Wallowa Falls Hydroelectric Project
FERC Project No. P-308
Updated Study Report
(Final Technical Report)

Instream Flow

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1.0 INTRODUCTION

PacifiCorp is in the process of relicensing the Wallowa Falls Hydroelectric Project (Project), in accordance with the Federal Energy Regulatory Commission's (FERC's) Integrated Licensing Process (ILP). During the application process, PacifiCorp identified a range of minimum flow releases from the Wallowa Falls diversion dam to be considered for the protection of habitat utilized by bull trout and kokanee in the Project's bypass reach. The current FERC license contains a provision for a minimum flow release of 0.5 cfs. A proposal to conduct a study that utilized the Instream Flow Incremental Methodology (IFIM) was developed and filed with FERC in the Revised Study Plans (PacifiCorp, 2011). IFIM provides a framework of data collection and modeling tools for water resources decision-making related to instream flow needs (Milhouse, Updike, & Schneider, 1989). The principal IFIM tool used for this study was the Physical Habitat Simulation System (PHABSIM), which is a data collection and modeling system used to simulate the relationship between stream flow and physical habitat for particular life stages of the species under study (Milhous & Waddle, 2012). This technical report describes the results of the Wallowa Falls IFIM Study, performed by PacifiCorp in 2012 and 2013.

2.0 BACKGROUND

2.1 DESCRIPTION OF PROJECT AREA AND STUDY AREA

The Project is located in Wallowa County, Oregon, approximately six miles south of the city of Joseph. The Project diverts water from the East Fork Wallowa River and from Royal Purple Creek to the West Fork Wallowa River. The Wallowa Falls diversion dam is located on the East Fork Wallowa River, approximately 1.7 miles upstream of the mouth. The dam creates a forebay with a surface area of about 0.25 acres. A small weir on Royal Purple Creek diverts up to 1 cfs into the forebay. An intake at the Wallowa Falls dam conveys up to 16 cfs from the forebay to the Wallowa Falls powerhouse via a pipeline, or penstock. The powerhouse tailrace discharges to the West Fork Wallowa River. As a result, the flows diverted from the dam to the powerhouse bypass the lower 1.7-mile reach of the East Fork Wallowa River (referred to below as the East Fork bypass reach). A general map of the Project area is provided in Figure 1, which features natural watercourses and the East Fork bypass reach.

Local topography divides the East Fork bypass reach into distinct lower and upper segments. The lower segment of the bypass reach (also termed the "lower bypass reach") is approximately 4,100 feet long and has an average slope between six and seven percent. Substrate is comprised chiefly of cobble and boulder. The predominant mesohabitat types include sequences of steep riffles and rapids. Individual pools are present in the lower bypass reach, but they are infrequent (approximately ten percent of the total habitat). The upper segment of the bypass reach (also termed the "upper bypass reach") is approximately 4,500 feet long and has an average slope between nineteen and twenty percent. Steep cascades with turbulent flow over boulders and bedrock chutes characterize the upper segment. The two segments are divided by Wallowa Falls, an impassable fish barrier. The PHABSIM study area (also termed the "study reach") was located within the lowest 1,500 feet of the lower bypass reach. Figure 1 highlights the study area within the larger context of the Project location. Habitat details specific to the study reach are described in the Results (Section 4.0).

2.2 Water Use and Availability

The Project is operated as a run-of-river generating plant due to the limited storage capacity of the small forebay. Because the Project operates in a run-of-river mode, PacifiCorp must reduce generation diversions any time inflows to the forebay are less than 16.8 cfs, which includes:

- 15 cfs, the Project's state-authorized water right from the East Fork Wallowa River;
- 1 cfs, the Project's state-authorized water right from Royal Purple Creek;
- 0.5 cfs, the current FERC-mandated minimum flow for the bypass reach, released at the dam; and
- 0.3 cfs, an additional discharge PacifiCorp elects to release at the dam to insure continuous compliance with the existing minimum flow provision.

