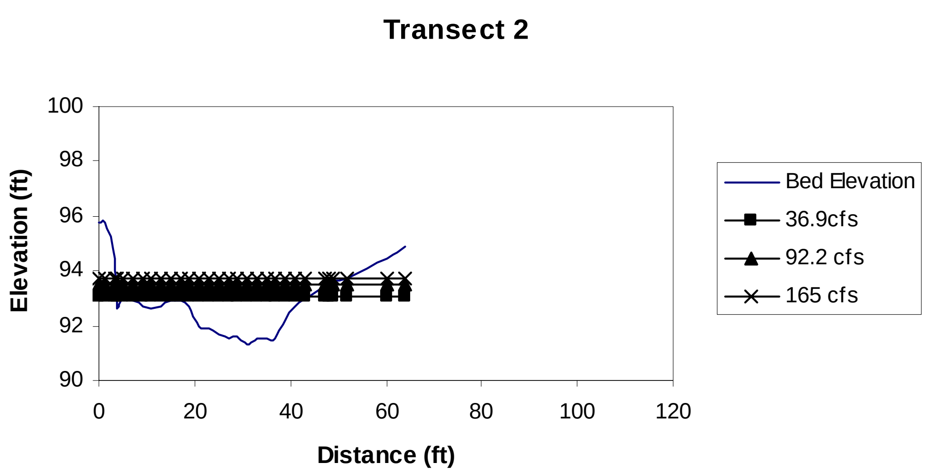

Transect 4
100
99
98
97
96
95
94
93
92
91
Elevation (ft)
0
10
20
30
40
50
Distance (ft)
Bed Elevation
23.3 cfs
69.2 cfs
127.7 cfs

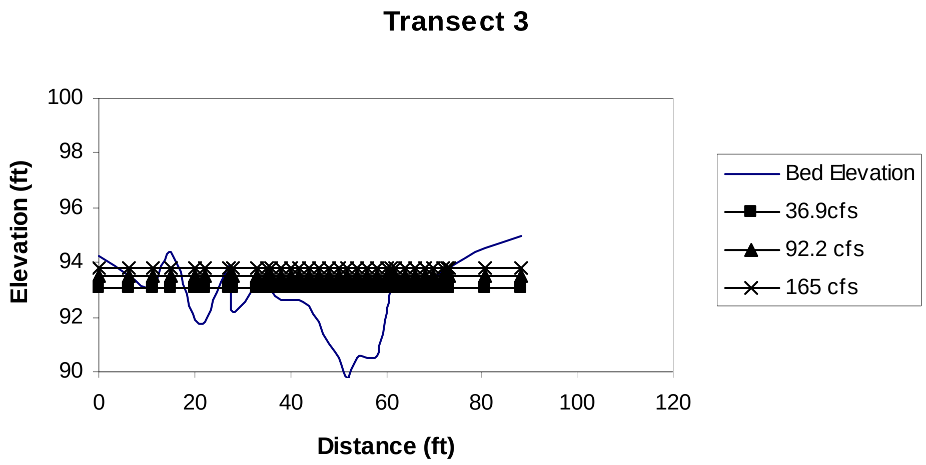

Transect 5
100
99
98
97
96
95
94
93
92
91
Elevation (ft)
0
10
20
30
40
50
Distance (ft)
Bed Elevation
23.3 cfs
69.2 cfs
127.7 cfs



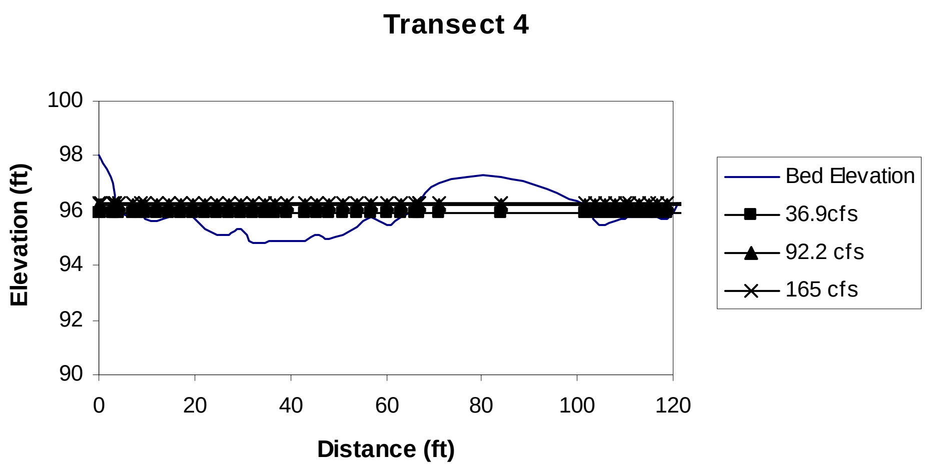
Hayden Creek, Site 2



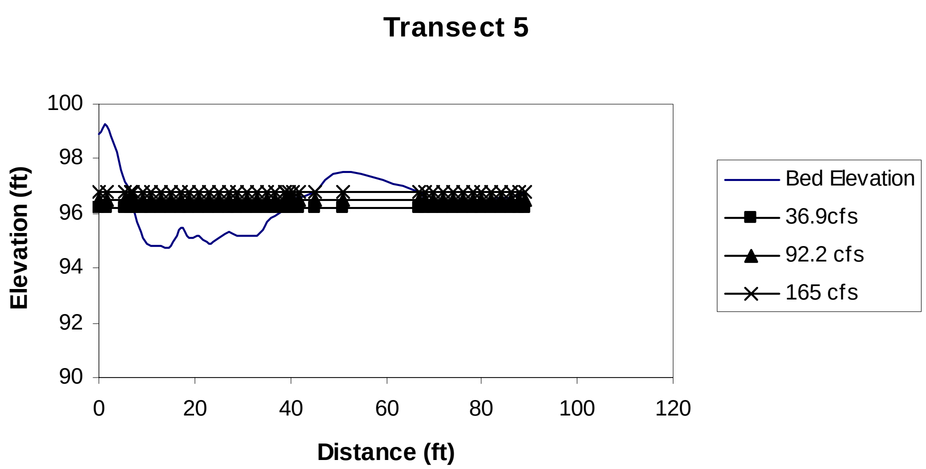




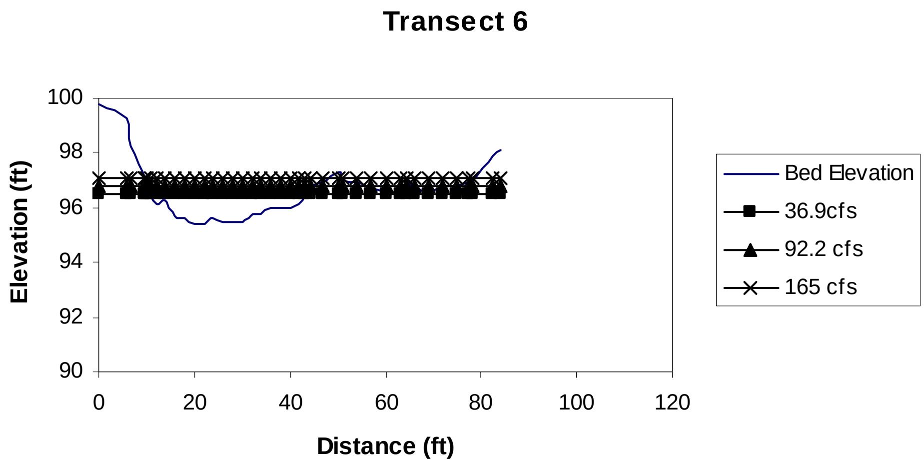
Transect 3
Elevation (ft)
100
98
96
94
92
90
0
20
40
60
80
100
120
Distance (ft)
Bed Elevation
36.9cfs
92.2 cfs
165 cfs



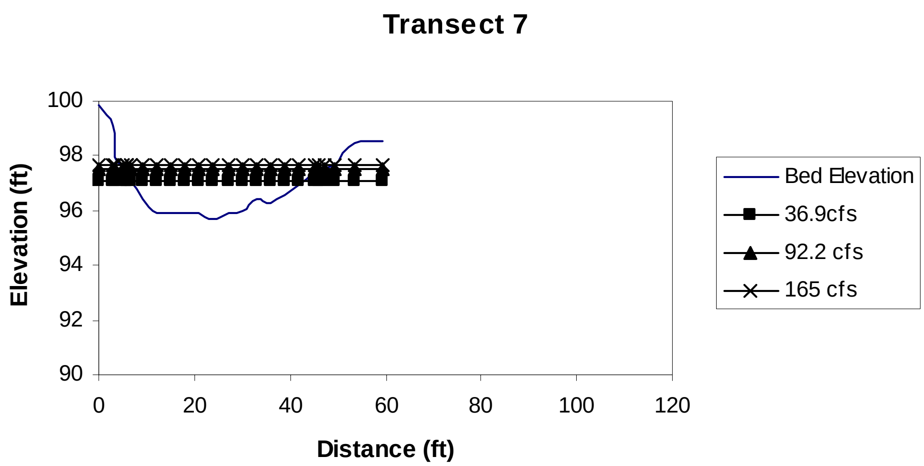
Transect 4
Elevation (ft)
100
98
96
94
92
90
0
20
40
60
80
100
120
Distance (ft)
Bed Elevation
36.9cfs
92.2 cfs
165 cfs



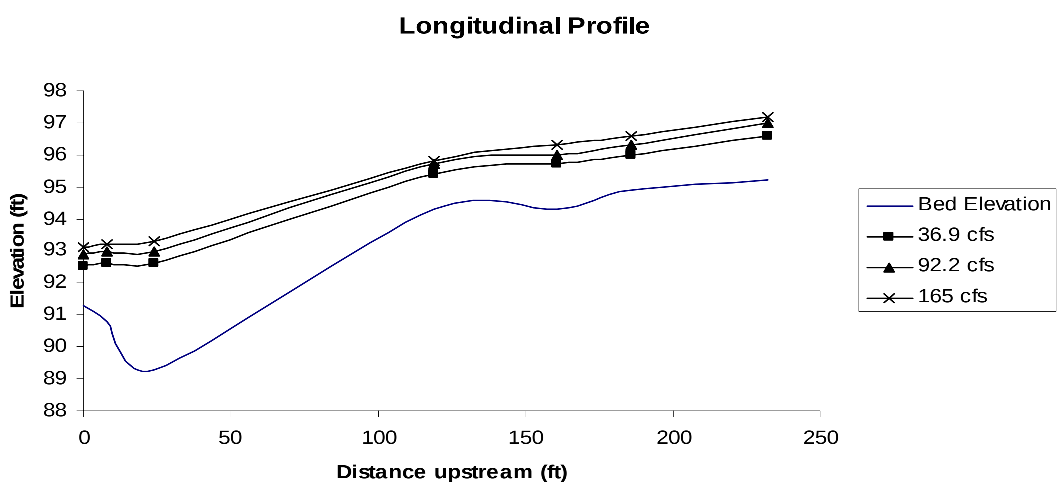
Transect 5
Elevation (ft)
100
98
96
94
92
90
0
20
40
60
80
100
120
Distance (ft)
Bed Elevation
36.9cfs
92.2 cfs
165 cfs



Transect 6
Elevation (ft)
100
98
96
94
92
90
0
20
40
60
80
100
120
Distance (ft)
Bed Elevation
36.9cfs
92.2 cfs
165 cfs

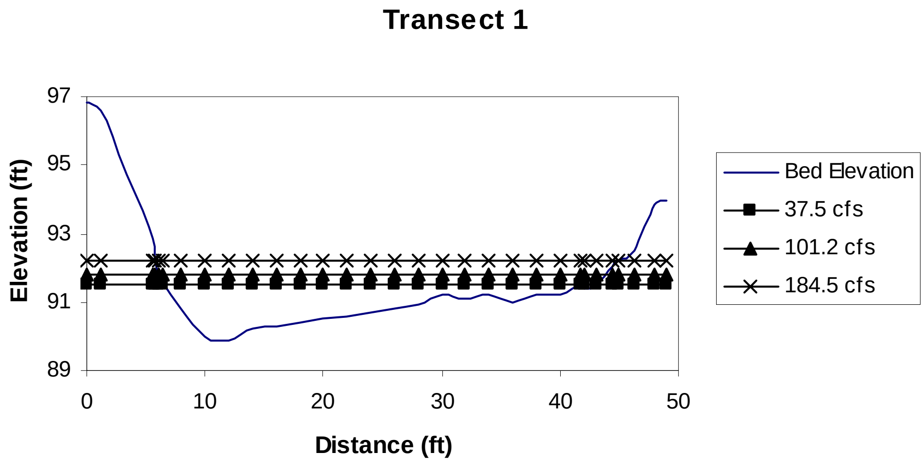


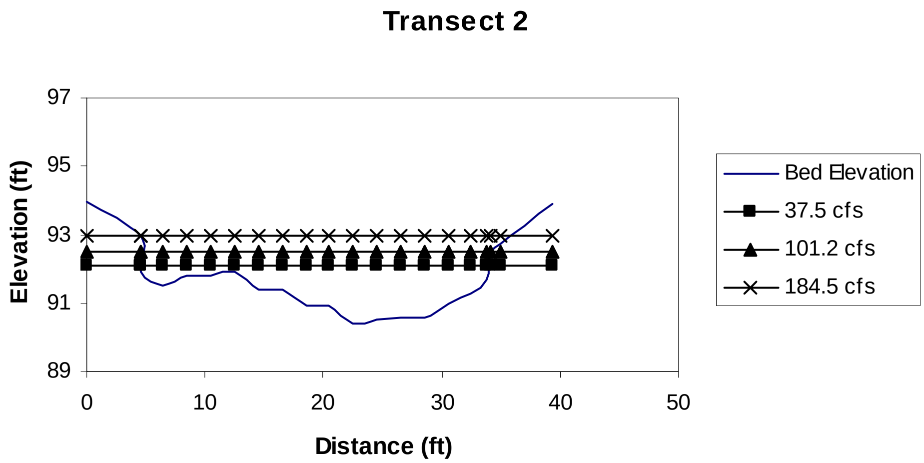
Transect 7
Elevation (ft)
100
98
96
94
92
90
0
20
40
60
80
100
120
Distance (ft)
Bed Elevation
36.9cfs
92.2 cfs
165 cfs

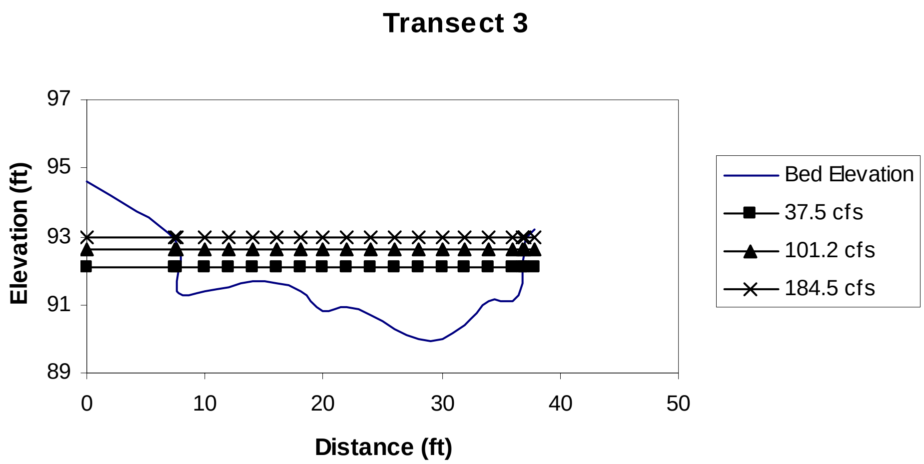


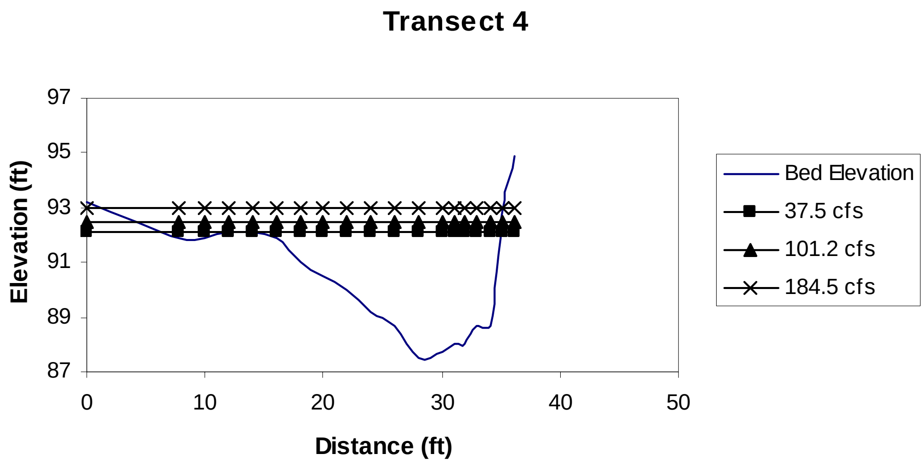
Longitudinal Profile
Elevation (ft)
98
97
96
95
94
93
92
91
90
89
88
0
50
100
150
200
250
Distance upstream (ft)
Bed Elevation
36.9 cfs
92.2 cfs
165 cfs

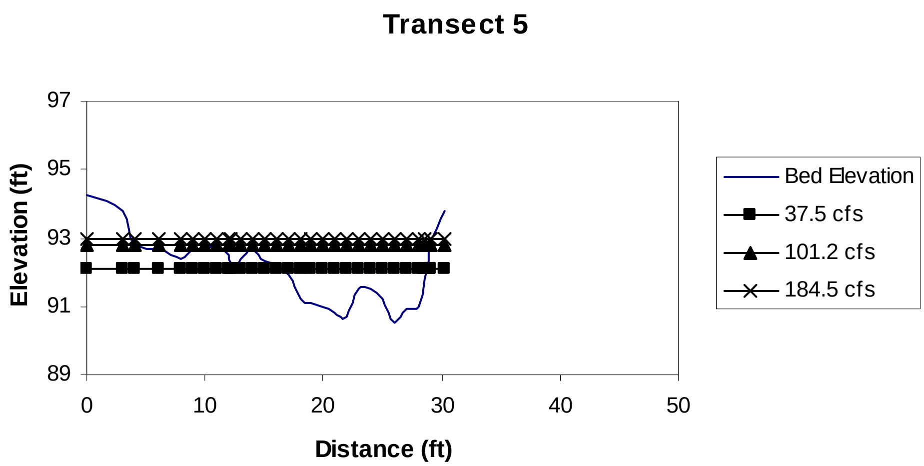
Hayden Creek, Site 3

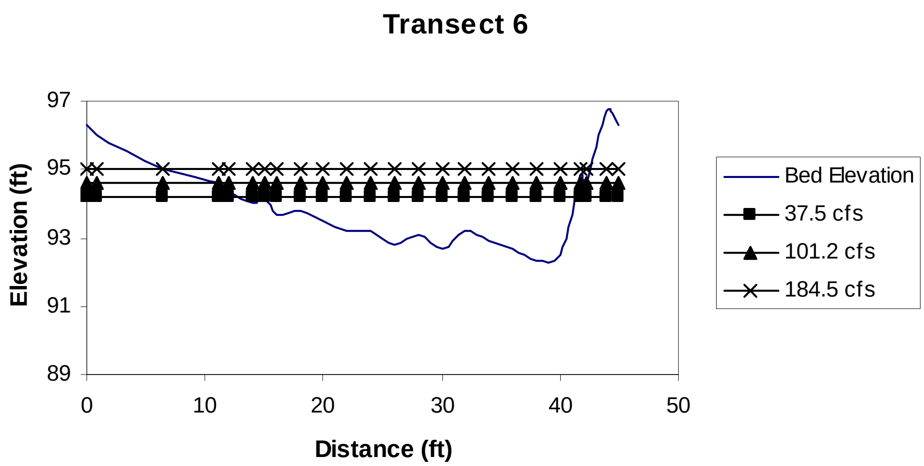


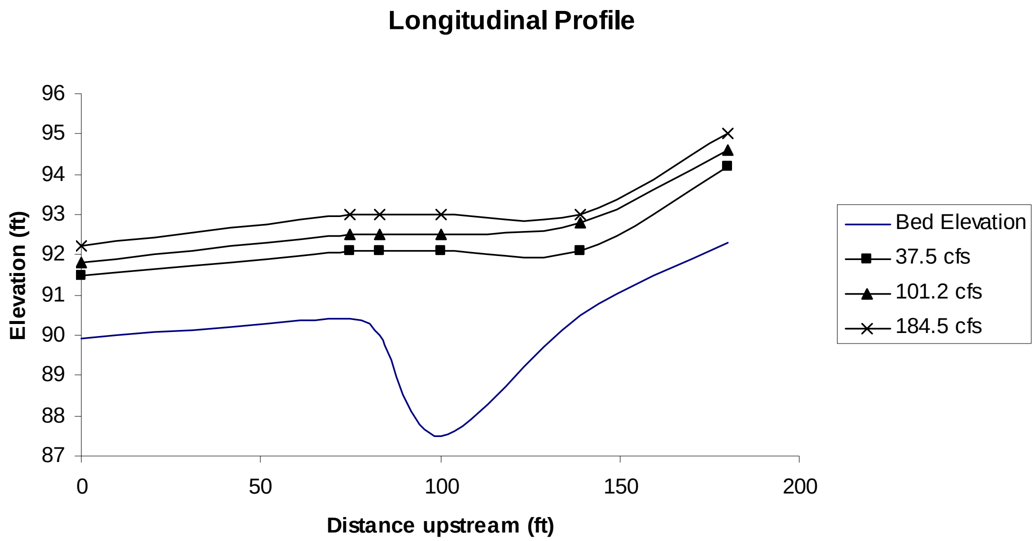





Transect 4
97
95
93
91
89
87
0
10
20
30
40
50
Elevation (ft)
Distance (ft)
Bed Elevation
37.5 cfs
101.2 cfs
184.5 cfs


Transect 5
97
95
93
91
89
0
10
20
30
40
50
Elevation (ft)
Distance (ft)
Bed Elevation
37.5 cfs
101.2 cfs
184.5 cfs


Transect 6
97
95
93
91
89
0
10
20
30
40
50
Elevation (ft)
Distance (ft)
Bed Elevation
37.5 cfs
101.2 cfs
184.5 cfs


Longitudinal Profile
Elevation (ft)
96
95
94
93
92
91
90
89
88
87
0
50
100
150
200
Distance upstream (ft)
Bed Elevation
37.5 cfs
101.2 cfs
184.5 cfs

APPENDIX D – HYDRAULIC CALIBRATION RESULTS

Table D-1 Water surface elevation calibration results (ft) for Big Eightmile Cr. Site 1 using the MANSQ model for both (1-2) transects.