To provide minimum flows in the bypass reach, water from the forebay is passed through the low-level outlet, a 24-inch pipe in the dam. The minimum flow is met via a nipple permanently installed in the low-level outlet headgate. Most of the year, 0.8 cfs (the FERC-mandated minimum of 0.5 cfs, plus the elective flow of 0.3 cfs) is passed through the low-level outlet. During the winter months, however, ice development on the low-level outlet may periodically impair flow releases. Accordingly, actual flows during the coldest months of the year may range from 0.5 cfs to 0.8 cfs. When inflows to the forebay exceed the 16.8 cfs threshold, the excess water is spilled over the top of the dam into the bypass reach. The spill period typically begins in May, and ends sometime between late-August and mid-September.

A historical record of daily average flows in the bypass reach is available from WY 1925 to WY 1983, and includes 50 complete water years of mean daily flows (abandoned USGS station number 13325000, Oregon Water Resources Department, 2013). The average flow in the bypass reach during the period of record is 15 cfs. The historical record indicates that flows in the bypass reach have ranged from a minimum of 0.66 cfs to a maximum of 130 cfs. Flows are lowest in March, and peak in June. Additional hydrology information is provided in the Results (Section 4.0).

Royal Purple Creek enters the bypass reach approximately 400 feet below Wallowa Falls diversion dam. Flow contributions to the bypass reach from Royal Purple Creek are negligible most of the year, except during the spring thaw period. Several intermittent and ephemeral water courses also contribute runoff flows to the bypass reach during spring thaw. During periods of baseflow, the major water source for bypassed flows is from contributions upstream of the project. Groundwater contributions to bypass flows have not yet been fully quantified, but groundwater appears to be a minor source. See the Water Resources Study Progress Report

(Draft Technical Report) for further discussion of hydrologic conditions, including baseflow and runoff, in the bypass reach.