Transect	Distance from next downstream transect (ft)	0.4 cfs			1.2 cfs		
		Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	97.92	97.92	0.00	98.02	98.99	-0.03
2	10	97.97	97.97	0.00	98.09	98.06	-0.03

Table D-2 Water surface elevation calibration results (ft) for Big Eightmile Cr. Site 2 using the STGQ model for all (1-4) transects.

Transect	Distance from next downstream transect (ft)	3.0 cfs			7.7 cfs			9.6 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	95.59	95.58	-0.01	95.77	95.82	0.05	95.92	95.88	-0.03
2	17	95.87	95.85	-0.01	96.05	96.09	0.04	96.19	96.16	-0.03
3	29	96.54	96.54	0.00	96.76	96.77	0.01	96.85	96.84	-0.01
4	29	97.42	97.41	-0.01	97.52	97.55	0.03	97.61	97.59	-0.02

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

Transect	Distance from next downstream transect (ft)	5.2 cfs			8.3 cfs			21.1 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	97.24	97.24	0.00	97.25	97.25	0.00	97.42	97.42	0.00
2	16	97.25	97.27	0.01	97.33	97.30	-0.03	97.50	97.51	0.02
3	6	97.26	97.27	0.01	97.34	97.31	-0.03	97.50	97.53	0.04
4	16	97.29	97.29	0.01	97.42	97.40	-0.02	97.65	97.66	0.01
5	71	98.34	98.34	-0.01	98.41	98.42	0.01	98.63	98.62	0.00

Table D-4 Water surface elevation calibration results (ft) for Big Eightmile Cr. Site 4 using the STGQ model for all (1-4) transects.

Transect	Distance from next downstream transect (ft)	10.1 cfs			15.7 cfs			33.5 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	98.32	98.33	0.01	98.45	98.43	-0.02	98.64	98.65	0.01
2	37	98.46	98.46	0.00	98.58	98.58	0.00	98.80	98.80	0.00
3	32	98.62	98.63	0.01	98.79	98.78	-0.01	99.08	99.08	0.01
4	25	98.96	98.97	0.01	99.12	99.09	-0.03	99.30	99.32	0.02

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

Transect	Distance from next downstream transect (ft)	10.4 cfs			20.1 cfs			46.1 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	92.72	92.72	0.00	92.89	92.89	0.00	93.19	93.19	0.00
2	26	92.75	92.74	0.00	92.91	92.95	0.03	93.26	93.28	0.02
3	34	93.70	93.70	0.00	93.91	93.91	-0.01	94.20	94.20	0.00
4	16	94.05	94.02	-0.03	94.17	94.22	0.05	94.53	94.52	-0.02
5	33	96.37	96.36	-0.01	96.55	96.58	0.02	96.92	96.91	-0.01

Table D-6 Water surface elevation calibration results (ft) for Bohannon Cr. Site 1 using STGQ.

Transect	Distance from next downstream transect (ft)	0.2 cfs			0.7 cfs			4.5 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	95.45	95.44	-0.01	95.54	95.55	0.01	95.76	95.75	-0.01
2	10	95.45	95.45	0.00	95.57	95.57	0.00	95.82	95.82	0.00
3	26	95.50	95.51	0.01	95.70	95.67	-0.03	96.03	96.06	0.03
4	15	95.93	95.94	0.01	96.08	96.04	-0.04	96.32	96.36	0.04
5	17	96.31	96.31	0.00	96.44	96.44	0.00	96.69	96.69	0.00

Table D-7 Water surface elevation calibration results (ft) for Bohannon Cr. Site 2 using the MANSQ model for transect 1, WSP for transects 2-4 and MANSQ for transects 5-7.

Transect	Distance from next downstream transect (ft)	1.5 cfs			1.8 cfs			7.7 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	97.11	97.16	0.05	97.16	97.18	0.02	97.39	97.40	0.01
2	8	97.44	97.44	0.00	97.46	97.46	0.00	97.64	97.64	0.00
3	8	97.46	97.45	-0.02	97.45	97.47	0.02	97.69	97.69	0.00
4	13	97.46	97.45	-0.01	97.42	97.47	0.05	97.71	97.70	-0.01
5	13	97.47	97.43	-0.04	97.47	97.46	-0.01	97.77	97.77	0.00
6	15	97.83	97.82	-0.01	97.79	97.84	0.05	98.08	98.08	0.00
7	51	98.52	98.48	-0.04	98.50	98.50	0.00	98.70	98.70	0.00

Table D-8 Water surface elevation calibration results (ft) for Bohannon Cr. Site 3 using the STGQ model for transects 1-4, WSP for transects 5-6 and STGQ for transect 7.

Transect	Distance from next downstream transect (ft)	3.9 cfs			5.8 cfs			17.2 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	90.73	90.74	0.02	90.85	90.81	-0.04	91.07	91.09	0.03
2	37	91.82	91.84	0.02	91.96	91.91	-0.04	92.14	92.16	0.03
3	39	93.04	93.04	0.00	93.11	93.11	0.00	93.36	93.35	0.00
4	19	93.39	93.40	0.01	93.49	93.48	-0.01	93.75	93.75	0.00
5	31	93.84	93.84	0.00	93.93	93.93	0.00	94.26	94.26	0.00
6	12	93.86	93.85	-0.01	93.99	93.95	-0.04	94.32	94.31	-0.01
7	18	94.65	94.63	-0.03	94.68	94.71	0.03	95.03	95.02	-0.01

Table D-9 Water surface elevation calibration results (ft) for Bohannon Cr. Site 4 using the STGQ model.

Transect	Distance from next downstream transect (ft)	1.4 cfs			1.6 cfs			4.2 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	92.56	92.56	0.00	92.58	92.58	0.00	92.73	92.73	0.00
2	61	94.09	94.09	0.00	94.10	94.10	0.00	94.18	94.18	0.00
3	37	97.42	97.44	0.02	97.50	97.46	-0.04	97.65	97.67	0.02
4	37	98.50	98.49	-0.01	98.49	98.50	0.01	98.60	98.60	0.00

Table D-10 Water surface elevation calibration results (ft) for Bohannon Cr. Site 5 (Reference site) using the WSP model for transects 1-2, STGQ for transects 3-5 and MANSQ for transect 6.

Transect	Distance from next downstream transect (ft)	3.7 cfs			10.3 cfs			17.4 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	89.67	89.67	0.00	89.69	89.69	0.00	89.90	89.90	0.00
2	9	89.67	89.67	0.00	89.75	89.72	-0.03	89.95	89.93	-0.01
3	13	92.05	92.04	-0.01	92.18	92.19	0.02	92.30	92.29	-0.01
4	60	97.98	97.97	-0.01	98.11	98.13	0.02	98.24	98.23	-0.01
5	49	103.46	103.41	-0.05	103.49	103.56	0.07	103.65	103.64	-0.01
6	64	107.80	107.75	-0.05	107.99	108.02	0.03	108.27	108.23	-0.04

Table D-11 Water surface elevation calibration results (ft) for Hayden Cr. Site 1 using the STGQ model for transects 1-2, WSP for transects 3-4 and STGQ for transect 5.

Transect	Distance from next downstream transect (ft)	23.3 cfs			69.2 cfs			127.7 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	93.04	93.05	0.01	93.43	93.41	-0.02	93.63	93.65	0.02
2	72	93.60	93.60	0.00	93.98	93.97	-0.01	94.23	94.23	0.01
3	8	93.82	93.82	0.00	94.09	94.09	0.00	94.34	94.34	0.00
4	27	93.82	93.84	0.01	94.17	94.16	-0.01	94.45	94.46	0.02
5	20	94.44	94.44	0.01	94.92	94.90	-0.02	95.19	95.21	0.02

Table D-12 Water surface elevation calibration results (ft) for Hayden Cr. Site 2 using the WSP model for transects 1-3 and STGQ for transects 4-7.

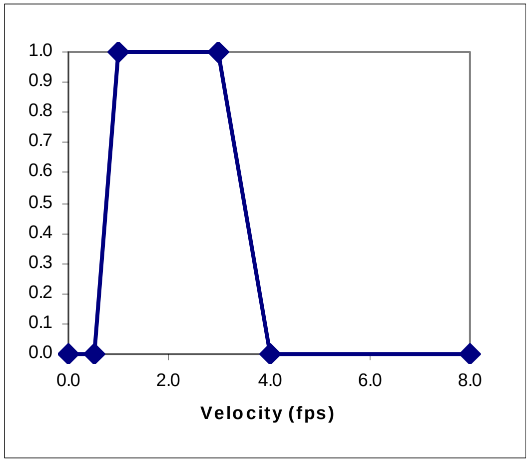
Transect	Distance from next downstream transect (ft)	36.9 cfs			92.2 cfs			165.0 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	92.52	92.52	0.00	92.87	92.87	0.00	93.10	93.10	0.00
2	8	92.56	92.55	-0.01	92.90	92.92	0.03	93.17	93.19	0.02
3	16	92.60	92.57	-0.04	92.95	92.95	0.00	93.26	93.24	-0.03
4	95	95.39	95.60	0.01	95.70	95.66	-0.03	95.84	95.87	0.03
5	42	95.68	95.68	0.00	96.03	96.03	0.00	96.31	96.31	0.00
6	25	96.04	96.02	-0.02	96.27	96.31	0.04	96.55	96.52	-0.02
7	46.5	96.61	96.61	0.00	96.96	96.97	0.01	97.25	97.24	-0.01

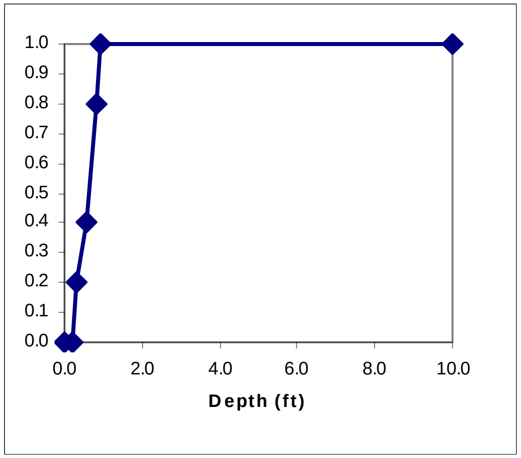
Table D-13 Water surface elevation calibration results (ft) for Hayden Cr. Site 3 using the STGQ model for transect 1, WSP for transects 2-4, MANSQ for transect 5 and STGQ for transect 6.

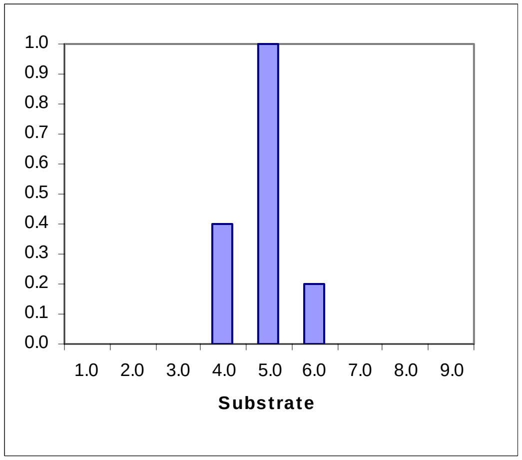
Transect	Distance from next downstream transect (ft)	37.5 cfs			101.2 cfs			184.5 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	91.49	91.47	-0.02	91.85	91.89	0.05	92.24	92.21	-0.03
2	75	92.09	92.09	0.00	92.48	92.48	0.00	92.96	92.96	0.00
3	8	92.12	92.10	-0.02	92.54	92.52	-0.02	93.00	93.02	0.02
4	17	92.13	92.12	-0.01	92.56	92.57	0.01	93.01	93.08	0.07
5	39	92.15	92.16	0.01	92.81	92.76	-0.05	93.02	93.06	0.04
6	41	94.17	94.16	-0.01	94.61	94.64	0.04	95.02	95.00	-0.02

APPENDIX E – HABITAT SUITABILITY CRITERIA

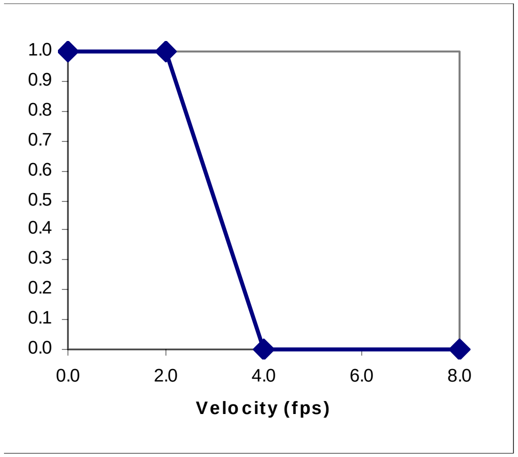
Chinook Salmon – spawning

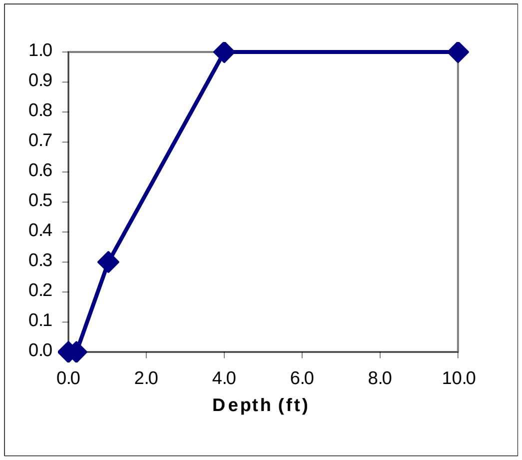


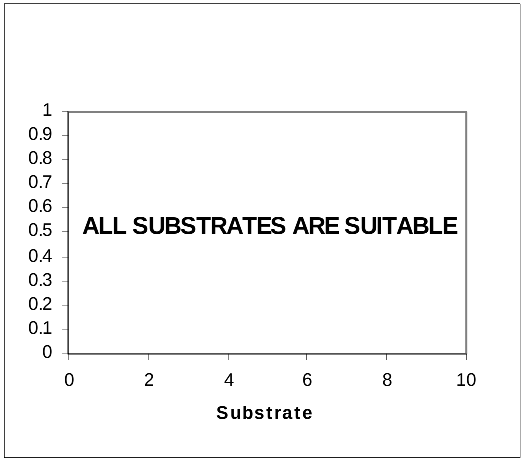




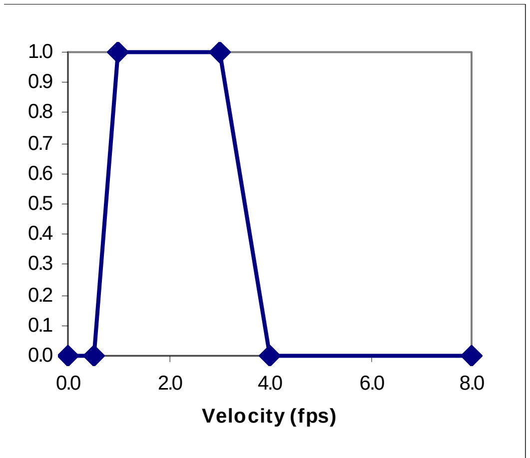
Chinook Salmon – adult holding

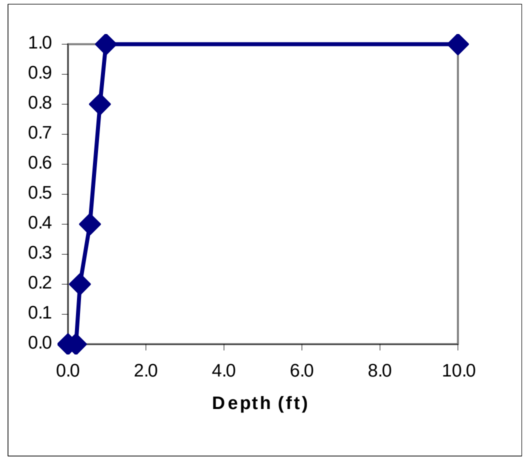


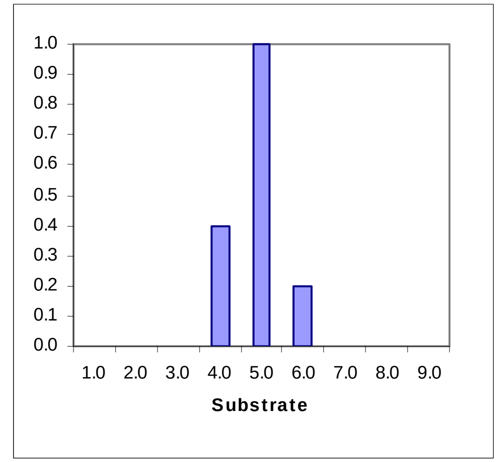




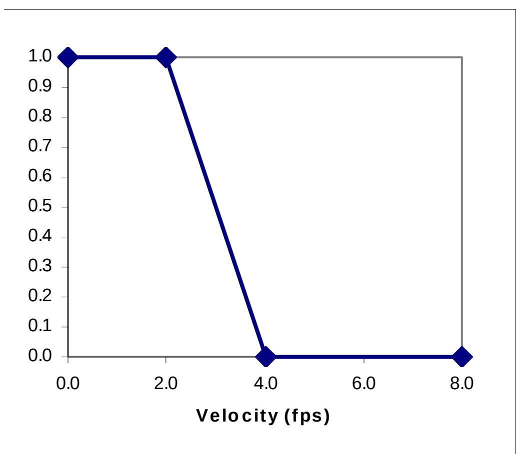
Steelhead – spawning

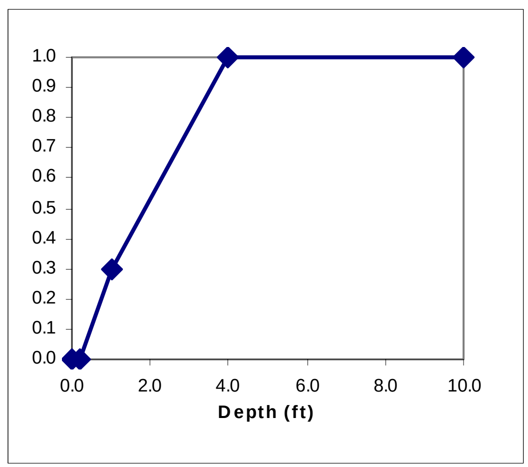


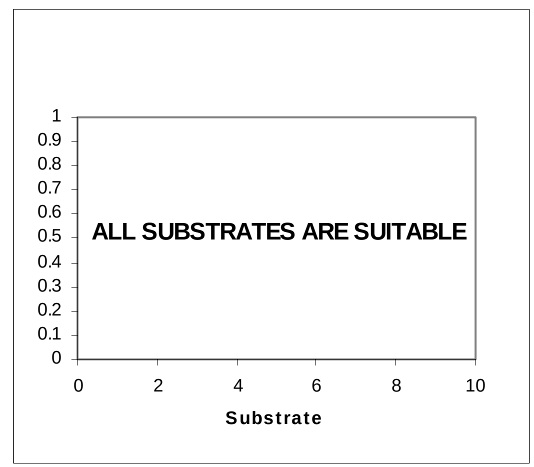




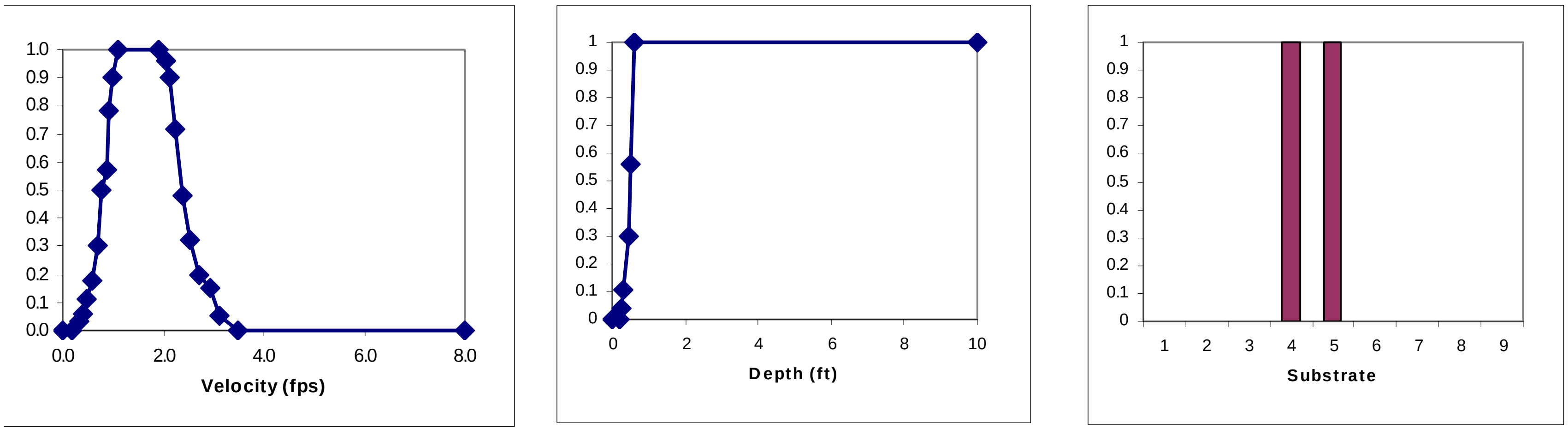
Steelhead – adult holding



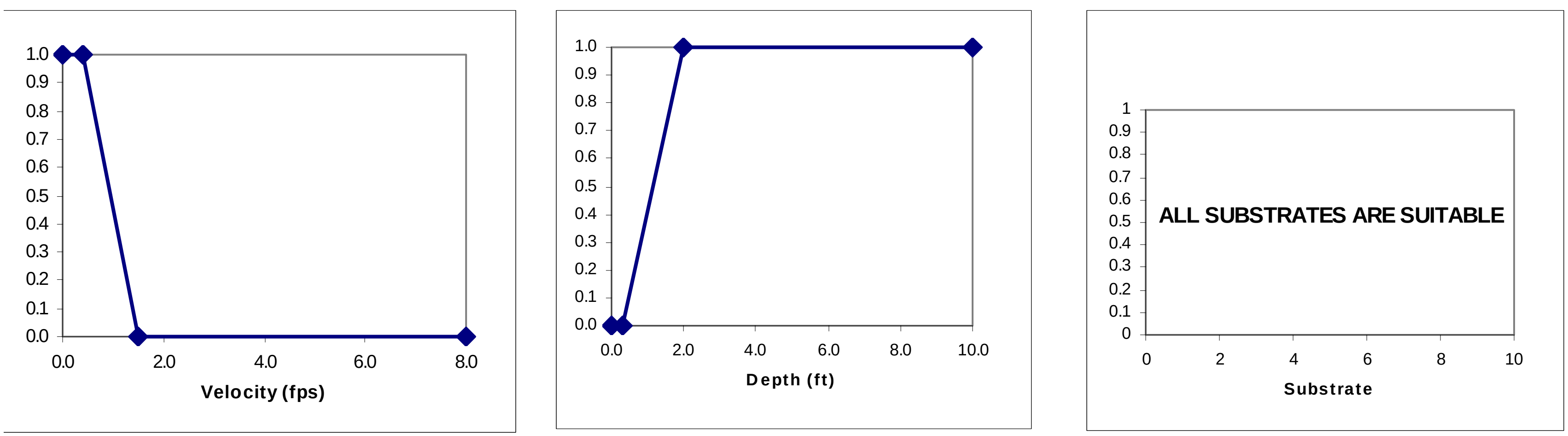




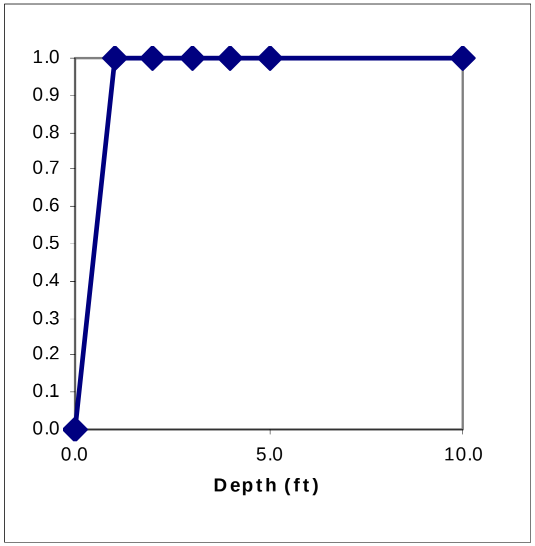
Bull trout - spawning



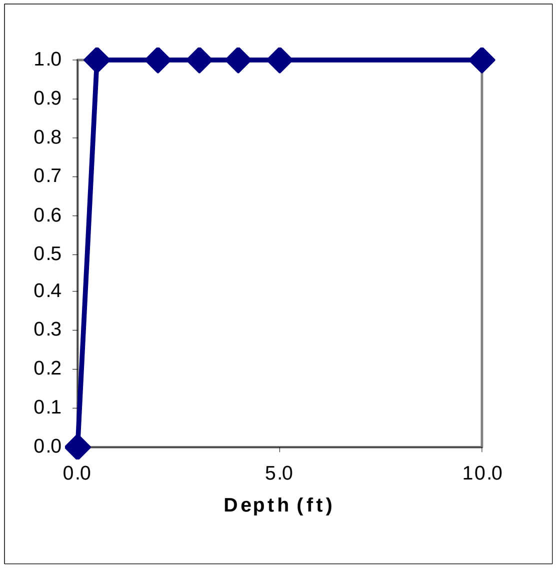
Bull trout – adult



Upstream anadromous passage



Upstream resident passage



APPENDIX F – WEIGHTED USABLE AREA (WUA) VERSUS DISCHARGE RELATIONSHIPS

Big Eightmile Creek, Reach 1 (Study Site 1):

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

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
0.4	5216.3	1137.3	241.5	26.0	8.9
0.6	5368.3	1473.8	473.1	33.7	17.4
0.8	6329.5	1915.3	716.5	43.8	26.3
1	6746.1	2131.4	955.0	48.7	35.1
1.4	7579.2	2415.1	1610.9	55.2	59.2
1.8	8216.8	2627.7	1757.2	60.0	64.6
2	8410.9	2819.1	1830.1	64.4	67.2
2.2	8534.7	2957.2	1881.6	67.6	69.1
2.4	8653.8	3054.7	1943.5	69.8	71.4
2.6	8766.9	3136.1	2000.6	71.6	73.5
2.8	8879.4	3210.6	2059.2	73.3	75.7
3	8979.4	3424.6	2114.4	78.2	77.7
3.2	9081.8	3564.6	2219.5	81.4	81.5
3.4	9172.3	3661.5	2287.5	83.7	84.0
3.6	9264.6	3745.1	2345.4	85.6	86.2
3.8	9359.5	3821.9	2466.2	87.3	90.6
4	9444.7	3889.7	2547.9	88.9	93.6
4.2	9523.7	3947.4	2608.9	90.2	95.9
4.4	9607.8	4244.3	2668.0	97.0	98.0
4.6	9689.6	4377.1	2721.9	100.0	100.0

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

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
0.4	5216.3	1137.3	241.5	26.0	8.9
0.6	5368.3	1473.8	473.1	33.7	17.4
0.8	6329.5	1915.3	716.5	43.8	26.3
1	6746.1	2131.4	955.0	48.7	35.1
1.4	7579.2	2415.1	1610.9	55.2	59.2
1.8	8216.8	2627.7	1757.2	60.0	64.6
2	8410.9	2819.1	1830.1	64.4	67.2
2.2	8534.7	2957.2	1881.6	67.6	69.1
2.4	8653.8	3054.7	1943.5	69.8	71.4
2.6	8766.9	3136.1	2000.6	71.6	73.5
2.8	8879.4	3210.6	2059.2	73.3	75.7
3	8979.4	3424.6	2114.4	78.2	77.7
3.2	9081.8	3564.6	2219.5	81.4	81.5
3.4	9172.3	3661.5	2287.5	83.7	84.0
3.6	9264.6	3745.1	2345.4	85.6	86.2
3.8	9359.5	3821.9	2466.2	87.3	90.6
4	9444.7	3889.7	2547.9	88.9	93.6
4.2	9523.7	3947.4	2608.9	90.2	95.9
4.4	9607.8	4244.3	2668.0	97.0	98.0
4.6	9689.6	4377.1	2721.9	100.0	100.0

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

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
0.4	5216.3	524.3	321.1	14.8	12.0
0.6	5368.3	897.6	536.8	25.3	20.0
0.8	6329.5	1325.1	780.1	37.4	29.1
1	6746.1	1614.4	958.5	45.5	35.8
1.4	7579.2	1957.3	1558.9	55.2	58.2
1.8	8216.8	2224.6	1902.2	62.7	71.0
2	8410.9	2308.5	2031.8	65.1	75.8
2.2	8534.7	2375.5	2154.8	67.0	80.4
2.4	8653.8	2453.9	2268.9	69.2	84.7
2.6	8766.9	2526.2	2354.7	71.2	87.9
2.8	8879.4	2584.7	2430.8	72.9	90.7
3	8979.4	2726.1	2480.9	76.9	92.6
3.2	9081.8	2836.6	2516.7	80.0	93.9
3.4	9172.3	2905.5	2545.9	81.9	95.0
3.6	9264.6	2966.2	2574.1	83.6	96.1
3.8	9359.5	3022.4	2599.4	85.2	97.0
4	9444.7	3069.6	2621.7	86.5	97.8
4.2	9523.7	3110.6	2641.7	87.7	98.6
4.4	9607.8	3426.3	2660.1	96.6	99.3
4.6	9689.6	3547.2	2679.4	100.0	100.0

Table F-4. Passage criteria assessment for transect 1 (riffle), Big Eightmile Creek Study Site 1, 2004.

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.4 ft depth	Percent stream width greater than 0.4 ft depth	Contiguous stream width greater than 0.4 ft depth	Percent contiguous stream width greater than 0.4 ft depth
0.4	5.9	0.1	2.3	0.1	2.3
0.6	5.9	0.4	7.2	0.4	7.2
0.8	6.0	0.7	10.9	0.7	10.9
1	6.0	0.8	14.0	0.8	14.0
1.2	7.5	1.8	23.4	1.1	14.8
1.4	7.6	2.2	28.3	1.2	15.9
1.6	7.7	2.5	32.7	1.3	16.8
1.8	7.8	2.9	36.4	1.4	17.6
2	7.9	3.2	39.8	1.5	18.3
2.2	8.0	3.4	42.9	1.5	19.0
2.4	8.1	4.6	56.6	4.6	56.4
2.6	8.2	4.7	56.9	4.6	56.4
2.8	8.3	4.7	57.1	4.6	56.3
3	8.3	4.8	57.3	4.7	56.3
3.2	8.4	4.8	57.5	4.7	56.2
3.4	8.4	4.9	57.7	4.7	56.2
3.6	8.5	4.9	57.9	4.8	56.1
3.8	8.6	5.0	58.0	4.8	56.1
4	8.6	5.0	58.2	4.8	56.0
4.2	8.7	5.1	58.3	4.9	56.0
4.4	8.7	5.1	58.5	4.9	56.0
4.6	8.8	5.1	58.6	4.9	55.9
4.8	8.8	5.2	58.8	4.9	55.9
5	8.9	5.2	58.9	4.9	55.9
Discharge (cfs)	stream width (ft)	Total stream width greater than 0.6 ft depth	Percent stream width greater than 0.6 ft depth	Contiguous stream width greater than 0.6 ft depth	Percent contiguous stream width greater than 0.6 ft depth
0.4	5.9	0.0	0.0	0.0	0.0
0.6	5.9	0.0	0.0	0.0	0.0
0.8	6.0	0.0	0.0	0.0	0.0
1	6.0	0.0	0.0	0.0	0.0
1.2	7.5	0.0	0.0	0.0	0.0
1.4	7.6	0.0	0.0	0.0	0.0
1.6	7.7	0.0	0.0	0.0	0.0
1.8	7.8	0.0	0.0	0.0	0.0
2	7.9	0.0	0.0	0.0	0.0
2.2	8.0	0.0	0.0	0.0	0.0
2.4	8.1	0.1	0.7	0.1	0.7
2.6	8.2	0.1	1.7	0.1	1.7
2.8	8.3	0.2	2.7	0.2	2.7
3	8.3	0.3	3.5	0.3	3.5
3.2	8.4	0.4	4.4	0.4	4.4
3.4	8.4	0.4	5.2	0.4	5.2
3.6	8.5	0.5	5.9	0.5	5.9
3.8	8.6	0.6	6.6	0.6	6.6
4	8.6	0.6	7.3	0.6	7.3

4.2	8.7	0.7	7.9	0.7	7.9
4.4	8.7	0.7	8.5	0.7	8.5
4.6	8.8	0.8	9.0	0.8	9.0
4.8	8.8	0.8	9.6	0.8	9.6
5	8.9	0.9	10.1	0.9	10.1
Discharge (cfs)	stream width (ft)	Total stream width greater than 0.8 ft depth	Percent stream width greater than 0.8 ft depth	Contiguous stream width greater than 0.8 ft depth	Percent contiguous stream width greater than 0.8 ft depth
0.4	5.9	0.0	0.0	0.0	0.0
0.6	5.9	0.0	0.0	0.0	0.0
0.8	6.0	0.0	0.0	0.0	0.0
1	6.0	0.0	0.0	0.0	0.0
1.2	7.5	0.0	0.0	0.0	0.0
1.4	7.6	0.0	0.0	0.0	0.0
1.6	7.7	0.0	0.0	0.0	0.0
1.8	7.8	0.0	0.0	0.0	0.0
2	7.9	0.0	0.0	0.0	0.0
2.2	8.0	0.0	0.0	0.0	0.0
2.4	8.1	0.0	0.0	0.0	0.0
2.6	8.2	0.0	0.0	0.0	0.0
2.8	8.3	0.0	0.0	0.0	0.0
3	8.3	0.0	0.0	0.0	0.0
3.2	8.4	0.0	0.0	0.0	0.0
3.4	8.4	0.0	0.0	0.0	0.0
3.6	8.5	0.0	0.0	0.0	0.0
3.8	8.6	0.0	0.0	0.0	0.0
4	8.6	0.0	0.0	0.0	0.0
4.2	8.7	0.0	0.0	0.0	0.0
4.4	8.7	0.0	0.0	0.0	0.0
4.6	8.8	0.0	0.0	0.0	0.0
4.8	8.8	0.0	0.0	0.0	0.0
5	8.9	0.0	0.0	0.0	0.0

Big Eightmile Creek, Reach 2 (Study Site 2):

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

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
1.5	10409.3	2644.3	908.3	35.4	27.1
2	11131.9	3029.7	1078.6	40.5	32.2
3	11935.8	3828.0	1411.9	51.2	42.2
5	12417.7	4924.0	1782.4	65.8	53.2
6	12732.9	5380.8	1887.9	71.9	56.4
7	12952.4	5699.4	2020.8	76.2	60.3
7.7	13093.9	5855.3	2110.8	78.3	63.0
8	13158.1	5928.3	2159.9	79.3	64.5
9	13385.8	6177.9	2333.5	82.6	69.7
9.6	13516.3	6296.6	2408.1	84.2	71.9
10	13600.3	6356.7	2479.1	85.0	74.0
11	13745.6	6492.0	2616.0	86.8	78.1
12	14144.9	6619.7	2725.4	88.5	81.4
13	14215.5	6720.8	2826.9	89.9	84.4
14	14282.5	6948.3	2944.8	92.9	87.9
15	14346.3	7096.3	3023.3	94.9	90.3
16	14407.2	7190.9	3088.8	96.1	92.2
17	14465.6	7257.7	3136.5	97.0	93.6
18	14521.7	7310.4	3165.3	97.7	94.5
19	14575.7	7358.6	3210.2	98.4	95.8
20	14627.7	7422.3	3249.9	99.2	97.0
21	14678.0	7471.5	3278.7	99.9	97.9
22	14726.8	7471.4	3284.0	99.9	98.0
23	14774.0	7479.8	3311.7	100.0	98.9
24	14819.8	7451.5	3334.2	99.6	99.5
25	14864.4	7474.5	3349.7	99.9	100.0
26	14907.7	7432.1	3339.0	99.4	99.7
27	14950.0	7376.4	3322.5	98.6	99.2

Table F-6. Weighted usable area (WUA) versus discharge relationships for Chinook salmon at Big Eightmile Creek, Study Site 2.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
1.5	10409.3	2644.3	908.3	35.4	27.1
2	11131.9	3029.7	1078.6	40.5	32.2
3	11935.8	3828.0	1411.9	51.2	42.2
5	12417.7	4924.0	1782.4	65.8	53.2
6	12732.9	5380.8	1887.9	71.9	56.4
7	12952.4	5699.4	2020.8	76.2	60.3
7.7	13093.9	5855.3	2110.8	78.3	63.0
8	13158.1	5928.3	2159.9	79.3	64.5
9	13385.8	6177.9	2333.5	82.6	69.7
9.6	13516.3	6296.6	2408.1	84.2	71.9
10	13600.3	6356.7	2479.1	85.0	74.0
11	13745.6	6492.0	2616.0	86.8	78.1
12	14144.9	6619.7	2725.4	88.5	81.4
13	14215.5	6720.8	2826.9	89.9	84.4
14	14282.5	6948.3	2944.8	92.9	87.9
15	14346.3	7096.3	3023.3	94.9	90.3
16	14407.2	7190.9	3088.8	96.1	92.2
17	14465.6	7257.7	3136.5	97.0	93.6
18	14521.7	7310.4	3165.3	97.7	94.5
19	14575.7	7358.6	3210.2	98.4	95.8
20	14627.7	7422.3	3249.9	99.2	97.0
21	14678.0	7471.5	3278.7	99.9	97.9
22	14726.8	7471.4	3284.0	99.9	98.0
23	14774.0	7479.8	3311.7	100.0	98.9
24	14819.8	7451.5	3334.2	99.6	99.5
25	14864.4	7474.5	3349.7	99.9	100.0
26	14907.7	7432.1	3339.0	99.4	99.7
27	14950.0	7376.4	3322.5	98.6	99.2

Table F-7. Weighted usable area (WUA) versus discharge relationships for bull trout at Big Eightmile Creek, Study Site 2.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
1.5	10409.3	1184.5	86.0	26.5	8.1
2	11131.9	1419.2	108.7	31.8	10.2
3	11935.8	1946.5	213.0	43.6	20.0
5	12417.7	2877.3	377.1	64.4	35.3
6	12732.9	3253.3	464.9	72.8	43.6
7	12952.4	3501.4	542.8	78.4	50.9
7.7	13093.9	3724.1	607.9	83.4	56.9
8	13158.1	3854.4	628.8	86.3	58.9
9	13385.8	4193.1	685.8	93.9	64.3
9.6	13516.3	4354.4	713.3	97.5	66.8
10	13600.3	4339.8	735.5	97.2	68.9
11	13745.6	4407.3	794.3	98.7	74.4
12	14144.9	4466.2	841.6	100.0	78.8
13	14215.5	4447.7	881.7	99.6	82.6
14	14282.5	4425.4	923.7	99.1	86.5
15	14346.3	4366.2	958.4	97.8	89.8
16	14407.2	4270.0	991.4	95.6	92.9
17	14465.6	4178.7	1021.7	93.6	95.7
18	14521.7	4202.8	1048.1	94.1	98.2
19	14575.7	4125.6	1064.6	92.4	99.7
20	14627.7	4022.2	1067.4	90.1	100.0
21	14678.0	3990.4	1064.5	89.3	99.7
22	14726.8	4001.5	1067.2	89.6	100.0
23	14774.0	4022.1	1061.3	90.1	99.4
24	14819.8	3983.8	1050.3	89.2	98.4
25	14864.4	3974.2	1052.6	89.0	98.6
26	14907.7	3998.2	1056.7	89.5	99.0
27	14950.0	3942.4	1054.3	88.3	98.8

Table F-8. Passage criteria assessment for transect 1 (riffle), Big Eightmile Creek Study Site 2, 2004.

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.4 ft depth	Percent stream width greater than 0.4 ft depth	Contiguous stream width greater than 0.4 ft depth	Percent contiguous stream width greater than 0.4 ft depth
1.5	11.0	0.7	6.6	0.7	6.6
2	12.4	1.5	11.9	1.5	11.9
3	12.7	3.3	25.7	3.3	25.7
4	13.0	5.8	45.0	5.8	45.0
5	13.2	6.3	47.8	6.3	47.8
6	13.7	8.4	61.1	7.9	57.9
7	14.2	9.4	66.1	8.5	59.9
7.7	14.5	10.1	69.6	8.7	60.3
8	14.6	10.4	71.1	8.8	60.2
9	15.0	11.4	75.9	9.0	59.8
9.6	15.3	12.0	78.4	9.1	59.5
10	15.4	12.3	80.0	9.2	59.4

11	15.6	12.5	80.3	12.5	80.3
12	15.7	12.7	80.8	12.7	80.8
13	15.7	12.8	81.2	12.8	81.2
14	15.8	12.9	81.6	12.9	81.6
15	15.8	13.0	81.9	13.0	81.9
16	15.9	13.1	82.2	13.1	82.2
17	15.9	13.2	82.5	13.2	82.5
18	16.0	13.3	83.4	13.3	83.4
19	16.0	13.6	84.7	13.6	84.7
20	16.1	13.8	85.9	13.8	85.9
21	16.1	14.1	87.1	14.1	87.1
22	16.2	14.3	88.3	14.3	88.3
23	16.2	14.5	89.4	14.5	89.4
24	16.3	14.7	90.5	14.7	90.5
25	16.3	14.9	91.6	14.9	91.6
26	16.3	15.1	92.6	15.1	92.6
27	16.4	15.3	93.6	15.3	93.6
28	16.4	15.6	94.8	15.6	94.8

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.6 ft depth	Percent stream width greater than 0.6 ft depth	Contiguous stream width greater than 0.6 ft depth	Percent contiguous stream width greater than 0.6 ft depth
1.5	11.0	0.0	0.0	0.0	0.0
2	12.4	0.0	0.0	0.0	0.0
3	12.7	0.0	0.0	0.0	0.0
4	13.0	0.6	4.8	0.6	4.8
5	13.2	1.4	11.0	1.4	11.0
6	13.7	2.9	21.5	2.9	21.5
7	14.2	3.4	23.8	3.4	23.8
7.7	14.5	5.6	38.8	5.6	38.8
8	14.6	5.7	39.1	5.7	39.1
9	15.0	6.0	40.1	6.0	40.1
9.6	15.3	6.2	40.6	6.2	40.6
10	15.4	6.3	40.9	6.3	40.9
11	15.6	8.0	51.3	7.7	49.5
12	15.7	**8.7**	**55.6**	**8.1**	**51.8**
13	15.7	9.4	59.6	8.5	54.0
14	15.8	10.1	63.7	8.7	55.3
15	15.8	10.8	68.0	8.9	56.0
16	15.9	11.5	72.1	9.0	56.6
17	15.9	12.1	76.0	9.1	57.1
18	16.0	12.5	77.9	12.5	77.9
19	16.0	12.6	78.3	12.6	78.3
20	16.1	12.6	78.6	12.6	78.6
21	16.1	12.7	78.9	12.7	78.9
22	16.2	12.8	79.2	12.8	79.2
23	16.2	12.9	79.5	12.9	79.5
24	16.3	13.0	79.7	13.0	79.7
25	16.3	13.0	79.9	13.0	79.9
26	16.3	13.1	80.2	13.1	80.2
27	16.4	13.2	80.4	13.2	80.4
28	16.4	13.3	80.9	13.3	80.9