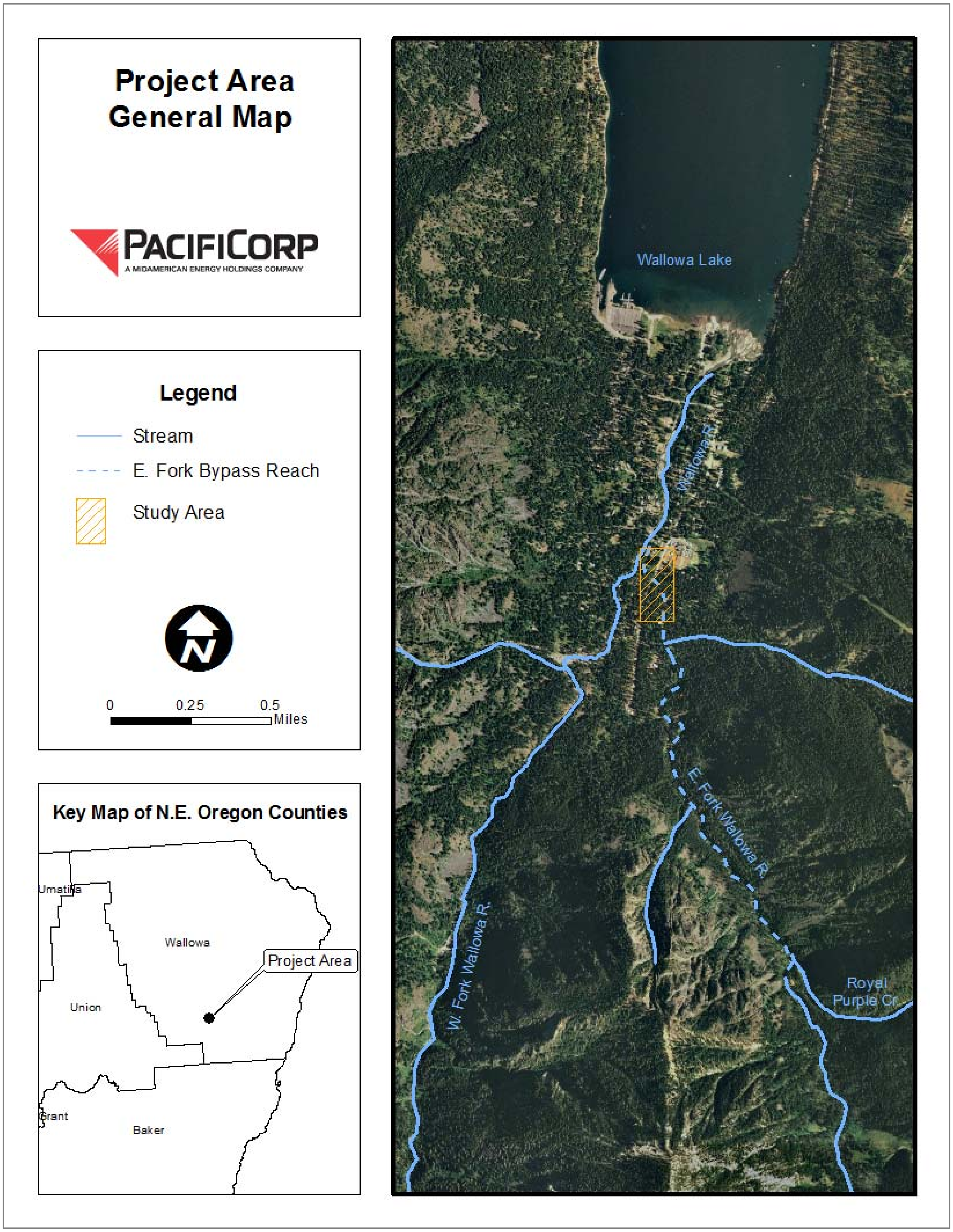

Figure 1. Location map of the Wallowa Falls IFIM study area.

2.3 FISH COMMUNITY AND TARGET SPECIES/LIFE STAGES

The suitability of fish habitat in the upper bypass reach is likely limited due to a high average gradient of nineteen to twenty percent, and a preponderance of turbulent bedrock chutes and cascades. Fish access to the upper bypass reach is blocked by Wallowa Falls. Below the falls in the lower bypass reach, there is documented presence of bull trout, kokanee, rainbow trout, and non-native brook trout. In concurrence with stakeholders, bull trout and kokanee were selected as the target species for the PHABSIM study. A periodicity table for the target species is provided in Table 1. Kokanee are only present in the lower bypass reach during spawning, incubation, and fry outmigration, which occurs shortly after fry emerge from the gravel. Adult kokanee generally access only the lower 500 to 600 feet of the bypass reach due to a partial passage barrier created by a municipal water pipe next to a private residence along the stream. Bull trout have been observed by PacifiCorp biologists throughout the lower bypass reach. PacifiCorp's most recent fisheries data suggest that the bypass reach supports an adfluvial bull trout population, with little evidence of a resident population (Doyle, 2013).

Table 1. Periodicity of target fish species and life stages in the bypass reach

Species	Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bull trout	Adults					■	■	■	■	■	■		
	Spawning									■	■		
	Juvenile	■	■	■	■	■	■	■	■	■	■	■	■
Kokanee	Spawning								■	■	■		

3.0 METHODS

PHABSIM was used to analyze the suitability of habitat for various life stages of bull trout and kokanee in the East Fork Wallowa River bypass reach over a range of assumed instream flow alternatives. The ultimate products of PHABSIM were relationships between habitat and flow, specific to each target species/life stage. The development and analysis of these habitat-flow relationships required several key study phases, including: (1) a stream habitat survey; (2) selection of the location and number of study transects; (3) hydraulic data collection; and (4) habitat simulation and analysis. The methodologies of the four study phases are described in the following subsections.