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.8 ft depth	Percent stream width greater than 0.8 ft depth	Contiguous stream width greater than 0.8 ft depth	Percent contiguous stream width greater than 0.8 ft depth
1.5	11.0	0.0	0.0	0.0	0.0
2	12.4	0.0	0.0	0.0	0.0
3	12.7	0.0	0.0	0.0	0.0
4	13.0	0.0	0.0	0.0	0.0
5	13.2	0.0	0.0	0.0	0.0
6	13.7	0.0	0.0	0.0	0.0
7	14.2	0.0	0.0	0.0	0.0
7.7	14.5	0.2	1.6	0.2	1.6
8	14.6	0.4	2.8	0.4	2.8
9	15.0	0.9	6.3	0.9	6.3
9.6	15.3	1.3	8.2	1.3	8.2
10	15.4	1.5	9.4	1.5	9.4
11	15.6	2.8	17.9	2.8	17.9
12	15.7	**3.1**	**19.7**	**3.1**	**19.7**
13	15.7	3.4	21.4	3.4	21.4
14	15.8	5.6	35.6	5.6	35.6
15	15.8	5.8	36.8	5.8	36.8
16	15.9	6.0	38.0	6.0	38.0
17	15.9	6.2	39.1	6.2	39.1
18	16.0	7.6	47.6	7.5	46.8
19	16.0	8.1	50.7	7.8	48.5
20	16.1	8.6	53.7	8.1	50.2
21	16.1	9.1	56.5	8.4	51.8
22	16.2	9.6	59.3	8.6	53.3
23	16.2	10.1	62.4	8.7	53.9
24	16.3	10.6	65.4	8.8	54.4
25	16.3	11.1	68.4	8.9	54.8
26	16.3	11.6	71.3	9.0	55.2
27	16.4	12.1	74.1	9.1	55.7
28	16.4	12.4	75.8	12.4	75.8

Big Eightmile Creek, Reach 3 (Study Site 3):

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

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
5	16164.6	5505.3	3731.5	61.3	50.5
5.2	16274.4	5756.3	4008.5	64.1	54.3
7	16555.3	6313.9	4385.9	70.3	59.4
8.3	17176.2	6515.5	4512.5	72.6	61.1
9	17685.2	6882.1	4897.0	76.7	66.3
11	18851.1	7268.4	5434.0	81.0	73.6
13	19645.5	7554.6	5799.2	84.2	78.5
15	20055.8	7881.7	6079.5	87.8	82.3
17	20427.8	8085.6	6398.4	90.1	86.6
19	20873.2	8304.1	6725.6	92.5	91.0
21	21031.7	8604.9	7045.4	95.9	95.4
21.1	21041.2	8628.7	7069.1	96.1	95.7
23	21163.8	8676.7	7238.9	96.7	98.0
25	21283.0	8897.2	7255.6	99.1	98.2
27	21392.5	8971.9	7326.2	100.0	99.2
29	21494.7	8975.8	7387.4	100.0	100.0
31	21592.5	8949.5	7370.3	99.7	99.8
33	21685.3	8813.5	7229.9	98.2	97.9
35	21774.5	8801.9	7190.0	98.1	97.3
37	21859.4	8702.6	7070.5	97.0	95.7
39	21941.4	8567.7	6869.8	95.5	93.0
41	22020.8	8378.8	6688.5	93.3	90.5
43	22096.7	8137.6	6467.9	90.7	87.6
45	22169.2	7928.2	6193.0	88.3	83.8
47	22240.8	7780.8	6013.1	86.7	81.4
49	22309.5	7631.9	5862.6	85.0	79.4
51	22376.3	7382.9	5683.2	82.3	76.9
53	22441.5	7214.0	5439.9	80.4	73.6
55	22504.1	7074.7	5187.5	78.8	70.2

Table F-10. Weighted usable area (WUA) versus discharge relationships for Chinook salmon at Big Eightmile Creek, Study Site 3.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
5	16164.6	5505.3	3731.5	61.3	50.5
5.2	16274.4	5756.3	4008.5	64.1	54.3
7	16555.3	6313.9	4385.9	70.3	59.4
8.3	17176.2	6515.5	4512.5	72.6	61.1
9	17685.2	6882.1	4897.0	76.7	66.3
11	18851.1	7268.4	5434.0	81.0	73.6
13	19645.5	7554.6	5799.2	84.2	78.5
15	20055.8	7881.7	6079.5	87.8	82.3
17	20427.8	8085.6	6398.4	90.1	86.6
19	20873.2	8304.1	6725.6	92.5	91.0
21	21031.7	8604.9	7045.4	95.9	95.4
21.1	21041.2	8628.7	7069.1	96.1	95.7
23	21163.8	8676.7	7238.9	96.7	98.0
25	21283.0	8897.2	7255.6	99.1	98.2
27	21392.5	8971.9	7326.2	100.0	99.2
29	21494.7	8975.8	7387.4	100.0	100.0
31	21592.5	8949.5	7370.3	99.7	99.8
33	21685.3	8813.5	7229.9	98.2	97.9
35	21774.5	8801.9	7190.0	98.1	97.3
37	21859.4	8702.6	7070.5	97.0	95.7
39	21941.4	8567.7	6869.8	95.5	93.0
41	22020.8	8378.8	6688.5	93.3	90.5
43	22096.7	8137.6	6467.9	90.7	87.6
45	22169.2	7928.2	6193.0	88.3	83.8
47	22240.8	7780.8	6013.1	86.7	81.4
49	22309.5	7631.9	5862.6	85.0	79.4
51	22376.3	7382.9	5683.2	82.3	76.9
53	22441.5	7214.0	5439.9	80.4	73.6
55	22504.1	7074.7	5187.5	78.8	70.2

Table F-11. Weighted usable area (WUA) versus discharge relationships for bull trout at Big Eightmile Creek, Study Site 3.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
5	16164.6	3365.0	1345.7	80.4	32.1
5.2	16274.4	3530.8	1574.7	84.4	37.6
7	16555.3	3744.5	1913.9	89.5	45.7
8.3	17176.2	3770.9	1980.9	90.1	47.3
9	17685.2	3905.2	2342.0	93.3	55.9
11	18851.1	4184.5	2736.4	100.0	65.3
13	19645.5	4148.0	3081.1	99.1	73.6
15	20055.8	4173.6	3383.0	99.7	80.8
17	20427.8	4018.5	3634.6	96.0	86.8
19	20873.2	3820.5	3863.8	91.3	92.3
21	21031.7	3830.7	3959.2	91.5	94.5
21.1	21041.2	3839.9	3978.6	91.8	95.0
23	21163.8	3662.8	4064.2	87.5	97.1
25	21283.0	3450.3	4118.4	82.5	98.4
27	21392.5	3441.6	4159.4	82.2	99.3
29	21494.7	3379.0	4187.5	80.8	100.0
31	21592.5	3221.3	4175.0	77.0	99.7
33	21685.3	3283.5	4124.5	78.5	98.5
35	21774.5	3307.6	4116.5	79.0	98.3
37	21859.4	3325.6	3963.1	79.5	94.6
39	21941.4	3262.1	3878.5	78.0	92.6
41	22020.8	3297.3	3793.9	78.8	90.6
43	22096.7	3317.2	3669.2	79.3	87.6
45	22169.2	3331.8	3456.6	79.6	82.5
47	22240.8	3319.0	3305.1	79.3	78.9
49	22309.5	3290.8	3194.6	78.6	76.3
51	22376.3	3227.8	3132.6	77.1	74.8
53	22441.5	3102.0	3068.5	74.1	73.3
55	22504.1	3086.3	2989.7	73.8	71.4

Table F-12. Passage criteria assessment for transect 1 (riffle), Big Eightmile Creek Study Site 3, 2004.

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.4 ft depth	Percent stream width greater than 0.4 ft depth	Contiguous stream width greater than 0.4 ft depth	Percent contiguous stream width greater than 0.4 ft depth
5	25.4	8.0	31.5	6.3	24.9
5.2	25.6	9.3	36.5	7.2	28.2
7	25.7	10.0	38.8	7.6	29.7
8.3	25.7	9.7	37.9	7.5	29.2
9	26.0	11.5	44.2	8.7	33.3
11	26.3	12.6	47.8	9.3	35.5
13	26.7	13.5	50.5	9.8	36.9
15	27.0	14.2	52.7	10.3	38.1
17	27.3	14.9	54.8	10.7	39.2
19	28.3	20.0	70.7	20.0	70.7
21	28.4	20.2	71.1	20.2	71.1

21.1	28.4	20.2	71.2	20.2	71.2
23	28.4	20.3	71.5	20.3	71.5
25	28.5	20.5	71.9	20.5	71.9
27	28.5	20.6	72.2	20.6	72.2
29	28.6	20.7	72.6	20.7	72.6
31	28.6	20.9	72.9	20.9	72.9
33	28.7	21.0	73.1	21.0	73.1
35	28.7	21.2	74.0	21.1	73.4
37	28.7	21.5	75.0	21.2	73.7
39	28.8	21.9	76.0	21.3	73.9
41	28.8	22.2	77.0	21.4	74.2
43	28.8	22.5	77.9	21.5	74.4
45	28.9	22.7	78.7	21.5	74.6
47	28.9	23.0	79.6	21.6	74.8
49	28.9	23.3	80.4	21.7	75.0
51	29.0	23.5	81.2	21.8	75.2
53	29.0	23.8	82.0	21.9	75.4
55	29.0	24.0	82.7	21.9	75.6
Discharge (cfs)	stream width (ft)	Total stream width greater than 0.6 ft depth	Percent stream width greater than 0.6 ft depth	Contiguous stream width greater than 0.6 ft depth	Percent contiguous stream width greater than 0.6 ft depth
5	25.4	0.2	1.0	0.2	1.0
5.2	25.6	0.9	3.6	0.9	3.6
7	25.7	1.2	4.8	1.2	4.8
8.3	25.7	1.1	4.4	1.1	4.4
9	26.0	2.0	7.7	2.0	7.7
11	26.3	4.1	15.7	4.1	15.7
13	26.7	4.7	17.6	4.7	17.6
15	27.0	5.2	19.2	5.2	19.2
17	27.3	5.6	20.7	5.6	20.7
19	28.3	7.5	26.7	6.0	21.3
21	28.4	8.3	29.3	6.5	23.1
21.1	28.4	8.4	29.8	6.6	23.4
23	28.4	9.0	31.6	7.0	24.6
25	28.5	9.6	33.8	7.4	26.0
27	28.5	10.2	35.9	7.8	27.4
29	28.6	10.8	37.7	8.2	28.7
31	28.6	11.3	39.6	8.6	29.9
33	28.7	11.8	41.2	8.9	31.0
35	28.7	12.2	42.7	9.1	31.8
37	28.7	12.6	43.8	9.3	32.5
39	28.8	12.9	45.0	9.5	33.2
41	28.8	13.3	46.1	9.7	33.8
43	28.8	13.6	47.2	9.9	34.4
45	28.9	13.9	48.1	10.1	34.9
47	28.9	14.2	49.1	10.3	35.5
49	28.9	14.5	50.1	10.4	36.0
51	29.0	14.8	51.0	10.6	36.5
53	29.0	15.0	51.9	10.7	37.0
55	29.0	15.3	52.7	10.9	37.5
Discharge	stream	Total stream	Percent stream width	Contiguous stream	Percent contiguous

(cfs)	width (ft)	width greater than 0.8 ft depth	greater than 0.8 ft depth	width greater than 0.8 ft depth	stream width greater than 0.8 ft depth
5	25.4	0.0	0.0	0.0	0.0
5.2	25.6	0.0	0.0	0.0	0.0
7	25.7	0.0	0.0	0.0	0.0
8.3	25.7	0.0	0.0	0.0	0.0
9	26.0	0.0	0.0	0.0	0.0
11	26.3	0.0	0.0	0.0	0.0
13	26.7	0.0	0.0	0.0	0.0
15	27.0	0.0	0.0	0.0	0.0
17	27.3	0.0	0.0	0.0	0.0
19	28.3	0.0	0.1	0.0	0.1
21	28.4	0.4	1.4	0.4	1.4
21.1	28.4	0.5	1.7	0.5	1.7
23	28.4	0.7	2.6	0.7	2.6
25	28.5	**1.1**	**3.7**	**1.1**	**3.7**
27	28.5	1.4	4.8	1.4	4.8
29	28.6	1.6	5.7	1.6	5.7
31	28.6	1.9	6.7	1.9	6.7
33	28.7	2.2	7.5	2.2	7.5
35	28.7	3.9	13.6	3.9	13.6
37	28.7	4.1	14.4	4.1	14.4
39	28.8	4.4	15.1	4.4	15.1
41	28.8	4.6	15.9	4.6	15.9
43	28.8	4.8	16.6	4.8	16.6
45	28.9	5.0	17.2	5.0	17.2
47	28.9	5.2	17.9	5.2	17.9
49	28.9	5.3	18.5	5.3	18.5
51	29.0	5.5	19.1	5.5	19.1
53	29.0	5.7	19.7	5.7	19.7
55	29.0	5.9	20.2	5.9	20.2

Big Eightmile Creek, Reach 4 (Study Site 4):

Table F-13. Weighted usable area (WUA) versus discharge relationships for steelhead at Big Eightmile Creek, Study Site 4.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
4	14598.5	6141.4	1575.6	40.6	65.5
7	17245.1	7343.8	1721.3	48.5	71.5
10.1	19991.5	7972.8	1819.5	52.7	75.6
13	22051.3	8644.9	1958.3	57.2	81.4
15.7	23526.6	8863.5	2185.0	58.6	90.8
16	23679.4	8900.4	2198.2	58.8	91.4
19	25105.3	9268.2	2264.9	61.3	94.1
22	27738.9	9598.3	2296.5	63.5	95.4
25	30686.4	10414.6	2273.0	68.9	94.5
28	33396.3	10867.0	2343.1	71.8	97.4
31	34002.9	12220.4	2378.9	80.8	98.9
33.5	34110.9	12625.7	2373.7	83.5	98.7
34	34141.3	12683.2	2375.3	83.8	98.7
37	34322.0	12998.4	2372.0	85.9	98.6
40	34493.4	13185.9	2406.0	87.2	100.0
43	34655.4	13222.4	2360.2	87.4	98.1
46	34814.2	14024.3	2218.8	92.7	92.2
49	34958.8	14613.8	2265.4	96.6	94.2
52	35096.8	14725.2	2246.5	97.3	93.4
55	35238.4	14771.4	2202.9	97.7	91.6
58	35374.4	14954.4	2223.8	98.9	92.4
61	35505.1	15053.4	2237.4	99.5	93.0
64	35631.1	15056.0	2258.1	99.5	93.9
67	35752.8	14985.8	2273.8	99.1	94.5
70	35870.4	15061.0	2281.8	99.6	94.8
73	35984.3	15074.8	2279.9	99.7	94.8
76	36094.8	15070.1	2262.5	99.6	94.0
79	36207.6	15105.0	2204.8	99.9	91.6
82	36319.2	15126.3	2180.8	100.0	90.6
85	36427.6	15062.3	2140.6	99.6	89.0

Table F-14. Weighted usable area (WUA) versus discharge relationships for Chinook salmon at Big Eightmile Creek, Study Site 4.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
4	14598.5	6141.4	1575.6	40.6	65.5
7	17245.1	7343.8	1721.3	48.5	71.5
10.1	19991.5	7972.8	1819.5	52.7	75.6
13	22051.3	8644.9	1958.3	57.2	81.4
15.7	23526.6	8863.5	2185.0	58.6	90.8
16	23679.4	8900.4	2198.2	58.8	91.4
19	25105.3	9268.2	2264.9	61.3	94.1
22	27738.9	9598.3	2296.5	63.5	95.4
25	30686.4	10414.6	2273.0	68.9	94.5
28	33396.3	10867.0	2343.1	71.8	97.4
31	34002.9	12220.4	2378.9	80.8	98.9
33.5	34110.9	12625.7	2373.7	83.5	98.7
34	34141.3	12683.2	2375.3	83.8	98.7
37	34322.0	12998.4	2372.0	85.9	98.6
40	34493.4	13185.9	2406.0	87.2	100.0
43	34655.4	13222.4	2360.2	87.4	98.1
46	34814.2	14024.3	2218.8	92.7	92.2
49	34958.8	14613.8	2265.4	96.6	94.2
52	35096.8	14725.2	2246.5	97.3	93.4
55	35238.4	14771.4	2202.9	97.7	91.6
58	35374.4	14954.4	2223.8	98.9	92.4
61	35505.1	15053.4	2237.4	99.5	93.0
64	35631.1	15056.0	2258.1	99.5	93.9
67	35752.8	14985.8	2273.8	99.1	94.5
70	35870.4	15061.0	2281.8	99.6	94.8
73	35984.3	15074.8	2279.9	99.7	94.8
76	36094.8	15070.1	2262.5	99.6	94.0
79	36207.6	15105.0	2204.8	99.9	91.6
82	36319.2	15126.3	2180.8	100.0	90.6
85	36427.6	15062.3	2140.6	99.6	89.0

Table F-15. Weighted usable area (WUA) versus discharge relationships for bull trout at Big Eightmile Creek, Study Site 4.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
4	14598.5	4603.4	22.7	34.7	3.6
7	17245.1	5466.2	39.5	41.2	6.3
10.1	19991.5	6158.7	63.4	46.5	10.2
13	22051.3	6129.3	96.3	46.2	15.4
15.7	23526.6	6060.5	131.8	45.7	21.1
16	23679.4	6079.2	133.5	45.9	21.4
19	25105.3	6288.5	150.9	47.4	24.2
22	27738.9	6381.3	164.9	48.1	26.4
25	30686.4	6606.6	183.0	49.8	29.3
28	33396.3	6682.5	242.8	50.4	38.9
31	34002.9	6538.0	301.9	49.3	48.3
33.5	34110.9	6557.6	350.4	49.5	56.1
34	34141.3	7121.0	356.8	53.7	57.1
37	34322.0	7450.6	398.3	56.2	63.8
40	34493.4	8282.0	440.1	62.5	70.4
43	34655.4	8787.8	471.5	66.3	75.5
46	34814.2	9067.2	494.6	68.4	79.2
49	34958.8	9209.3	512.7	69.5	82.1
52	35096.8	9396.7	527.4	70.9	84.4
55	35238.4	9621.2	538.5	72.6	86.2
58	35374.4	9721.6	552.0	73.3	88.4
61	35505.1	11026.4	571.0	83.2	91.4
64	35631.1	11602.7	587.0	87.5	94.0
67	35752.8	11892.6	590.7	89.7	94.6
70	35870.4	12226.7	593.7	92.2	95.0
73	35984.3	12463.5	596.2	94.0	95.4
76	36094.8	12700.0	604.5	95.8	96.8
79	36207.6	12895.6	618.1	97.3	98.9
82	36319.2	13068.0	623.3	98.6	99.8
85	36427.6	13258.7	624.7	100.0	100.0

Table F-16. Passage criteria assessment for transect 1 (glide), Big Eightmile Creek Study Site 4, 2004.