3.1 STREAM HABITAT SURVEY

A habitat survey was performed to inventory the existing instream habitat in the lower bypass reach, and thus guide the selection of the location of the PHABSIM study reach. On April 11, 2012, PacifiCorp surveyed mesohabitat (i.e., basic types of habitat units in the stream, such as pools, runs, and riffles, among others), beginning at the mouth of the East Fork Wallowa River and ending approximately 1000 feet downstream of the falls. Consistent with the approved IFIM study plan, stream habitat units were identified using US Forest Service Region 6 protocol (U.S. Forest Service, 2009). Certain common habitat survey parameters were not collected because they were not relevant this particular PHABSIM application, including recording bankfull widths, documenting unstable banks, mapping riparian vegetation, and recording water temperature.

3.2 TRANSECT SELECTION

On June 12, 2012, a stakeholder meeting was held with interested parties to determine the number and location of study transects. Participants included the U.S. Fish and Wildlife Service, U.S. Forest Service, Oregon Department of Fish and Wildlife, Oregon Department of Environmental Quality, and FERC. The group conducted a site visit to the bypass reach to select the study reach and transect locations. Fourteen proposed transects were flagged within the lowest 1,500 feet of the lower bypass reach (Figure 2). The remaining upstream portion of the lower bypass reach, and the entire upper bypass reach, are characterized by high gradients and turbulent conditions. Hydraulic parameter data such as water velocities and water surface elevations from these reaches could not be accurately collected or properly simulated in the PHABSIM modeling portion of the methodology. The stakeholder group considered the proposed study reach and all 14 transects satisfactory for modeling all life stages of bull trout habitat. Transects selected included four low gradient, riffle-type sites, and ten higher gradient, riffle/rapid-type sites. The stakeholder group also agreed that only the lowest four transects were to be used for modeling kokanee spawning. A passage barrier between transects four and five prevented the majority of kokanee from spawning upstream of transect four. Photographs of the fourteen transects, taken at a flow of 5.3 cfs, are displayed in Appendix A.

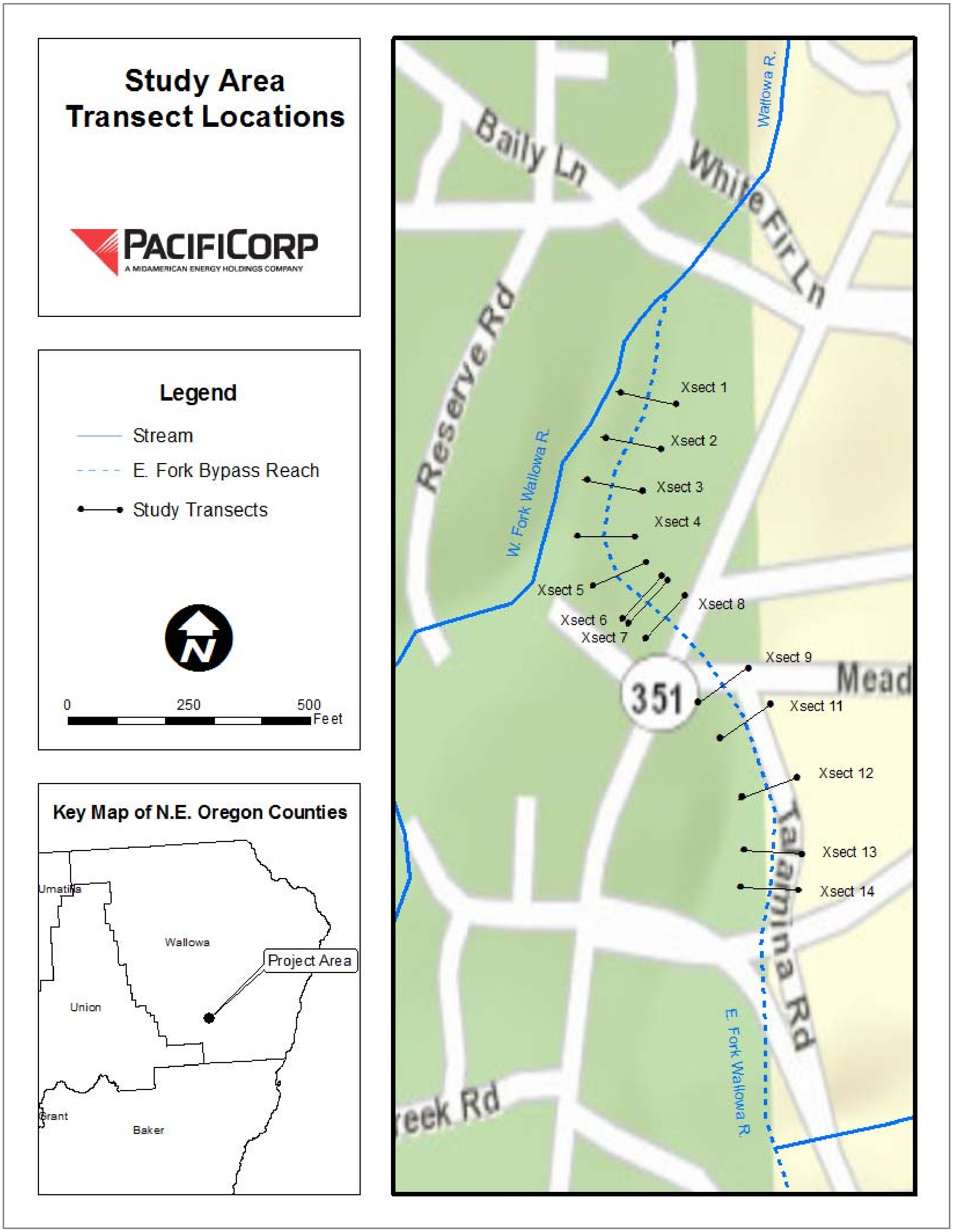

Figure 2. Map of Wallowa Falls IFIM study reach and transect locations.

3.3 Development of Habitat Suitability Criteria

The purpose of PHABSIM is to transform multiple habitat parameters (depth, velocity, cover, substrate, etc.) into a single computation of available habitat for each simulated flow. Habitat suitability criteria (HSC) are used as the transfer function in the habitat computation. HSC can be visualized as a curve, in which the x-axis represents the variable parameter (e.g. depth), and the y-axis represents the suitability rating. The variables of each habitat parameter are scored on a scale of 0 (unsuitable) to 1 (most suitable). Specific HSC are developed for each target species/life stage, and are based on the known behaviors and characteristics of the specific organism. For this particular study, depth and velocity were scored as continuous variables on a suitability scale of 0 to 1 for each species/life stage. Cover was scored as a binary variable. Although cover is an important component of fish habitat, cover is rare in the bypass reach. To ensure that areas of usable habitat would not be discounted or minimized during the modeling process due to a lack of cover, cover was scored as 0.8 (absent) or 1.0 (present). Substrate was not used as a model input, due to a general uniformity of large cobble and boulder at all transects.

PacifiCorp developed three sets of HSC for bull trout, which included: (1) adult adfluvial criteria; (2) juvenile adfluvial criteria; and (3) spawning criteria. Kokanee only utilize the bypass reach for spawning, and so a single set of HSC was developed for the kokanee spawning life stage. The HSC were developed for water velocity (feet per second), water depth (feet), and cover.

Literature-based information and stakeholder input were the two primary sources for development of the HSC. No site-specific suitability data were collected for any of the species. The main literature sources for bull trout included criteria developed by CH2M Hill (ongoing unpublished) and Maret et al. (2003). Criteria from these two sources were chosen because they had been developed for bull trout IFIM studies on streams of similar size and gradient to the bypass reach. The proposed HSC for kokanee spawning were developed by Bovee (1978), which were the only kokanee criteria found in the literature.

The HSC developed by PacifiCorp were issued to stakeholders for review. PacifiCorp met with stakeholders on June 12, 2012 in Enterprise, Oregon. Minor changes were applied to many of the HSC with the group’s consensus. The depth and velocity HSC developed in the workshop are provided in Appendix B.