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.4 ft depth	Percent stream width greater than 0.4 ft depth	Contiguous stream width greater than 0.4 ft depth	Percent contiguous stream width greater than 0.4 ft depth
4	18.8	7.0	37.1	4.3	23.0
7	25.1	13.2	52.5	6.4	25.5
10.1	32.1	15.6	48.7	8.7	27.0
13	37.4	16.6	44.4	9.0	24.2
15.7	41.6	17.0	40.8	17.0	40.8
16	42.0	17.0	40.4	17.0	40.4
19	46.1	17.2	37.3	17.2	37.3
22	54.0	18.0	33.4	17.6	32.6
25	62.9	19.2	30.5	18.2	28.9
28	71.2	20.3	28.6	18.7	26.3

31	72.8	22.8	31.3	20.6	28.3
33.5	72.9	25.0	34.3	20.7	28.4
34	72.9	25.4	34.9	20.7	28.4
37	73.1	27.9	38.2	20.8	28.4
40	73.2	30.3	41.4	20.8	28.5
43	73.3	32.5	44.4	20.9	28.5
46	73.4	34.6	47.2	21.0	28.6
49	73.5	36.7	49.9	21.0	28.6
52	73.6	38.6	52.5	21.1	28.7
55	73.7	40.5	54.9	21.2	28.7
58	73.8	42.3	57.3	21.2	28.8
61	73.9	44.0	59.6	22.7	30.8
64	74.0	45.7	61.7	24.4	32.9
67	74.1	47.3	63.8	25.9	35.0
70	74.2	51.8	69.7	27.8	37.5
73	74.3	55.9	75.2	29.7	40.0
76	74.4	59.9	80.5	31.6	42.4
79	74.5	63.8	85.6	33.4	44.8
82	74.6	67.6	90.6	35.1	47.1
85	74.7	71.3	95.5	36.9	49.3
Discharge (cfs)	stream width (ft)	Total stream width greater than 0.6 ft depth	Percent stream width greater than 0.6 ft depth	Contiguous stream width greater than 0.6 ft depth	Percent contiguous stream width greater than 0.6 ft depth
4	18.8	2.4	12.7	2.4	12.7
7	25.1	3.9	15.4	3.2	12.7
10.1	32.1	6.1	19.0	4.0	12.5
13	37.4	8.6	23.0	4.9	13.1
15.7	41.6	12.5	30.0	6.3	15.1
16	42.0	12.7	30.2	6.3	15.0
19	46.1	14.5	31.4	6.6	14.4
22	54.0	15.5	28.8	8.6	16.0
25	62.9	16.2	25.7	8.9	14.1
28	71.2	16.7	23.5	9.1	12.8
31	72.8	16.9	23.3	16.9	23.3
33.5	72.9	17.0	23.4	17.0	23.4
34	72.9	17.1	23.4	17.1	23.4
37	73.1	17.2	23.5	17.2	23.5
40	73.2	17.5	23.9	17.4	23.7
43	73.3	18.3	25.0	17.7	24.2
46	73.4	19.1	26.0	18.1	24.7
49	73.5	19.8	27.0	18.5	25.1
52	73.6	20.5	27.9	20.5	27.9
55	73.7	22.4	30.4	20.6	27.9
58	73.8	24.2	32.8	20.6	28.0
61	73.9	26.0	35.1	20.7	28.0
64	74.0	27.6	37.3	20.8	28.0
67	74.1	29.3	39.5	20.8	28.1
70	74.2	30.8	41.5	20.9	28.1
73	74.3	32.4	43.5	20.9	28.1
76	74.4	33.9	45.5	21.0	28.2
79	74.5	35.3	47.4	21.0	28.2

82	74.6	36.7	49.2	21.0	28.2
85	74.7	38.1	51.0	21.1	28.2
Discharge (cfs)	stream width (ft)	Total stream width greater than 0.8 ft depth	Percent stream width greater than 0.8 ft depth	Contiguous stream width greater than 0.8 ft depth	Percent contiguous stream width greater than 0.8 ft depth
4	18.8	1.4	7.4	1.4	7.4
7	25.1	1.8	7.2	1.8	7.2
10.1	32.1	2.2	6.9	2.2	6.9
13	37.4	2.7	7.2	2.7	7.2
15.7	41.6	3.5	8.4	3.1	7.3
16	42.0	3.6	8.6	3.1	7.4
19	46.1	4.5	9.9	3.4	7.5
22	54.0	5.9	10.9	3.9	7.3
25	62.9	7.5	11.9	4.5	7.2
28	71.2	8.9	12.5	5.0	7.1
31	72.8	12.2	16.7	6.2	8.5
33.5	72.9	13.1	18.0	6.4	8.8
34	72.9	13.3	18.3	6.4	8.8
37	73.1	**14.4**	**19.8**	**6.6**	**9.1**
40	73.2	15.3	20.9	8.5	11.7
43	73.3	15.7	21.4	8.7	11.9
46	73.4	16.1	21.9	8.9	12.1
49	73.5	16.5	22.4	9.0	12.2
52	73.6	16.8	22.9	16.8	22.9
55	73.7	16.9	22.9	16.9	22.9
58	73.8	17.0	23.0	17.0	23.0
61	73.9	17.1	23.1	17.1	23.1
64	74.0	17.2	23.2	17.2	23.2
67	74.1	17.2	23.2	17.2	23.2
70	74.2	17.7	23.9	17.5	23.5
73	74.3	18.3	24.6	17.7	23.8
76	74.4	18.8	25.3	18.0	24.1
79	74.5	19.3	25.9	18.2	24.4
82	74.6	19.8	26.6	18.5	24.7
85	74.7	20.3	27.2	18.7	25.0

Big Eightmile Creek, Reach 5 (Study Site 5, Reference Site):

Table F-17. Weighted usable area (WUA) versus discharge relationships for steelhead at Big Eightmile Creek, Study Site 5.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
4	14794.5	6402.0	202.5	59.2	12.1
8	15934.1	8004.7	430.0	74.1	25.8
10.4	16409.3	8511.1	502.7	78.8	30.1
12	16781.3	8899.2	508.9	82.3	30.5
16	17403.9	9580.2	553.8	88.7	33.2
20.1	18190.7	10214.0	572.8	94.5	34.3
24	19063.2	10481.4	658.2	97.0	39.4
28	19654.1	10619.8	774.1	98.3	46.4
32	20098.9	10770.3	851.8	99.7	51.0
36	20759.2	10793.0	924.4	99.9	55.4
40	21028.8	10777.1	1168.6	99.7	70.0
44	21243.8	10806.6	1326.3	100.0	79.4
46.1	21347.7	10702.2	1380.1	99.0	82.7
48	21428.9	10649.8	1419.2	98.5	85.0
52	21609.8	10588.4	1473.6	98.0	88.3
56	21777.2	10227.6	1537.2	94.6	92.1
60	21936.7	10028.3	1568.3	92.8	93.9
64	22091.3	9928.9	1579.4	91.9	94.6
68	22238.1	9781.8	1623.8	90.5	97.2
72	22378.0	9535.3	1646.0	88.2	98.6
76	22511.6	9354.3	1638.7	86.6	98.1
80	22639.5	9345.6	1649.1	86.5	98.8
84	22762.6	9322.8	1659.7	86.3	99.4
88	22880.4	9237.9	1659.4	85.5	99.4
92	22994.2	9181.8	1665.2	85.0	99.7
96	23103.8	9171.1	1666.8	84.9	99.8
100	23209.9	9104.6	1667.4	84.3	99.9
104	23312.3	9076.2	1669.7	84.0	100.0
108	23411.7	9045.8	1656.2	83.7	99.2
112	23507.8	9046.2	1628.0	83.7	97.5

Table F-18. Weighted usable area (WUA) versus discharge relationships for Chinook salmon at Big Eightmile Creek, Study Site 5.

	WUA (ft²)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
4	14794.5	6402.0	202.5	59.2	12.1
8	15934.1	8004.7	430.0	74.1	25.8
10.4	16409.3	8511.1	502.7	78.8	30.1
12	16781.3	8899.2	508.9	82.3	30.5
16	17403.9	9580.2	553.8	88.7	33.2
20.1	18190.7	10214.0	572.8	94.5	34.3
24	19063.2	10481.4	658.2	97.0	39.4
28	19654.1	10619.8	774.1	98.3	46.4
32	20098.9	10770.3	851.8	99.7	51.0
36	20759.2	10793.0	924.4	99.9	55.4
40	21028.8	10777.1	1168.6	99.7	70.0
44	21243.8	10806.6	1326.3	100.0	79.4
46.1	21347.7	10702.2	1380.1	99.0	82.7
48	21428.9	10649.8	1419.2	98.5	85.0
52	21609.8	10588.4	1473.6	98.0	88.3
56	21777.2	10227.6	1537.2	94.6	92.1
60	21936.7	10028.3	1568.3	92.8	93.9
64	22091.3	9928.9	1579.4	91.9	94.6
68	22238.1	9781.8	1623.8	90.5	97.2
72	22378.0	9535.3	1646.0	88.2	98.6
76	22511.6	9354.3	1638.7	86.6	98.1
80	22639.5	9345.6	1649.1	86.5	98.8
84	22762.6	9322.8	1659.7	86.3	99.4
88	22880.4	9237.9	1659.4	85.5	99.4
92	22994.2	9181.8	1665.2	85.0	99.7
96	23103.8	9171.1	1666.8	84.9	99.8
100	23209.9	9104.6	1667.4	84.3	99.9
104	23312.3	9076.2	1669.7	84.0	100.0
108	23411.7	9045.8	1656.2	83.7	99.2
112	23507.8	9046.2	1628.0	83.7	97.5

Table F-19. Weighted usable area (WUA) versus discharge relationships for bull trout at Big Eightmile Creek, Study Site 5.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
4	14794.5	4947.7	150.5	57.3	23.1
8	15934.1	5807.2	243.0	67.2	37.3
10.4	16409.3	6188.2	284.3	71.6	43.7
12	16781.3	6642.9	295.4	76.9	45.4
16	17403.9	7654.9	331.0	88.6	50.8
20.1	18190.7	8403.8	399.5	97.2	61.4
24	19063.2	8641.5	445.8	100.0	68.5
28	19654.1	8487.4	479.2	98.2	73.6
32	20098.9	8382.7	504.6	97.0	77.5
36	20759.2	8258.2	534.1	95.6	82.0
40	21028.8	8093.1	545.5	93.7	83.8
44	21243.8	7873.4	582.0	91.1	89.4
46.1	21347.7	7870.8	592.1	91.1	90.9
48	21428.9	7847.6	594.5	90.8	91.3
52	21609.8	7967.3	596.4	92.2	91.6
56	21777.2	7881.8	609.4	91.2	93.6
60	21936.7	7835.7	618.6	90.7	95.0
64	22091.3	7705.2	619.5	89.2	95.2
68	22238.1	7657.8	625.5	88.6	96.1
72	22378.0	7617.5	632.2	88.2	97.1
76	22511.6	7595.4	640.9	87.9	98.4
80	22639.5	7667.7	649.9	88.7	99.8
84	22762.6	7652.9	649.1	88.6	99.7
88	22880.4	7590.8	651.0	87.8	100.0
92	22994.2	7507.5	648.6	86.9	99.6
96	23103.8	7496.7	642.2	86.8	98.6
100	23209.9	7478.0	623.7	86.5	95.8
104	23312.3	7457.6	620.9	86.3	95.4
108	23411.7	7419.1	617.2	85.9	94.8
112	23507.8	7305.0	612.3	84.5	94.0

Table F-20. Passage criteria assessment for transect 5 (riffle), Big Eightmile Creek Study Site 5, 2004.

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.4 ft depth	Percent stream width greater than 0.4 ft depth	Contiguous stream width greater than 0.4 ft depth	Percent contiguous stream width greater than 0.4 ft depth
4	18.9	7.2	37.9	3.9	20.7
8	19.9	14.2	71.4	8.7	43.6
10.4	20.5	16.5	80.7	14.5	70.9
12	21.1	18.3	86.8	18.3	86.8
16	21.5	18.8	87.6	18.8	87.6
20.1	22.3	19.2	86.4	19.2	86.4
24	22.7	19.6	86.6	19.6	86.6
28	22.9	20.1	87.4	20.1	87.4
32	23.2	20.4	88.1	20.4	88.1
36	23.4	21.1	90.4	21.1	90.4

40	23.7	21.3	89.8	21.3	89.8
44	24.1	21.5	89.2	21.5	89.2
46.1	24.2	21.6	89.2	21.5	89.0
48	24.3	21.8	89.6	21.6	88.8
52	24.5	22.2	90.3	21.7	88.4
56	24.7	22.5	91.0	21.8	88.1
60	24.9	22.7	90.9	22.7	90.9
64	25.1	22.8	90.7	22.8	90.7
68	25.3	22.9	90.6	22.9	90.6
72	25.5	23.0	90.5	23.0	90.5
76	25.6	23.1	90.4	23.1	90.4
80	25.8	23.3	90.2	23.3	90.2
84	25.9	23.4	90.1	23.4	90.1
88	26.1	23.5	90.3	23.5	90.3
92	26.2	23.7	90.6	23.7	90.6
96	26.3	23.9	90.8	23.9	90.8
100	26.5	24.1	91.0	24.1	91.0
104	26.6	24.2	91.1	24.2	91.1
108	26.7	24.4	91.2	24.4	91.2
112	26.8	24.5	91.2	24.5	91.2

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.6 ft depth	Percent stream width greater than 0.6 ft depth	Contiguous stream width greater than 0.6 ft depth	Percent contiguous stream width greater than 0.6 ft depth
4	18.9	3.3	17.4	2.5	13.3
8	19.9	6.9	34.8	3.8	18.9
10.4	20.5	7.7	37.8	4.3	21.0
12	21.1	9.4	44.2	8.2	38.7
16	21.5	15.1	70.2	8.8	40.8
20.1	22.3	16.8	75.6	14.7	66.0
24	22.7	18.5	81.7	18.5	81.7
28	22.9	18.9	82.2	18.9	82.2
32	23.2	19.1	82.5	19.1	82.5
36	23.4	19.4	82.9	19.4	82.9
40	23.7	19.7	82.9	19.7	82.9
44	24.1	20.0	83.0	20.0	83.0
46.1	24.2	20.1	83.1	20.1	83.1
48	24.3	20.2	83.2	20.2	83.2
52	24.5	20.5	83.5	20.5	83.5
56	24.7	20.7	83.8	20.7	83.8
60	24.9	21.2	85.2	21.2	85.2
64	25.1	21.4	85.1	21.4	85.1
68	25.3	21.5	85.0	21.5	85.0
72	25.5	21.7	85.3	21.6	84.7
76	25.6	22.0	85.8	21.6	84.5
80	25.8	22.2	86.3	21.7	84.3
84	25.9	22.5	86.8	21.8	84.1
88	26.1	22.6	86.8	22.6	86.8
92	26.2	22.7	86.7	22.7	86.7
96	26.3	22.8	86.6	22.8	86.6
100	26.5	22.9	86.6	22.9	86.6
104	26.6	23.0	86.5	23.0	86.5

108	26.7	23.1	86.4	23.1	86.4
112	26.8	23.2	86.4	23.2	86.4

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.8 ft depth	Percent stream width greater than 0.8 ft depth	Contiguous stream width greater than 0.8 ft depth	Percent contiguous stream width greater than 0.8 ft depth
4	18.9	0.7	3.7	0.7	3.7
8	19.9	2.9	14.6	2.3	11.5
10.4	20.5	3.9	19.1	2.7	13.3
12	21.1	6.1	28.8	3.2	15.2
16	21.5	7.1	32.9	3.9	18.0
20.1	22.3	7.9	35.5	4.4	19.8
24	22.7	11.7	51.5	8.4	37.1
28	22.9	15.3	66.7	13.8	60.2
32	23.2	16.4	70.7	14.4	62.3
36	23.4	18.3	78.4	18.3	78.4
40	23.7	18.6	78.2	18.6	78.2
44	24.1	18.8	78.1	18.8	78.1
46.1	24.2	18.9	78.0	18.9	78.0
48	24.3	**19.0**	**78.1**	**19.0**	**78.1**
52	24.5	19.2	78.2	19.2	78.2
56	24.7	19.4	78.2	19.4	78.2
60	24.9	19.6	78.5	19.6	78.5
64	25.1	19.8	78.8	19.8	78.8
68	25.3	20.0	79.0	20.0	79.0
72	25.5	20.2	79.3	20.2	79.3
76	25.6	20.4	79.5	20.4	79.5
80	25.8	20.5	79.7	20.5	79.7
84	25.9	20.7	79.9	20.7	79.9
88	26.1	21.2	81.4	21.2	81.4
92	26.2	21.3	81.3	21.3	81.3
96	26.3	21.4	81.2	21.4	81.2
100	26.5	21.5	81.2	21.5	81.2
104	26.6	21.6	81.4	21.6	81.0
108	26.7	21.9	81.8	21.6	80.9
112	26.8	22.1	82.2	21.7	80.7

Bohannon Creek, Reach 1 (Study Site 1):

Table F-21. Weighted usable area (WUA) versus discharge relationships for steelhead at Bohannon Creek, Study Site 1.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
0.2	4309.0	1307.6	42.0	37.9	5.6
0.7	4989.1	1692.9	113.4	49.1	15.1
1	5178.1	1894.9	143.8	54.9	19.2
2	5595.3	2257.0	223.6	65.4	29.8
3	5764.4	2509.9	358.3	72.8	47.8
4.5	5991.5	2757.5	532.3	79.9	71.0
5	6052.1	2824.2	553.2	81.9	73.8
6	6161.4	2932.6	586.1	85.0	78.1
7	6258.4	3022.6	622.3	87.6	83.0
8	6349.0	3097.3	655.7	89.8	87.4
9	6433.4	3159.8	684.2	91.6	91.2
10	6511.5	3212.3	705.8	93.1	94.1
11	6584.2	3257.9	723.4	94.4	96.5
12	6652.5	3348.9	737.7	97.1	98.4
13	6716.9	3449.4	750.0	100.0	100.0

Table F-22. Weighted usable area (WUA) versus discharge relationships for Chinook salmon at Bohannon Creek, Study Site 1.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
0.2	4309.0	1307.6	42.0	37.9	5.6
0.7	4989.1	1692.9	113.4	49.1	15.1
1	5178.1	1894.9	143.8	54.9	19.2
2	5595.3	2257.0	223.6	65.4	29.8
3	5764.4	2509.9	358.3	72.8	47.8
4.5	5991.5	2757.5	532.3	79.9	71.0
5	6052.1	2824.2	553.2	81.9	73.8
6	6161.4	2932.6	586.1	85.0	78.1
7	6258.4	3022.6	622.3	87.6	83.0
8	6349.0	3097.3	655.7	89.8	87.4
9	6433.4	3159.8	684.2	91.6	91.2
10	6511.5	3212.3	705.8	93.1	94.1
11	6584.2	3257.9	723.4	94.4	96.5
12	6652.5	3348.9	737.7	97.1	98.4
13	6716.9	3449.4	750.0	100.0	100.0

Table F-23. Weighted usable area (WUA) versus discharge relationships for bull trout at Bohannon Creek, Study Site 1.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
0.2	4309.0	1108.2	0.0	31.8	0.0
0.7	4989.1	1604.6	0.0	46.0	0.0
1	5178.1	1734.7	0.0	49.8	0.0
2	5595.3	2106.6	0.0	60.4	0.0
3	5764.4	2398.5	15.0	68.8	42.4
4.5	5991.5	2669.8	30.9	76.6	87.3
5	6052.1	2744.2	31.5	78.7	89.0
6	6161.4	2889.6	32.5	82.9	91.8
7	6258.4	3008.4	33.1	86.3	93.5
8	6349.0	3104.9	33.6	89.1	94.9
9	6433.4	3201.0	34.1	91.8	96.2
10	6511.5	3296.1	34.5	94.6	97.3
11	6584.2	3365.4	34.8	96.6	98.3
12	6652.5	3427.9	35.1	98.4	99.2
13	6716.9	3485.0	35.4	100.0	100.0

Table F-24. Passage criteria assessment for transect 4 (glide), Bohannon Creek Study Site 1, 2004.

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.4 ft depth	Percent stream width greater than 0.4 ft depth	Contiguous stream width greater than 0.4 ft depth	Percent contiguous stream width greater than 0.4 ft depth
0.2	3.3	0.0	0.0	0.0	0.0
0.7	4.5	0.1	2.7	0.1	2.7
1.0	4.7	0.2	5.0	0.2	5.0
2.0	5.7	0.5	9.2	0.5	9.2
3.0	5.9	2.2	36.9	1.0	17.1
4.5	6.1	3.6	58.6	2.1	34.3
5.0	6.2	4.0	64.2	2.2	35.5
6.0	6.4	4.4	69.6	3.0	47.3
7.0	6.5	4.8	73.2	3.1	48.3
8.0	6.6	5.1	77.0	3.7	55.1
9.0	6.8	5.5	80.7	3.9	57.6
10.0	6.9	5.8	83.5	5.8	83.5
11.0	7.0	5.8	83.2	5.8	83.2
12.0	7.1	5.9	82.8	5.9	82.8
13.0	7.3	6.0	82.6	6.0	82.6
Discharge (cfs)	stream width (ft)	Total stream width greater than 0.6 ft depth	Percent stream width greater than 0.6 ft depth	Contiguous stream width greater than 0.6 ft depth	Percent contiguous stream width greater than 0.6 ft depth
0.2	3.3	0.0	0.0	0.0	0.0
0.7	4.5	0.0	0.0	0.0	0.0
1.0	4.7	0.0	0.0	0.0	0.0
2.0	5.7	0.0	0.0	0.0	0.0
3.0	5.9	0.2	3.2	0.2	3.2
4.5	6.1	0.4	7.3	0.4	7.3
5.0	6.2	0.5	8.4	0.5	8.4
6.0	6.4	1.7	26.8	0.8	12.6

7.0	6.5	2.5	38.0	1.1	17.6
8.0	6.6	3.1	46.9	2.0	29.9
9.0	6.8	3.7	54.5	2.1	31.5
10.0	6.9	4.2	60.7	2.9	42.2
11.0	7.0	4.4	63.1	3.0	42.9
12.0	7.1	4.7	65.4	3.1	43.5
13.0	7.3	4.9	67.6	3.5	48.4

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.8 ft depth	Percent stream width greater than 0.8 ft depth	Contiguous stream width greater than 0.8 ft depth	Percent contiguous stream width greater than 0.8 ft depth
0.2	3.3	0.0	0.0	0.0	0.0
0.7	4.5	0.0	0.0	0.0	0.0
1.0	4.7	0.0	0.0	0.0	0.0
2.0	5.7	0.0	0.0	0.0	0.0
3.0	5.9	0.0	0.0	0.0	0.0
4.5	6.1	0.0	0.0	0.0	0.0
5.0	6.2	0.0	0.0	0.0	0.0
6.0	6.4	0.1	1.7	0.1	1.7
7.0	6.5	0.2	3.6	0.2	3.6
8.0	6.6	0.4	5.3	0.4	5.3
9.0	6.8	0.5	6.8	0.5	6.8
10.0	6.9	1.1	16.5	0.6	8.2
11.0	7.0	1.7	24.5	0.8	11.4
12.0	7.1	**2.3**	**31.8**	**1.1**	**14.8**
13.0	7.3	2.8	38.4	1.9	26.2

Bohannon Creek, Reach 2 (Study Site 2):

Table F-25. Weighted usable area (WUA) versus discharge relationships for steelhead at Bohannon Creek, Study Site 2.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
1.5	7007.5	1569.6	1560.2	40.9	40.4
1.8	7142.4	1742.0	1767.1	45.3	45.7
2	7212.3	1808.5	1862.3	47.1	48.2
3	8107.0	2318.8	2401.2	60.4	62.1
4	9318.2	2709.6	2729.5	70.5	70.6
5	9587.9	2985.6	2969.1	77.7	76.8
6	10261.2	3229.6	3217.6	84.1	83.2
7	10677.4	3360.3	3451.8	87.5	89.3
7.7	10965.9	3487.1	3561.2	90.8	92.1
8	11114.4	3513.9	3599.4	91.5	93.1
9	11435.8	3565.6	3669.9	92.8	94.9
10	11650.8	3802.6	3791.5	99.0	98.1
11	11854.0	3841.7	3865.6	100.0	100.0
12	11998.5	3774.7	3752.2	98.3	97.1
13	12182.5	3762.7	3694.1	97.9	95.6
14	12352.8	3576.8	3483.8	93.1	90.1
15	12461.5	3368.0	3162.4	87.7	81.8
16	12523.0	3332.7	3158.9	86.8	81.7
17	12584.6	3278.1	3122.2	85.3	80.8

Table F-26. Weighted usable area (WUA) versus discharge relationships for Chinook salmon at Bohannon Creek, Study Site 2.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
1.5	7007.5	1569.6	1560.2	40.9	40.4
1.8	7142.4	1742.0	1767.1	45.3	45.7
2	7212.3	1808.5	1862.3	47.1	48.2
3	8107.0	2318.8	2401.2	60.4	62.1
4	9318.2	2709.6	2729.5	70.5	70.6
5	9587.9	2985.6	2969.1	77.7	76.8
6	10261.2	3229.6	3217.6	84.1	83.2
7	10677.4	3360.3	3451.8	87.5	89.3
7.7	10965.9	3487.1	3561.2	90.8	92.1
8	11114.4	3513.9	3599.4	91.5	93.1
9	11435.8	3565.6	3669.9	92.8	94.9
10	11650.8	3802.6	3791.5	99.0	98.1
11	11854.0	3841.7	3865.6	100.0	100.0
12	11998.5	3774.7	3752.2	98.3	97.1
13	12182.5	3762.7	3694.1	97.9	95.6
14	12352.8	3576.8	3483.8	93.1	90.1
15	12461.5	3368.0	3162.4	87.7	81.8
16	12523.0	3332.7	3158.9	86.8	81.7
17	12584.6	3278.1	3122.2	85.3	80.8

Table F-27. Weighted usable area (WUA) versus discharge relationships for bull trout at Bohannon Creek, Study Site 2.