3.4 Wetted Perimeter and the Seasonal Limits HSC

The HSC for bull trout in the East Fork bypass reach were not considered applicable during the winter months, when bull trout are exposed to stream temperatures that are near-freezing for extended periods of time. In such cold environments, bull trout experience reduced metabolic rates, and must modify their behavior in order to minimize energy expenditures. Overwintering bull trout have been repeatedly documented exploiting refuge areas. Behaviors such as sheltering in interstitial spaces in the substrate during the day, holding in zero or near-zero velocities on the surface of the substrate at night, and lethargically foraging in slow stream margins at night are typical of the winter ecology of trout (CH2M Hill, 1996, Bonneau & Dennis, 1998, Muhlfeld et al, 2003). The HSC used in this study were developed from literature specific to summer and spawning seasons, when bull trout are more likely to utilize the water column. Due to the seasonal differences in ecology, wetted perimeter was chosen as a more applicable index of bull trout habitat in the winter than WUA developed from the HSC. Furthermore, the winter months are associated with the bull trout incubation period. The viability of incubating eggs and alevin is more dependent on remaining wet than on any combination of depth, velocity and cover that constitutes WUA. Wetted perimeter is therefore a suitable metric for evaluating the flows required to insure that the channel bottom remains filled with water throughout the incubation period.

Typically, wetted perimeter is applied only to riffles, where it is considered to be an index of macroinvertebrate habitat and by extension, food production for fish rearing (Gippel & Stewardson, 1998). Due to the uniform mesohabitat in the East Fork bypass reach, all of the transects were established in riffles and rapids (in the bypass reach, rapids were simply higher-gradient riffles), and were therefore suitable candidates for the wetted perimeter analysis. Riffles, which are characteristically shallow habitat features, are the most susceptible type of habitat to changes in water surface level relative to changes in flow. As such, minimum flow decisions based on the protection of wetted perimeter in the riffles would effectively protect the deeper pockets and other refuge habitat used by overwintering bull trout.

3.5 FIELD DATA COLLECTION

PacifiCorp surveyed the study transects per the surveying protocol called for in the U.S. Fish and Wildlife Service's IFIM Informational Paper No. 26 (Milhouse, Updike, & Schneider, 1989). The transect head and tail stakes were established above the ordinary high water mark. The channel profile and water surface elevations were surveyed at each transect using a standard level-and-rod. Water velocities were collected using a FlowTracker® meter at intervals such that no one "cell" along the transect contained more than about 5 percent of the total flow.

After completion of the transect survey, PacifiCorp collected hydraulic and habitat data at each transect location during three separate flow release events. The flow release events were targeted at 16 cfs, 8 cfs, and 4 cfs, which represented the high, medium, and low range of flows at which accurate calibration data could be collected in the field[1]. The actual flow releases were very close to the targets: data were collected at calibration flows of 15 cfs on July 22, 2012, 8.5 cfs on August 21, and 5.3 cfs on August 22. The hydraulic variables collected for PHABSIM modeling during the flow releases are described in Table 2.

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[1] The hydraulic models used by PHABSIM assume that the water surface elevation does not change across a single transect (Waddle, 2012). In the East Fork bypass reach, flows greater than approximately 20 cfs create turbulent conditions that are not compatible with the PHABSIM assumption of an even water surface.

Table 2. Hydraulic variables collected at each transect during the target flow releases.