	WUA (ft²)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
1.5	7007.5	388.3	1103.4	28.6	44.5
1.8	7142.4	418.0	1276.5	30.8	51.5
2	7212.3	418.8	1378.7	30.9	55.6
3	8107.0	589.8	1911.8	43.5	77.1
4	9318.2	648.7	2169.0	47.8	87.4
5	9587.9	706.3	2244.6	52.0	90.5
6	10261.2	776.9	2363.1	57.2	95.3
7	10677.4	865.0	2411.6	63.7	97.2
7.7	10965.9	904.3	2480.6	66.6	100.0
8	11114.4	919.0	2465.9	67.7	99.4
9	11435.8	947.3	2366.2	69.8	95.4
10	11650.8	1017.1	2345.4	74.9	94.6
11	11854.0	1028.3	2160.8	75.8	87.1
12	11998.5	1054.9	1884.5	77.7	76.0
13	12182.5	1122.4	1941.7	82.7	78.3
14	12352.8	1143.2	1949.1	84.2	78.6
15	12461.5	1167.0	1914.3	86.0	77.2
16	12523.0	1317.5	1976.8	97.1	79.7
17	12584.6	1357.2	2015.4	100.0	81.2

Table F-28. Passage criteria assessment for transect 2 (hydraulic control), Bohannon Creek Study Site 2, 2004.

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.4 ft depth	Percent stream width greater than 0.4 ft depth	Contiguous stream width greater than 0.4 ft depth	Percent contiguous stream width greater than 0.4 ft depth
1.5	9.6	0.0	0.0	0.0	0.0
1.8	10.1	0.0	0.0	0.0	0.0
2	9.0	0.0	0.0	0.0	0.0
3	11.0	0.0	0.0	0.0	0.0
4	11.3	4.1	36.1	3.8	33.5
5	11.4	4.7	41.3	4.1	36.0
6	11.4	5.3	46.3	4.4	38.5
7	11.8	6.6	56.4	6.6	56.4
7.7	12.1	6.8	56.0	6.8	56.0
8	12.3	6.9	55.8	6.9	55.8
9	12.8	7.1	55.3	7.1	55.3
10	13.1	7.2	55.0	7.2	55.0
11	13.2	7.3	55.6	7.3	55.6
12	13.3	7.5	56.3	7.5	56.3
13	13.4	7.6	56.9	7.6	56.9
14	13.5	7.8	57.6	7.8	57.6
15	13.5	7.8	57.9	7.8	57.9
16	13.6	8.7	63.8	8.5	62.2
17	13.7	9.0	65.7	8.5	62.5

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.6 ft depth	Percent stream width greater than 0.6 ft depth	Contiguous stream width greater than 0.6 ft depth	Percent contiguous stream width greater than 0.6 ft depth
1.5	9.6	0.0	0.0	0.0	0.0
1.8	10.1	0.0	0.0	0.0	0.0
2	9.0	0.0	0.0	0.0	0.0
3	11.0	0.0	0.0	0.0	0.0
4	11.3	0.0	0.0	0.0	0.0
5	11.4	0.0	0.0	0.0	0.0
6	11.4	0.0	0.0	0.0	0.0
7	11.8	0.0	0.0	0.0	0.0
7.7	12.1	0.0	0.0	0.0	0.0
8	12.3	0.0	0.0	0.0	0.0
9	12.8	0.0	0.0	0.0	0.0
10	13.1	0.0	0.0	0.0	0.0
11	13.2	3.9	29.6	3.7	28.0
12	13.3	4.3	32.4	3.9	29.4
13	13.4	4.7	35.1	4.1	30.6
14	13.5	5.1	37.8	4.3	31.9
15	13.5	5.3	39.2	4.4	32.5
16	13.6	6.6	48.3	6.6	48.3
17	13.7	6.6	48.6	6.6	48.6

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.8 ft depth	Percent stream width greater than 0.8 ft depth	Contiguous stream width greater than 0.8 ft depth	Percent contiguous stream width greater than 0.8 ft depth
1.5	9.6	0.0	0.0	0.0	0.0
1.8	10.1	0.0	0.0	0.0	0.0
2	9.0	0.0	0.0	0.0	0.0
3	11.0	0.0	0.0	0.0	0.0
4	11.3	0.0	0.0	0.0	0.0
5	11.4	0.0	0.0	0.0	0.0
6	11.4	0.0	0.0	0.0	0.0
7	11.8	0.0	0.0	0.0	0.0
7.7	12.1	0.0	0.0	0.0	0.0
8	12.3	0.0	0.0	0.0	0.0
9	12.8	0.0	0.0	0.0	0.0
10	13.1	0.0	0.0	0.0	0.0
11	13.2	0.0	0.0	0.0	0.0
12	13.3	0.0	0.0	0.0	0.0
13	13.4	0.0	0.0	0.0	0.0
14	13.5	0.0	0.0	0.0	0.0
15	13.5	0.0	0.0	0.0	0.0
16	13.6	0.0	0.0	0.0	0.0
17	13.7	0.0	0.0	0.0	0.0

Bohannon Creek, Reach 3 (Study Site 3):

Table F-29. Weighted usable area (WUA) versus discharge relationships for steelhead at Bohannon Creek, Study Site 3.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
1.5	10927.8	2293.1	1101.6	29.7	20.8
3	12420.8	3301.8	1943.6	42.8	36.8
3.9	13005.9	3833.6	2282.0	49.7	43.2
5	13503.4	4450.9	2760.1	57.7	52.2
5.8	13859.4	4887.0	3058.5	63.4	57.8
7	14094.7	5369.1	3373.7	69.6	63.8
9	14348.6	5971.8	3740.5	77.4	70.7
11	14584.7	6555.0	4255.2	85.0	80.5
13	14791.9	6978.9	4580.9	90.5	86.6
15	15010.0	7280.9	4858.8	94.4	91.9
17	15208.1	7486.1	5026.5	97.1	95.1
17.2	15228.6	7504.0	5043.0	97.3	95.4
19	15441.4	7628.0	5141.1	98.9	97.2
21	15615.6	7713.3	5234.9	100.0	99.0
23	15959.0	7712.0	5287.9	100.0	100.0
25	16309.7	7652.4	5205.2	99.2	98.4
27	16633.2	7630.9	5264.9	98.9	99.6
29	16738.3	7601.3	5272.3	98.5	99.7
31	16838.0	7545.6	5228.1	97.8	98.9
33	16934.1	7494.5	5221.5	97.2	98.7
35	17025.9	7444.6	5173.4	96.5	97.8
37	17114.8	7387.3	5047.5	95.8	95.5
39	17200.6	7382.1	4945.0	95.7	93.5
41	17283.0	7211.3	4713.0	93.5	89.1
43	17363.0	7119.9	4634.7	92.3	87.6

Table F-30. Weighted usable area (WUA) versus discharge relationships for Chinook salmon at Bohannon Creek, Study Site 3.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
1.5	10927.8	2293.1	1101.6	29.7	20.8
3	12420.8	3301.8	1943.6	42.8	36.8
3.9	13005.9	3833.6	2282.0	49.7	43.2
5	13503.4	4450.9	2760.1	57.7	52.2
5.8	13859.4	4887.0	3058.5	63.4	57.8
7	14094.7	5369.1	3373.7	69.6	63.8
9	14348.6	5971.8	3740.5	77.4	70.7
11	14584.7	6555.0	4255.2	85.0	80.5
13	14791.9	6978.9	4580.9	90.5	86.6
15	15010.0	7280.9	4858.8	94.4	91.9
17	15208.1	7486.1	5026.5	97.1	95.1
17.2	15228.6	7504.0	5043.0	97.3	95.4
19	15441.4	7628.0	5141.1	98.9	97.2
21	15615.6	7713.3	5234.9	100.0	99.0
23	15959.0	7712.0	5287.9	100.0	100.0
25	16309.7	7652.4	5205.2	99.2	98.4
27	16633.2	7630.9	5264.9	98.9	99.6
29	16738.3	7601.3	5272.3	98.5	99.7
31	16838.0	7545.6	5228.1	97.8	98.9
33	16934.1	7494.5	5221.5	97.2	98.7
35	17025.9	7444.6	5173.4	96.5	97.8
37	17114.8	7387.3	5047.5	95.8	95.5
39	17200.6	7382.1	4945.0	95.7	93.5
41	17283.0	7211.3	4713.0	93.5	89.1
43	17363.0	7119.9	4634.7	92.3	87.6

Table F-31. Weighted usable area (WUA) versus discharge relationships for bull trout at Bohannon Creek, Study Site 3.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
1.5	10927.8	1344.3	294.6	40.3	10.7
3	12420.8	1648.0	790.0	49.4	28.8
3.9	13005.9	1744.2	981.2	52.2	35.8
5	13503.4	1973.5	1206.3	59.1	44.0
5.8	13859.4	2164.4	1334.2	64.8	48.7
7	14094.7	2343.8	1577.5	70.2	57.5
9	14348.6	2697.5	1908.6	80.8	69.6
11	14584.7	2917.6	2276.4	87.4	83.0
13	14791.9	3080.1	2528.1	92.2	92.2
15	15010.0	3338.9	2687.4	100.0	98.0
17	15208.1	3297.4	2741.1	98.8	100.0
17.2	15228.6	3290.0	2741.6	98.5	100.0
19	15441.4	3302.5	2703.1	98.9	98.6
21	15615.6	3183.0	2672.3	95.3	97.5
23	15959.0	3067.9	2625.8	91.9	95.8
25	16309.7	3032.0	2577.7	90.8	94.0
27	16633.2	3053.3	2494.8	91.4	91.0
29	16738.3	3041.5	2436.7	91.1	88.9
31	16838.0	3029.0	2368.6	90.7	86.4
33	16934.1	3056.9	2289.6	91.6	83.5
35	17025.9	3072.0	2218.1	92.0	80.9
37	17114.8	3063.1	2116.7	91.7	77.2
39	17200.6	3052.8	2012.4	91.4	73.4
41	17283.0	3020.7	1925.0	90.5	70.2
43	17363.0	3018.5	1835.8	90.4	67.0

Table F-32. Passage criteria assessment for transect 1 (riffle), Bohannon Creek Study Site 3, 2004.

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.4 ft depth	Percent stream width greater than 0.4 ft depth	Contiguous stream width greater than 0.4 ft depth	Percent contiguous stream width greater than 0.4 ft depth
1.5	12.6	0.0	0.0	0.0	0.0
3	15.4	0.0	0.0	0.0	0.0
3.9	16.1	0.0	0.0	0.0	0.0
5	16.9	0.0	0.0	0.0	0.0
5.8	17.1	0.2	1.0	0.2	1.0
7	17.3	0.6	3.7	0.6	3.7
9	17.4	6.6	37.8	3.1	17.8
11	17.5	8.5	48.5	3.6	20.7
13	17.7	12.2	69.2	4.6	26.0
15	17.8	13.6	76.6	5.2	29.4
17	17.9	14.9	83.5	5.8	32.5
17.2	17.9	15.0	84.1	5.9	32.9
19	18.1	15.8	86.9	11.4	62.6
21	18.2	16.4	90.0	11.7	64.4
23	18.3	17.0	92.9	12.1	66.1
25	18.3	17.2	93.7	17.2	93.7
27	18.4	17.3	93.8	17.3	93.8
29	18.5	17.4	94.0	17.4	94.0
31	18.5	17.4	94.1	17.4	94.1
33	18.6	17.5	94.2	17.5	94.2
35	18.6	17.6	94.3	17.6	94.3
37	18.7	17.6	94.4	17.6	94.4
39	18.7	17.7	94.5	17.7	94.5
41	18.8	17.8	94.6	17.8	94.6
43	18.8	17.8	94.7	17.8	94.7
Discharge (cfs)	stream width (ft)	Total stream width greater than 0.6 ft depth	Percent stream width greater than 0.6 ft depth	Contiguous stream width greater than 0.6 ft depth	Percent contiguous stream width greater than 0.6 ft depth
1.5	12.6	0.0	0.0	0.0	0.0
3	15.4	0.0	0.0	0.0	0.0
3.9	16.1	0.0	0.0	0.0	0.0
5	16.9	0.0	0.0	0.0	0.0
5.8	17.1	0.0	0.0	0.0	0.0
7	17.3	0.0	0.0	0.0	0.0
9	17.4	0.0	0.0	0.0	0.0
11	17.5	0.0	0.0	0.0	0.0
13	17.7	0.1	0.4	0.1	0.4
15	17.8	0.6	3.4	0.6	3.4
17	17.9	1.1	6.1	1.1	6.1
17.2	17.9	1.1	6.4	1.1	6.4
19	18.1	7.2	39.6	3.3	18.0
21	18.2	8.5	46.7	3.6	19.9
23	18.3	9.8	53.5	4.0	21.8
25	18.3	12.9	70.1	4.9	26.6
27	18.4	13.9	75.4	5.3	29.0
29	18.5	14.8	80.4	5.8	31.3

31	18.5	15.6	84.1	11.2	60.7
33	18.6	16.1	86.5	11.5	62.1
35	18.6	16.5	88.8	11.8	63.4
37	18.7	17.0	91.0	12.1	64.7
39	18.7	17.2	91.7	17.2	91.7
41	18.8	17.2	91.8	17.2	91.8
43	18.8	17.3	92.0	17.3	92.0
Discharge (cfs)	stream width (ft)	Total stream width greater than 0.8 ft depth	Percent stream width greater than 0.8 ft depth	Contiguous stream width greater than 0.8 ft depth	Percent contiguous stream width greater than 0.8 ft depth
1.5	12.6	0.0	0.0	0.0	0.0
3	15.4	0.0	0.0	0.0	0.0
3.9	16.1	0.0	0.0	0.0	0.0
5	16.9	0.0	0.0	0.0	0.0
5.8	17.1	0.0	0.0	0.0	0.0
7	17.3	0.0	0.0	0.0	0.0
9	17.4	0.0	0.0	0.0	0.0
11	17.5	0.0	0.0	0.0	0.0
13	17.7	0.0	0.0	0.0	0.0
15	17.8	0.0	0.0	0.0	0.0
17	17.9	0.0	0.0	0.0	0.0
17.2	17.9	0.0	0.0	0.0	0.0
19	18.1	0.0	0.0	0.0	0.0
21	18.2	0.0	0.0	0.0	0.0
23	18.3	0.0	0.0	0.0	0.0
25	18.3	0.3	1.7	0.3	1.7
27	18.4	0.7	3.8	0.7	3.8
29	18.5	1.1	5.7	1.1	5.7
31	18.5	6.8	36.5	3.1	17.0
33	18.6	7.8	42.0	3.4	18.5
35	18.6	8.8	47.3	3.7	19.9
37	18.7	9.8	52.4	4.0	21.3
39	18.7	12.6	67.5	4.8	25.5
41	18.8	13.4	71.6	5.1	27.4
43	18.8	14.2	75.6	5.5	29.2

Bohannon Creek, Reach 4 (Study Site 4):

Table F-33. Weighted usable area (WUA) versus discharge relationships for steelhead at Bohannon Creek, Study Site 4.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
0.5	6315.9	571.5	349.6	12.4	10.6
1	7303.4	1095.8	701.5	23.8	21.2
1.4	7869.0	1429.4	985.3	31.1	29.8
1.5	7954.0	1499.2	1047.4	32.6	31.6
1.6	8035.2	1568.8	1104.8	34.1	33.4
2	9055.8	1870.3	1337.2	40.7	40.4
2.5	9568.0	2065.6	1490.7	44.9	45.0
3	10022.1	2317.6	1672.6	50.4	50.5
3.5	10426.1	2558.4	1883.7	55.6	56.9
4	10794.1	2792.4	2039.6	60.7	61.6
4.2	10930.4	2855.7	2096.4	62.1	63.3
4.5	11106.7	2933.9	2203.0	63.8	66.5
5	11346.6	3065.3	2360.5	66.6	71.3
5.5	11563.7	3162.3	2488.7	68.7	75.2
6	11770.4	3237.6	2571.6	70.4	77.7
7	11984.1	3492.4	2829.6	75.9	85.5
9	12186.3	4162.9	3205.0	90.5	96.8
10	12285.8	4367.3	3261.4	94.9	98.5
11	12380.4	4486.4	3284.4	97.5	99.2
12	12469.4	4599.7	3310.8	100.0	100.0

Table F-34. Weighted usable area (WUA) versus discharge relationships for Chinook salmon at Bohannon Creek, Study Site 4.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
0.5	6315.9	571.5	349.6	12.4	10.6
1	7303.4	1095.8	701.5	23.8	21.2
1.4	7869.0	1429.4	985.3	31.1	29.8
1.5	7954.0	1499.2	1047.4	32.6	31.6
1.6	8035.2	1568.8	1104.8	34.1	33.4
2	9055.8	1870.3	1337.2	40.7	40.4
2.5	9568.0	2065.6	1490.7	44.9	45.0
3	10022.1	2317.6	1672.6	50.4	50.5
3.5	10426.1	2558.4	1883.7	55.6	56.9
4	10794.1	2792.4	2039.6	60.7	61.6
4.2	10930.4	2855.7	2096.4	62.1	63.3
4.5	11106.7	2933.9	2203.0	63.8	66.5
5	11346.6	3065.3	2360.5	66.6	71.3
5.5	11563.7	3162.3	2488.7	68.7	75.2
6	11770.4	3237.6	2571.6	70.4	77.7
7	11984.1	3492.4	2829.6	75.9	85.5
9	12186.3	4162.9	3205.0	90.5	96.8
10	12285.8	4367.3	3261.4	94.9	98.5
11	12380.4	4486.4	3284.4	97.5	99.2
12	12469.4	4599.7	3310.8	100.0	100.0

Table F-35. Weighted usable area (WUA) versus discharge relationships for bull trout at Bohannon Creek, Study Site 4.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
0.5	6315.9	112.6	236.0	5.5	22.5
1	7303.4	241.9	306.2	11.9	29.2
1.4	7869.0	285.7	338.7	14.1	32.3
1.5	7954.0	295.6	346.1	14.6	33.0
1.6	8035.2	313.6	352.3	15.5	33.6
2	9055.8	510.7	412.3	25.2	39.4
2.5	9568.0	573.6	453.0	28.3	43.3
3	10022.1	650.2	487.7	32.0	46.6
3.5	10426.1	706.1	610.2	34.8	58.3
4	10794.1	837.8	668.7	41.3	63.9
4.2	10930.4	852.7	682.0	42.0	65.1
4.5	11106.7	880.9	698.2	43.4	66.7
5	11346.6	965.2	749.0	47.6	71.5
5.5	11563.7	978.1	771.1	48.2	73.6
6	11770.4	1022.2	789.4	50.4	75.4
7	11984.1	1419.5	1017.6	70.0	97.2
9	12186.3	1609.0	1047.3	79.3	100.0
10	12285.8	1927.7	1020.6	95.0	97.4
11	12380.4	2028.8	909.4	100.0	86.8
12	12469.4	1932.4	848.2	95.2	81.0

Table F-36. Passage criteria assessment for transect 1 (riffle), Bohannon Creek Study Site 4, 2004.

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.4 ft depth	Percent stream width greater than 0.4 ft depth	Contiguous stream width greater than 0.4 ft depth	Percent contiguous stream width greater than 0.4 ft depth
0.5	8.5	0.0	0.0	0.0	0.0
1	10.4	0.0	0.0	0.0	0.0
1.4	10.6	0.0	0.0	0.0	0.0
1.5	10.6	0.0	0.0	0.0	0.0
1.6	10.7	0.0	0.0	0.0	0.0
2	10.8	0.1	1.0	0.1	1.0
2.5	11.0	0.6	5.6	0.6	5.6
3	11.2	1.1	9.5	1.1	9.5
3.5	11.3	1.5	12.9	1.5	12.9
4	11.4	3.3	28.5	1.8	16.0
4.5	11.5	4.0	35.0	2.2	18.7
5	11.6	4.8	41.0	2.5	21.2
5.5	11.7	5.5	46.4	2.8	23.5
6	11.8	7.4	62.2	7.0	59.4
7	12.0	8.2	68.4	7.5	62.1
9	12.3	9.7	78.8	8.2	66.6
10	12.5	10.4	83.4	10.4	83.4
11	12.7	10.5	83.3	10.5	83.3
12	12.8	10.7	83.2	10.7	83.2

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.6 ft depth	Percent stream width greater than 0.6 ft depth	Contiguous stream width greater than 0.6 ft depth	Percent contiguous stream width greater than 0.6 ft depth
0.5	8.5	0.0	0.0	0.0	0.0
1	10.4	0.0	0.0	0.0	0.0
1.4	10.6	0.0	0.0	0.0	0.0
1.5	10.6	0.0	0.0	0.0	0.0
1.6	10.7	0.0	0.0	0.0	0.0
2	10.8	0.0	0.0	0.0	0.0
2.5	11.0	0.0	0.0	0.0	0.0
3	11.2	0.0	0.0	0.0	0.0
3.5	11.3	0.0	0.0	0.0	0.0
4	11.4	0.0	0.0	0.0	0.0
4.5	11.5	0.0	0.0	0.0	0.0
5	11.6	0.0	0.0	0.0	0.0
5.5	11.7	0.0	0.0	0.0	0.0
6	11.8	0.0	0.4	0.0	0.4
7	12.0	0.6	4.6	0.6	4.6
9	12.3	1.4	11.7	1.4	11.7
10	12.5	3.3	26.5	1.8	14.8
11	12.7	4.2	33.0	2.2	17.5
12	12.8	5.0	39.1	2.6	20.1

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.8 ft depth	Percent stream width greater than 0.8 ft depth	Contiguous stream width greater than 0.8 ft depth	Percent contiguous stream width greater than 0.8 ft depth
0.5	8.5	0.0	0.0	0.0	0.0
1	10.4	0.0	0.0	0.0	0.0
1.4	10.6	0.0	0.0	0.0	0.0
1.5	10.6	0.0	0.0	0.0	0.0
1.6	10.7	0.0	0.0	0.0	0.0
2	10.8	0.0	0.0	0.0	0.0
2.5	11.0	0.0	0.0	0.0	0.0
3	11.2	0.0	0.0	0.0	0.0
3.5	11.3	0.0	0.0	0.0	0.0
4	11.4	0.0	0.0	0.0	0.0
4.5	11.5	0.0	0.0	0.0	0.0
5	11.6	0.0	0.0	0.0	0.0
5.5	11.7	0.0	0.0	0.0	0.0
6	11.8	0.0	0.0	0.0	0.0
7	12.0	0.0	0.0	0.0	0.0
9	12.3	0.0	0.0	0.0	0.0
10	12.5	0.0	0.0	0.0	0.0
11	12.7	0.0	0.0	0.0	0.0
12	12.8	0.0	0.0	0.0	0.0

Bohannon Creek, Reach 5 (Study Site 5, Reference Site):

Table F-37. Weighted usable area (WUA) versus discharge relationships for steelhead at Bohannon Creek, Study Site 5.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
1.5	11010.4	3172.6	1411.3	49.0	48.0
3.5	13321.7	4010.9	1784.6	62.0	60.7
3.7	13436.4	4348.3	1913.9	67.2	65.1
5.5	14100.3	4692.4	2141.8	72.5	72.9
7.5	14641.3	5233.6	2352.2	80.9	80.1
9.5	14972.4	5499.4	2471.5	85.0	84.1
11.5	15291.4	5891.0	2584.4	91.0	88.0
13.5	15662.4	6156.8	2678.9	95.1	91.2
15.5	15938.5	6357.7	2748.2	98.2	93.5
17.4	16272.1	6471.2	2808.6	100.0	95.6
17.5	16280.7	6451.5	2803.3	99.7	95.4
19.5	16520.4	6458.3	2895.0	99.8	98.5
21.5	16756.1	6402.8	2895.2	98.9	98.5
23.5	16981.5	6441.4	2926.8	99.5	99.6
25.5	17195.6	6452.9	2938.3	99.7	100.0
27.5	17454.0	6423.9	2895.8	99.3	98.6
29.5	17698.4	6390.5	2859.1	98.8	97.3
31.5	17918.7	6338.8	2854.1	98.0	97.1
33.5	18079.7	6230.7	2819.7	96.3	96.0
35.5	18232.5	6151.6	2750.2	95.1	93.6
37.5	18378.3	5996.3	2677.2	92.7	91.1
39.5	18519.5	5863.2	2626.2	90.6	89.4
41.5	18662.0	5860.8	2614.5	90.6	89.0
43.5	18809.4	5772.7	2582.4	89.2	87.9

Table F-38. Weighted usable area (WUA) versus discharge relationships for Chinook salmon at Bohannon Creek, Study Site 5.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
1.5	11010.4	3172.6	1411.3	49.0	48.0
3.5	13321.7	4010.9	1784.6	62.0	60.7
3.7	13436.4	4348.3	1913.9	67.2	65.1
5.5	14100.3	4692.4	2141.8	72.5	72.9
7.5	14641.3	5233.6	2352.2	80.9	80.1
9.5	14972.4	5499.4	2471.5	85.0	84.1
11.5	15291.4	5891.0	2584.4	91.0	88.0
13.5	15662.4	6156.8	2678.9	95.1	91.2
15.5	15938.5	6357.7	2748.2	98.2	93.5
17.4	16272.1	6471.2	2808.6	100.0	95.6
17.5	16280.7	6451.5	2803.3	99.7	95.4
19.5	16520.4	6458.3	2895.0	99.8	98.5
21.5	16756.1	6402.8	2895.2	98.9	98.5
23.5	16981.5	6441.4	2926.8	99.5	99.6
25.5	17195.6	6452.9	2938.3	99.7	100.0
27.5	17454.0	6423.9	2895.8	99.3	98.6
29.5	17698.4	6390.5	2859.1	98.8	97.3
31.5	17918.7	6338.8	2854.1	98.0	97.1
33.5	18079.7	6230.7	2819.7	96.3	96.0
35.5	18232.5	6151.6	2750.2	95.1	93.6
37.5	18378.3	5996.3	2677.2	92.7	91.1
39.5	18519.5	5863.2	2626.2	90.6	89.4
41.5	18662.0	5860.8	2614.5	90.6	89.0
43.5	18809.4	5772.7	2582.4	89.2	87.9

Table F-39. Weighted usable area (WUA) versus discharge relationships for bull trout at Bohannon Creek, Study Site 5.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
1.5	11010.4	1345.0	125.6	37.5	15.4
3.5	13321.7	2043.8	203.1	57.0	24.8
3.7	13436.4	2212.0	263.4	61.7	32.2
5.5	14100.3	2337.7	311.3	65.2	38.1
7.5	14641.3	2671.1	387.5	74.5	47.4
9.5	14972.4	2999.6	450.0	83.6	55.0
11.5	15291.4	3198.6	501.6	89.2	61.3
13.5	15662.4	3345.9	548.8	93.3	67.1
15.5	15938.5	3499.3	590.2	97.6	72.2
17.4	16272.1	3586.2	638.5	100.0	78.1
17.5	16280.7	3540.8	636.2	98.7	77.8
19.5	16520.4	3298.5	669.8	92.0	81.9
21.5	16756.1	3149.1	695.4	87.8	85.0
23.5	16981.5	3064.1	712.7	85.4	87.2
25.5	17195.6	2973.6	741.4	82.9	90.7
27.5	17454.0	2945.9	767.9	82.1	93.9
29.5	17698.4	2889.8	790.3	80.6	96.6
31.5	17918.7	2718.4	808.0	75.8	98.8
33.5	18079.7	2567.3	816.5	71.6	99.9
35.5	18232.5	2425.9	817.7	67.6	100.0
37.5	18378.3	2414.4	811.2	67.3	99.2
39.5	18519.5	2395.0	810.0	66.8	99.1
41.5	18662.0	2393.5	801.0	66.7	98.0
43.5	18809.4	2414.5	792.0	67.3	96.9

Table F-40. Passage criteria assessment for transect 1 (riffle), Bohannon Creek Study Site 5, 2004.

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.4 ft depth	Percent stream width greater than 0.4 ft depth	Contiguous stream width greater than 0.4 ft depth	Percent contiguous stream width greater than 0.4 ft depth
1.5	12.4	3.4	27.5	1.6	12.6
3.5	15.2	7.1	46.7	2.8	18.5
3.7	15.4	8.7	56.5	8.7	56.5
5.5	15.4	8.7	56.4	8.7	56.4
7.5	16.2	8.9	54.6	8.9	54.6
9.5	16.3	9.0	55.2	9.0	55.2
11.5	16.3	9.1	55.7	9.1	55.7
13.5	16.4	11.0	67.3	9.4	57.6
15.5	16.4	11.9	72.6	9.7	59.3
17.4	16.5	13.0	79.0	10.1	61.4
17.5	16.5	12.8	77.4	10.0	60.9
19.5	16.5	15.0	90.9	15.0	90.9
21.5	16.5	15.1	91.1	15.1	91.1
23.5	16.6	15.1	91.2	15.1	91.2
25.5	16.6	15.2	91.4	15.2	91.4
27.5	16.6	15.2	91.5	15.2	91.5

29.5	16.7	15.3	91.7	15.3	91.7
31.5	16.7	15.3	91.8	15.3	91.8
33.5	16.7	15.4	91.9	15.4	91.9
35.5	16.7	15.4	92.0	15.4	92.0
37.5	16.8	15.4	92.1	15.4	92.1
39.5	16.8	15.5	92.2	15.5	92.2
41.5	16.8	16.2	96.3	16.2	96.3
43.5	17.0	16.2	95.7	16.2	95.7
Discharge (cfs)	stream width (ft)	Total stream width greater than 0.6 ft depth	Percent stream width greater than 0.6 ft depth	Contiguous stream width greater than 0.6 ft depth	Percent contiguous stream width greater than 0.6 ft depth
1.5	12.4	0.0	0.0	0.0	0.0
3.5	15.2	0.0	0.0	0.0	0.0
3.7	15.4	3.2	20.6	1.5	9.7
5.5	15.4	3.0	19.2	1.5	9.4
7.5	16.2	4.7	29.0	1.9	11.4
9.5	16.3	6.2	37.9	2.4	14.6
11.5	16.3	7.4	45.1	2.9	18.0
13.5	16.4	8.6	52.4	8.6	52.4
15.5	16.4	8.7	52.8	8.7	52.8
17.4	16.5	8.8	53.3	8.8	53.3
17.5	16.5	8.8	53.2	8.8	53.2
19.5	16.5	8.8	53.6	8.8	53.6
21.5	16.5	8.9	53.9	8.9	53.9
23.5	16.6	9.0	54.2	9.0	54.2
25.5	16.6	9.0	54.5	9.0	54.5
27.5	16.6	9.1	54.7	9.1	54.7
29.5	16.7	10.5	63.1	9.3	55.6
31.5	16.7	11.0	66.1	9.4	56.6
33.5	16.7	11.5	69.0	9.6	57.5
35.5	16.7	12.0	71.6	9.8	58.4
37.5	16.8	12.4	74.3	9.9	59.2
39.5	16.8	12.9	76.9	10.1	60.1
41.5	16.8	15.0	89.0	15.0	89.0
43.5	17.0	15.0	88.6	15.0	88.6
Discharge (cfs)	stream width (ft)	Total stream width greater than 0.8 ft depth	Percent stream width greater than 0.8 ft depth	Contiguous stream width greater than 0.8 ft depth	Percent contiguous stream width greater than 0.8 ft depth
1.5	12.4	0.0	0.0	0.0	0.0
3.5	15.2	0.0	0.0	0.0	0.0
3.7	15.4	0.0	0.0	0.0	0.0
5.5	15.4	0.0	0.0	0.0	0.0
7.5	16.2	0.0	0.0	0.0	0.0
9.5	16.3	0.0	0.0	0.0	0.0
11.5	16.3	0.0	0.0	0.0	0.0
13.5	16.4	2.0	12.0	1.2	7.5
15.5	16.4	2.9	17.8	1.4	8.8
17.4	16.5	4.1	24.8	1.7	10.4
17.5	16.5	3.8	23.0	1.6	10.0
19.5	16.5	4.6	27.9	1.8	11.1
21.5	16.5	5.4	32.4	2.0	12.1
23.5	16.6	6.1	36.6	2.3	14.1

25.5	16.6	6.7	40.5	2.6	15.9
27.5	16.6	7.3	44.1	2.9	17.6
29.5	16.7	8.5	51.3	8.5	51.3
31.5	16.7	8.6	51.5	8.6	51.5
33.5	16.7	8.6	51.7	8.6	51.7
35.5	16.7	8.7	51.9	8.7	51.9
37.5	16.8	8.7	52.1	8.7	52.1
39.5	16.8	8.8	52.3	8.8	52.3
41.5	16.8	8.8	52.4	8.8	52.4
43.5	17.0	8.9	52.3	8.9	52.3

Hayden Creek, Reach 1 (Study Site 1):

Table F-41. Weighted usable area (WUA) versus discharge relationships for steelhead at Hayden Creek, Study Site 1.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
9	27968.3	12839.4	49.4	65.5	4.0
20	30469.7	16463.1	53.4	84.0	4.4
23.3	30815.6	17073.4	53.4	87.1	4.4
30	31602.1	18053.3	216.9	92.1	17.8
40	32425.7	19021.0	330.8	97.0	27.1
50	33038.0	19488.2	535.0	99.4	43.9
60	33475.2	19602.3	645.0	100.0	52.9
69.2	33700.5	19445.0	692.7	99.2	56.8
70	33733.9	19474.8	693.7	99.3	56.9
80	33961.1	19561.0	742.7	99.8	60.9
90	34168.9	19495.4	788.2	99.5	64.6
100	34355.5	19296.0	942.5	98.4	77.3
110	34512.3	18937.1	1059.0	96.6	86.8
120	35198.8	18448.0	1121.7	94.1	92.0
127.7	35375.2	17753.0	1158.1	90.6	95.0
130	35437.7	17505.0	1163.5	89.3	95.4
140	35724.4	15881.2	1188.2	81.0	97.4
150	35981.2	13982.1	1207.4	71.3	99.0
160	36194.1	12588.8	1212.3	64.2	99.4
170	36391.8	11341.0	1212.9	57.9	99.5
180	36581.0	10292.9	1195.2	52.5	98.0
190	36744.7	9912.0	1203.6	50.6	98.7
200	36898.9	9578.3	1208.5	48.9	99.1
210	37047.6	9053.5	1209.4	46.2	99.2
220	37191.2	8774.0	1219.5	44.8	100.0

Table F-42. Weighted usable area (WUA) versus discharge relationships for Chinook salmon at Hayden Creek, Study Site 1.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
9	27968.3	12839.4	49.4	65.5	4.0
20	30469.7	16463.1	53.4	84.0	4.4
23.3	30815.6	17073.4	53.4	87.1	4.4
30	31602.1	18053.3	216.9	92.1	17.8
40	32425.7	19021.0	330.8	97.0	27.1
50	33038.0	19488.2	535.0	99.4	43.9
60	33475.2	19602.3	645.0	100.0	52.9
69.2	33700.5	19445.0	692.7	99.2	56.8
70	33733.9	19474.8	693.7	99.3	56.9
80	33961.1	19561.0	742.7	99.8	60.9
90	34168.9	19495.4	788.2	99.5	64.6
100	34355.5	19296.0	942.5	98.4	77.3
110	34512.3	18937.1	1059.0	96.6	86.8
120	35198.8	18448.0	1121.7	94.1	92.0
127.7	35375.2	17753.0	1158.1	90.6	95.0
130	35437.7	17505.0	1163.5	89.3	95.4
140	35724.4	15881.2	1188.2	81.0	97.4
150	35981.2	13982.1	1207.4	71.3	99.0
160	36194.1	12588.8	1212.3	64.2	99.4
170	36391.8	11341.0	1212.9	57.9	99.5
180	36581.0	10292.9	1195.2	52.5	98.0
190	36744.7	9912.0	1203.6	50.6	98.7
200	36898.9	9578.3	1208.5	48.9	99.1
210	37047.6	9053.5	1209.4	46.2	99.2
220	37191.2	8774.0	1219.5	44.8	100.0

Table F-43. Weighted usable area (WUA) versus discharge relationships for bull trout at Hayden Creek, Study Site 1.

	WUA (ft²)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
9	27968.3	10108.8	0.0	68.3	0.0
20	30469.7	13123.8	0.0	88.7	0.0
23.3	30815.6	14078.7	0.0	95.1	0.0
30	31602.1	14688.4	0.0	99.3	0.0
40	32425.7	14798.0	0.0	100.0	0.0
50	33038.0	14029.7	0.0	94.8	0.0
60	33475.2	12669.4	0.0	85.6	0.0
69.2	33700.5	10502.8	0.0	71.0	0.0
70	33733.9	10358.1	0.0	70.0	0.0
80	33961.1	9964.4	0.0	67.3	0.0
90	34168.9	9553.7	0.0	64.6	0.0
100	34355.5	8847.6	0.0	59.8	0.0
110	34512.3	8605.8	0.0	58.2	0.0
120	35198.8	8272.1	0.0	55.9	0.0
127.7	35375.2	7762.3	0.0	52.5	0.0
130	35437.7	7490.0	0.0	50.6	0.0
140	35724.4	7242.5	0.0	48.9	0.0
150	35981.2	7062.5	3.0	47.7	43.9
160	36194.1	6785.6	4.1	45.9	60.5
170	36391.8	6719.3	4.8	45.4	70.9
180	36581.0	6591.5	5.4	44.5	78.8
190	36744.7	6368.4	5.8	43.0	85.4
200	36898.9	6111.1	6.2	41.3	90.8
210	37047.6	5855.0	6.5	39.6	95.6
220	37191.2	5860.7	6.8	39.6	100.0

Table F-44. Passage criteria assessment for transect 2 (riffle), Hayden Creek Study Site 1, 2004.

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.4 ft depth	Percent stream width greater than 0.4 ft depth	Contiguous stream width greater than 0.4 ft depth	Percent contiguous stream width greater than 0.4 ft depth
9	31.5	17.9	56.8	8.1	25.8
20	33.0	29.1	88.2	15.7	47.5
23.3	33.1	29.9	90.3	15.9	47.9
30	33.7	30.7	90.9	16.2	48.2
40	34.4	31.6	91.7	16.7	48.4
50	35.0	32.3	92.3	17.0	48.6
60	35.4	32.9	92.8	32.9	92.8
69.2	35.5	33.0	93.0	33.0	93.0
70	35.5	33.0	93.0	33.0	93.0
80	35.6	33.3	93.5	33.2	93.1
90	35.7	33.7	94.3	33.3	93.3
100	35.8	34.0	95.0	33.5	93.4
110	35.9	34.4	95.7	33.6	93.6
120	37.0	34.7	93.7	33.7	91.1
127.7	37.1	34.9	93.9	33.8	91.0

130	37.2	34.9	94.0	33.8	91.0
140	37.3	35.2	94.3	33.9	90.8
150	37.5	35.4	94.4	35.4	94.4
160	37.7	35.5	94.2	35.5	94.2
170	37.8	35.5	94.0	35.5	94.0
180	37.9	35.6	93.8	35.6	93.8
190	38.1	35.6	93.6	35.6	93.6
200	38.2	35.7	93.5	35.7	93.5
210	38.3	35.8	93.3	35.8	93.3
220	38.4	35.8	93.1	35.8	93.1
Discharge (cfs)	stream width (ft)	Total stream width greater than 0.6 ft depth	Percent stream width greater than 0.6 ft depth	Contiguous stream width greater than 0.6 ft depth	Percent contiguous stream width greater than 0.6 ft depth
9	31.5	9.8	31.2	6.1	19.4
20	33.0	17.8	53.8	8.1	24.5
23.3	33.1	23.4	70.6	14.9	45.1
30	33.7	26.9	79.8	15.3	45.4
40	34.4	29.3	85.2	15.7	45.7
50	35.0	30.4	86.7	16.1	46.0
60	35.4	31.0	87.5	16.4	46.3
69.2	35.5	31.5	88.8	16.7	46.9
70	35.5	31.6	88.9	16.7	46.9
80	35.6	32.1	90.1	16.9	47.5
90	35.7	32.6	91.2	17.2	48.0
100	35.8	32.9	91.8	32.9	91.8
110	35.9	33.0	91.9	33.0	91.9
120	37.0	33.1	89.6	33.1	89.5
127.7	37.1	33.4	89.8	33.2	89.4
130	37.2	33.4	89.9	33.2	89.4
140	37.3	33.7	90.2	33.3	89.3
150	37.5	33.9	90.5	33.4	89.2
160	37.7	34.2	90.8	33.5	89.0
170	37.8	34.4	91.0	33.6	88.9
180	37.9	34.6	91.3	33.7	88.8
190	38.1	34.8	91.5	33.8	88.7
200	38.2	35.1	91.8	33.9	88.6
210	38.3	35.3	92.0	33.9	88.6
220	38.4	35.4	92.1	35.4	92.1
Discharge (cfs)	stream width (ft)	Total stream width greater than 0.8 ft depth	Percent stream width greater than 0.8 ft depth	Contiguous stream width greater than 0.8 ft depth	Percent contiguous stream width greater than 0.8 ft depth
9	31.5	0.0	0.0	0.0	0.0
20	33.0	9.6	29.1	6.0	18.2
23.3	33.1	11.8	35.5	7.0	21.2
30	33.7	14.6	43.4	7.5	22.3
40	34.4	18.1	52.7	8.2	23.7
50	35.0	25.5	72.8	15.2	43.3
60	35.4	28.2	79.6	15.5	43.7
69.2	35.5	29.3	82.4	15.7	44.3
70	35.5	29.4	82.6	15.7	44.3
80	35.6	30.2	84.6	16.0	44.9
90	35.7	30.6	85.7	16.2	45.4

100	35.8	31.1	86.7	16.4	45.9
110	35.9	31.5	87.7	16.6	46.3
120	37.0	31.9	86.1	16.8	45.5
127.7	37.1	32.2	86.6	17.0	45.6
130	37.2	32.2	86.7	17.0	45.7
140	37.3	32.6	87.2	17.2	45.9
150	37.5	32.9	87.6	32.9	87.6
160	37.7	32.9	87.5	32.9	87.5
170	37.8	33.0	87.4	33.0	87.4
180	37.9	33.1	87.3	33.1	87.3
190	38.1	33.3	87.5	33.2	87.2
200	38.2	33.5	87.8	33.3	87.1
210	38.3	33.7	88.0	33.4	87.0
220	38.4	33.9	88.2	33.4	87.0

Hayden Creek, Reach 2 (Study Site 2):

Table F-45. Weighted usable area (WUA) versus discharge relationships for steelhead at Hayden Creek, Study Site 2.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
15	35053.6	16362.0	6236.8	60.0	39.4
30	40730.3	19647.5	7802.4	72.0	49.3
36.9	42449.8	21173.5	8130.0	77.6	51.3
40	43180.0	21650.3	8322.1	79.4	52.6
45	44030.8	22221.8	8637.6	81.5	54.5
50	45573.9	22814.8	9221.1	83.7	58.2
55	46832.9	23433.2	9877.4	85.9	62.4
60	47814.4	23894.5	10385.2	87.6	65.6
65	48718.4	24328.7	10876.8	89.2	68.7
70	49528.9	24823.5	11268.8	91.0	71.2
75	50192.7	25094.7	11583.3	92.0	73.1
80	51044.5	25740.6	11759.7	94.4	74.3
85	51683.2	25947.7	11859.1	95.1	74.9
90	52926.3	26041.1	11949.8	95.5	75.5
92.2	53873.1	26145.7	12019.1	95.9	75.9
95	54246.1	26200.9	12125.0	96.1	76.6
100	54985.8	26441.3	12226.2	97.0	77.2
105	55685.2	26676.8	12310.3	97.8	77.7
110	57455.6	26907.1	12343.3	98.7	77.9
115	58088.8	26949.9	12422.7	98.8	78.4
125	59203.8	27272.2	12539.9	100.0	79.2
130	59694.5	27122.3	12458.2	99.5	78.7
135	60164.8	26879.7	12482.3	98.6	78.8
140	60550.9	26791.8	13306.9	98.2	84.0
145	60948.2	26646.9	14258.3	97.7	90.0
150	61377.0	26633.5	14915.6	97.7	94.2
155	61710.6	26471.6	15295.0	97.1	96.6
160	62231.9	26259.0	15707.2	96.3	99.2
165	62555.6	26101.7	15835.7	95.7	100.0

Table F-46. Weighted usable area (WUA) versus discharge relationships for Chinook salmon at Hayden Creek, Study Site 2.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
15	35053.6	16362.0	6236.8	60.0	39.4
30	40730.3	19647.5	7802.4	72.0	49.3
36.9	42449.8	21173.5	8130.0	77.6	51.3
40	43180.0	21650.3	8322.1	79.4	52.6
45	44030.8	22221.8	8637.6	81.5	54.5
50	45573.9	22814.8	9221.1	83.7	58.2
55	46832.9	23433.2	9877.4	85.9	62.4
60	47814.4	23894.5	10385.2	87.6	65.6
65	48718.4	24328.7	10876.8	89.2	68.7
70	49528.9	24823.5	11268.8	91.0	71.2
75	50192.7	25094.7	11583.3	92.0	73.1
80	51044.5	25740.6	11759.7	94.4	74.3
85	51683.2	25947.7	11859.1	95.1	74.9
90	52926.3	26041.1	11949.8	95.5	75.5
92.2	53873.1	26145.7	12019.1	95.9	75.9
95	54246.1	26200.9	12125.0	96.1	76.6
100	54985.8	26441.3	12226.2	97.0	77.2
105	55685.2	26676.8	12310.3	97.8	77.7
110	57455.6	26907.1	12343.3	98.7	77.9
115	58088.8	26949.9	12422.7	98.8	78.4
125	59203.8	27272.2	12539.9	100.0	79.2
130	59694.5	27122.3	12458.2	99.5	78.7
135	60164.8	26879.7	12482.3	98.6	78.8
140	60550.9	26791.8	13306.9	98.2	84.0
145	60948.2	26646.9	14258.3	97.7	90.0
150	61377.0	26633.5	14915.6	97.7	94.2
155	61710.6	26471.6	15295.0	97.1	96.6
160	62231.9	26259.0	15707.2	96.3	99.2
165	62555.6	26101.7	15835.7	95.7	100.0

Table F-47. Weighted usable area (WUA) versus discharge relationships for bull trout at Hayden Creek, Study Site 2.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
15	35053.6	13660.6	1414.3	72.2	33.4
30	40730.3	16190.5	2230.9	85.5	52.6
36.9	42449.8	17593.1	2526.8	92.9	59.6
40	43180.0	17781.1	2636.8	93.9	62.2
45	44030.8	18159.2	2799.2	95.9	66.1
50	45573.9	18690.1	3044.6	98.7	71.8
55	46832.9	18891.8	3244.5	99.8	76.6
60	47814.4	18932.2	3458.6	100.0	81.6
65	48718.4	18794.7	3730.3	99.3	88.0
70	49528.9	18520.9	3941.4	97.8	93.0
75	50192.7	18091.0	4120.0	95.6	97.2
80	51044.5	18003.0	4189.5	95.1	98.9
85	51683.2	17606.8	4179.8	93.0	98.6
90	52926.3	17303.7	4207.5	91.4	99.3
92.2	53873.1	16910.3	4227.5	89.3	99.8
95	54246.1	16783.9	4237.5	88.7	100.0
100	54985.8	16299.0	4234.6	86.1	99.9
105	55685.2	16368.6	4182.3	86.5	98.7
110	57455.6	16182.2	4131.0	85.5	97.5
115	58088.8	15848.5	4085.6	83.7	96.4
125	59203.8	15408.4	3966.0	81.4	93.6
130	59694.5	14750.3	3927.7	77.9	92.7
135	60164.8	14218.4	3846.9	75.1	90.8
140	60550.9	13983.5	3761.8	73.9	88.8
145	60948.2	13432.5	3655.6	71.0	86.3
150	61377.0	12829.4	3467.0	67.8	81.8
155	61710.6	12370.4	3372.2	65.3	79.6
160	62231.9	11957.9	3410.2	63.2	80.5
165	62555.6	11575.4	3375.7	61.1	79.7

Table F-48. Passage criteria assessment for transect 4 (riffle), Hayden Creek Study Site 2, 2004.

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.4 ft depth	Percent stream width greater than 0.4 ft depth	Contiguous stream width greater than 0.4 ft depth	Percent contiguous stream width greater than 0.4 ft depth
15	49.2	30.5	62.0	23.3	47.4
30	68.8	33.1	48.0	33.1	48.0
37	73.2	33.7	46.0	33.7	46.0
45	76.6	37.4	48.9	34.4	44.9
60	80.6	44.0	54.6	35.4	43.9
75	81.4	50.2	61.8	36.2	44.5
90	82.0	55.2	67.3	37.0	45.1
92	82.1	55.9	68.1	37.1	45.1
105	82.8	65.6	79.3	43.7	52.8
120	83.8	69.4	82.8	45.0	53.7
135	84.7	72.8	86.0	46.2	54.5
150	85.7	75.3	87.9	47.2	55.1
165	86.6	77.6	89.5	48.2	55.7
Discharge (cfs)	stream width (ft)	Total stream width greater than 0.6 ft depth	Percent stream width greater than 0.6 ft depth	Contiguous stream width greater than 0.6 ft depth	Percent contiguous stream width greater than 0.6 ft depth
15	49.2	19.6	39.8	14.8	30.1
30	68.8	28.8	41.9	22.7	33.0
37	73.2	30.9	42.2	23.5	32.0
45	76.6	31.8	41.5	31.8	41.5
60	80.6	32.9	40.8	32.9	40.8
75	81.4	33.7	41.5	33.7	41.5
90	82.0	37.8	46.1	34.5	42.0
92	82.1	38.4	46.8	34.6	42.1
105	82.8	41.6	50.3	35.1	42.4
120	83.8	45.8	54.7	35.6	42.6
135	84.7	49.7	58.7	36.2	42.7
150	85.7	53.0	61.8	36.6	42.8
165	86.6	56.0	64.7	37.1	42.8
Discharge (cfs)	stream width (ft)	Total stream width greater than 0.8 ft depth	Percent stream width greater than 0.8 ft depth	Contiguous stream width greater than 0.8 ft depth	Percent contiguous stream width greater than 0.8 ft depth
15	49.2	5.1	10.4	5.1	10.4
30	68.8	16.6	24.1	14.0	20.4
37	73.2	20.4	27.8	15.0	20.4
45	76.6	25.0	32.7	21.3	27.8
60	80.6	28.3	35.1	22.5	27.9
75	81.4	31.0	38.1	23.5	28.9
90	82.0	31.8	38.8	31.8	38.8
92	82.1	32.0	38.9	32.0	38.9
105	82.8	32.6	39.4	32.6	39.4
120	83.8	33.1	39.6	33.1	39.6
135	84.7	33.7	39.7	33.7	39.7
150	85.7	36.0	42.0	34.1	39.8
165	86.6	38.5	44.4	34.6	39.9

Hayden Creek, Reach 3 (Study Site 3):

Table F-49. Weighted usable area (WUA) versus discharge relationships for steelhead at Hayden Creek, Study Site 3.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
15	22100.9	10684.6	1840.2	66.4	46.2
20	24244.4	11508.7	2042.4	71.5	51.2
25	25152.1	12486.0	2266.6	77.6	56.9
30	25707.8	13310.2	2536.6	82.7	63.6
35	26318.8	13982.1	2819.9	86.8	70.8
37.5	26710.8	14415.7	2950.7	89.5	74.0
40	26979.6	14522.5	3007.4	90.2	75.5
45	27375.7	14850.9	3120.6	92.2	78.3
50	27687.5	15241.2	3321.3	94.7	83.3
55	27858.4	15504.5	3454.5	96.3	86.7
60	28003.7	15813.4	3555.4	98.2	89.2
65	28257.7	15955.7	3608.1	99.1	90.5
70	28517.6	16069.7	3733.1	99.8	93.7
75	28784.9	16100.1	3785.6	100.0	95.0
80	29040.5	16041.6	3859.0	99.6	96.8
85	29276.2	15968.7	3963.1	99.2	99.4
90	29488.9	15818.5	3985.4	98.3	100.0
95	29724.7	15634.1	3981.3	97.1	99.9
100	30543.9	15375.5	3856.3	95.5	96.8
101.2	30608.5	15311.7	3813.5	95.1	95.7
120	31530.1	14764.7	3692.0	91.7	92.6
140	32051.9	13327.2	3839.7	82.8	96.3
160	32531.2	12184.5	3604.6	75.7	90.4
180	32968.1	10983.4	3625.6	68.2	91.0
184.5	33117.6	11056.7	3671.4	68.7	92.1
200	33309.3	10592.8	3523.8	65.8	88.4
220	33638.2	10603.5	3534.6	65.9	88.7

Table F-50. Weighted usable area (WUA) versus discharge relationships for Chinook salmon at Hayden Creek, Study Site 3.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
15	22100.9	10684.6	1840.2	66.4	46.2
20	24244.4	11508.7	2042.4	71.5	51.2
25	25152.1	12486.0	2266.6	77.6	56.9
30	25707.8	13310.2	2536.6	82.7	63.6
35	26318.8	13982.1	2819.9	86.8	70.8
37.5	26710.8	14415.7	2950.7	89.5	74.0
40	26979.6	14522.5	3007.4	90.2	75.5
45	27375.7	14850.9	3120.6	92.2	78.3
50	27687.5	15241.2	3321.3	94.7	83.3
55	27858.4	15504.5	3454.5	96.3	86.7
60	28003.7	15813.4	3555.4	98.2	89.2
65	28257.7	15955.7	3608.1	99.1	90.5
70	28517.6	16069.7	3733.1	99.8	93.7
75	28784.9	16100.1	3785.6	100.0	95.0
80	29040.5	16041.6	3859.0	99.6	96.8
85	29276.2	15968.7	3963.1	99.2	99.4
90	29488.9	15818.5	3985.4	98.3	100.0
95	29724.7	15634.1	3981.3	97.1	99.9
100	30543.9	15375.5	3856.3	95.5	96.8
101.2	30608.5	15311.7	3813.5	95.1	95.7
120	31530.1	14764.7	3692.0	91.7	92.6
140	32051.9	13327.2	3839.7	82.8	96.3
160	32531.2	12184.5	3604.6	75.7	90.4
180	32968.1	10983.4	3625.6	68.2	91.0
184.5	33117.6	11056.7	3671.4	68.7	92.1
200	33309.3	10592.8	3523.8	65.8	88.4
220	33638.2	10603.5	3534.6	65.9	88.7

Table F-51. Weighted usable area (WUA) versus discharge relationships for bull trout at Hayden Creek, Study Site 3.

	WUA (ft^2)/1,000 ft			Percent of optimal habitat	
Discharge	Total Area	Adult	Spawning	Adult	Spawning
15	22100.9	9893.2	0.0	80.4	0.0
20	24244.4	10386.5	0.0	84.4	0.0
25	25152.1	10714.9	44.7	87.1	3.0
30	25707.8	11131.2	110.9	90.5	7.4
35	26318.8	11761.1	156.8	95.6	10.5
37.5	26710.8	12148.0	181.4	98.7	12.1
40	26979.6	12130.5	201.6	98.6	13.5
45	27375.7	12305.6	257.3	100.0	17.2
50	27687.5	12193.3	310.3	99.1	20.7
55	27858.4	11933.1	385.1	97.0	25.7
60	28003.7	11658.8	433.2	94.7	28.9
65	28257.7	11597.7	471.1	94.2	31.5
70	28517.6	11270.0	490.2	91.6	32.7
75	28784.9	10988.8	498.8	89.3	33.3
80	29040.5	10604.0	506.1	86.2	33.8
85	29276.2	10275.9	513.8	83.5	34.3
90	29488.9	10038.3	529.8	81.6	35.4
95	29724.7	9594.1	541.8	78.0	36.2
100	30543.9	9380.3	555.8	76.2	37.1
101.2	30608.5	9136.0	593.5	74.2	39.6
120	31530.1	8703.3	747.9	70.7	49.9
140	32051.9	8345.9	937.0	67.8	62.6
160	32531.2	8299.2	1014.1	67.4	67.7
180	32968.1	7929.4	1166.5	64.4	77.9
184.5	33117.6	8243.0	1211.5	67.0	80.9
200	33309.3	8252.6	1325.7	67.1	88.5
220	33638.2	8592.5	1497.3	69.8	100.0

Table F-52. Passage criteria assessment for transect 1 (riffle), Hayden Creek Study Site 3, 2004.

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.4 ft depth	Percent stream width greater than 0.4 ft depth	Contiguous stream width greater than 0.4 ft depth	Percent contiguous stream width greater than 0.4 ft depth
15	28.0	17.1	61.0	17.1	61.0
20	33.2	19.1	57.4	19.1	57.4
37.5	35.9	23.1	64.4	21.7	60.5
40	36.4	23.8	65.4	21.9	60.3
60	37.2	33.3	89.6	33.3	89.6
80	37.7	34.3	90.9	34.3	90.9
100	38.2	36.3	95.0	35.1	92.0
101.2	38.2	36.4	95.3	35.2	92.1
120	38.5	36.8	95.7	36.8	95.7
140	38.8	37.2	95.8	37.2	95.8
160	39.0	37.5	96.0	37.5	96.0
180	39.3	37.8	96.2	37.8	96.2
184.5	39.3	37.8	96.2	37.8	96.2
200	39.5	38.0	96.2	38.0	96.2

220	39.8	38.2	96.1	38.2	96.1

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.6 ft depth	Percent stream width greater than 0.6 ft depth	Contiguous stream width greater than 0.6 ft depth	Percent contiguous stream width greater than 0.6 ft depth
15	28.0	12.6	73.6	12.6	73.6
20	33.2	14.6	76.5	14.6	76.5
37.5	35.9	19.5	84.6	19.5	84.6
40	36.4	20.1	84.4	20.1	84.4
60	37.2	22.8	68.3	21.6	64.9
80	37.7	29.8	86.8	22.7	66.2
100	38.2	33.5	92.5	33.5	92.5
101.2	38.2	33.6	92.3	33.6	92.3
120	38.5	34.2	93.0	34.2	93.0
140	38.8	35.6	95.7	34.9	93.8
160	39.0	36.6	97.7	36.6	97.7
180	39.3	36.9	97.7	36.9	97.7
184.5	39.3	37.0	97.7	37.0	97.7
200	39.5	37.1	97.8	37.1	97.8
220	39.8	37.4	97.8	37.4	97.8

Discharge (cfs)	stream width (ft)	Total stream width greater than 0.8 ft depth	Percent stream width greater than 0.8 ft depth	Contiguous stream width greater than 0.8 ft depth	Percent contiguous stream width greater than 0.8 ft depth
15	28.0	8.1	47.2	8.1	47.2
20	33.2	10.1	52.9	10.1	52.9
37.5	35.9	15.1	65.2	15.1	65.2
40	36.4	15.6	65.6	15.6	65.6
60	37.2	19.3	57.9	19.3	57.9
80	37.7	21.0	61.1	21.0	61.1
100	38.2	23.6	65.2	21.9	60.3
101.2	38.2	23.8	65.4	21.9	60.3
120	38.5	29.3	79.6	22.7	61.5
140	38.8	33.3	89.6	33.3	89.6
160	39.0	33.8	90.3	33.8	90.3
180	39.3	34.3	91.0	34.3	91.0
184.5	39.3	34.5	91.3	34.5	91.1
200	39.5	35.5	93.3	34.8	91.6
220	39.8	36.5	95.6	36.5	95.6

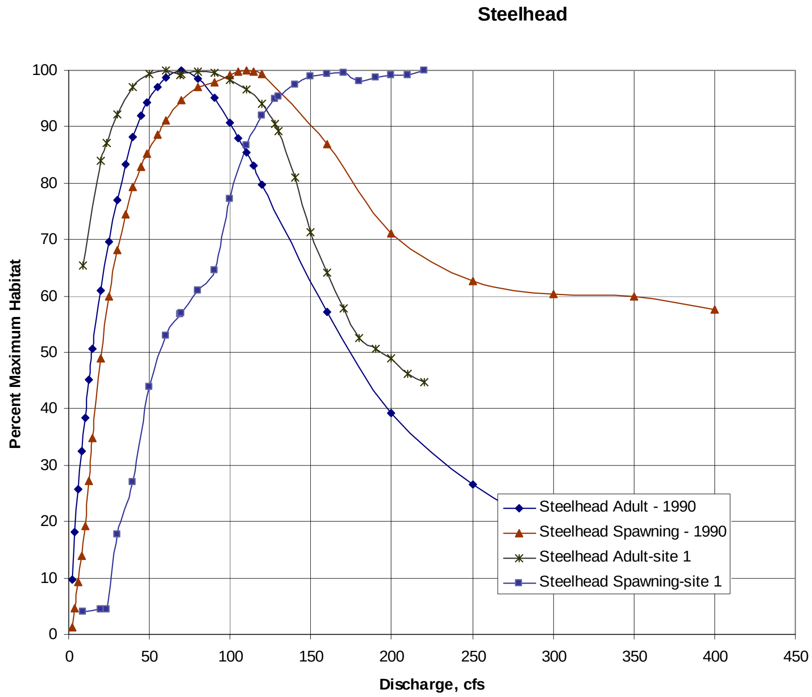


Figure F-1. Habitat versus flow relationships for steelhead in Hayden Creek comparing EA Engineering study (below Basin Creek confluence) and Reclamation's study (2004–Study Site 1)

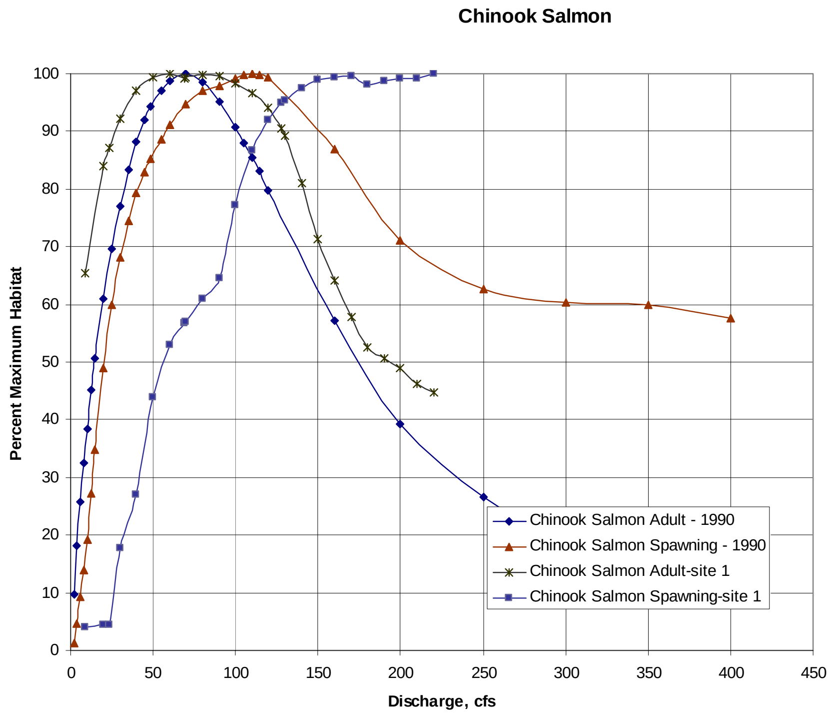


Figure F-2. Habitat versus flow relationships for Chinook Salmon in Hayden Creek comparing EA Engineering study (below Basin Creek confluence) and Reclamation's study (2004 – Study Site 1).

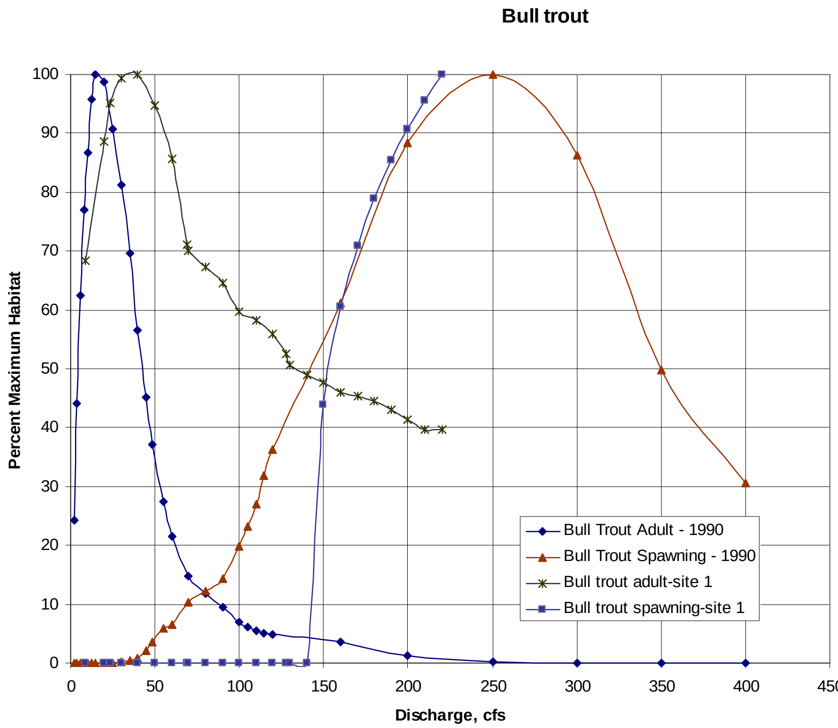


Figure F-3. Habitat versus flow relationships for bull trout in Hayden Creek comparing EA Engineering study (below Basin Creek confluence) and Reclamation's study (2004 – Study Site 1).