Variable	Units	Description
Temporary stage	Feet	Mobile staff gage was placed at each location to monitory changes in stage during measurements
Water surface elevation	Feet	Surveyed and averaged right and left edge of water to the hundredths of a foot
X-distance (station)	Feet	Increments of a transect between survey stakes where hydraulic variables are measured
Water depth	Feet	Measured with top-setting wading rod at each station
Bed elevations	Feet	Determined indirectly (surveyed water surface elevation minus water depth)
Mean column water velocity	Feet per second	Measured at each station with a FlowTracker®acoustic doppler velocimeter, averaged over 30 seconds
Cover	Binary	Presence/absence at each station

3.6 MODELING

Hydraulic simulations were performed using PHABSIM over a range of flows, from 0.8 cfs to 40 cfs. The lowest flow, 0.8 cfs, was selected because it represented the existing minimum flow, or baseline condition, to which the fish community is currently exposed. The highest flow modeled, 40 cfs, was selected because (1) the model appeared to accurately predict hydraulic conditions up to approximately 40 cfs; and (2) the water surface overtops the low terraces at transect numbers one through three when flows are greater than approximately 40 cfs, thereby imparting field data limitations to accurate modeling in the lowest cross sections of the study reach.

The “one-flow" PHABSIM modeling method was used[2]. This option uses one set of measured velocities for all verticals at the calibration flow and solves Manning's equation on an individual cell basis (with cell depth in place of hydraulic radius) to derive a roughness or velocity distribution factor. The roughness values (“Manning’s n values”) derived from solving Manning’s equation for the calibration flows are used as a template to predict velocities at all

[2] The hydraulic model in PHABSIM was originally configured to use the three flow data sets together using a least-squares regression fit of log-velocity against log-discharge for the verticals on each transect. However, it has been well established that the three-flow regression configuration of IFG4 performs poorly when applied to high gradient streams or streams containing many large bed elements (e.g. boulders) due to the inability to accurately simulate hydraulic complexities (Milhous 1985, Payne 1987). Due to such poor performance, the Instream Flow Group issued an advisory cautioning use of three-flow velocity regression method (Milhous & Schneider, 1985).

other discharges. The one-flow method produces a separate PHABSIM model for each of the three calibration flows. Habitat simulation results from the three models are then merged to produce a single, continuous flow-habitat relationship. This action is described in greater detail in the Habitat Modeling sub-section below.

Transect Weighting

Although transects are usually located in a variety of habitat types, the number and placement of transects may not necessarily be proportionate to the actual habitat composition inventoried during the stream habitat survey (discussed previously). The application of a weighting system to individual transects is often performed to accurately characterize stream habitat composition within the study reach. In this particular study, the transects were equally weighted, as agreed to during the stakeholder meeting on June 12, 2012. The rationale for applying equal weight to each transect was that there are few distinguishable differences in habitat types (e.g., the lack of definitive riffle/pool/run complexes). At low flows, the stream consists largely of pocket water, and at higher flows, the stream transitions to alternating rapid and cascade features. Consequently, transects were established at cross-sections of stream that met the fundamental assumptions of the PHABSIM hydraulic models, represented the stream morphology as a whole, and were agreed upon in the field by resource agency personnel involved in this project.

Although data were collected at fourteen transects, transect number ten was dropped from the analysis because the data could not be calibrated in PHABSIM with any confidence. Each of the remaining thirteen transects were assigned an arbitrary length of 100 feet (i.e. the weighting factor), resulting in a study reach length of 1,300 feet. For the kokanee habitat simulation, the same weighting scheme was applied only to the first four transects. Based on PacifiCorp's field observations and conversations with streamside property owners, it was determined that kokanee rarely spawned above transect number four due to an upstream passage impediment (as described previously in section 2.3).

Water Surface Elevation

Water surface elevations at each transect were simulated over the range of flows modeled using a subroutine in the PHABSIM model. The WSL subroutine uses a regression-based simulation known as the stage-flow (STGQ) method to develop a log-log relationship between stage (the surveyed water surface elevations) and the measured flows. This is commonly referred to as the stage-discharge relationship for each transect. A tabular summary of the surveyed and calibrated water surface elevations is provided in Appendix C.

Velocity Simulations

Velocities were simulated with PHABSIM's velocity subroutine, VELSIM. As described above, the "one-flow" PHABSIM modeling method was used, resulting in three models calibrated to the velocity data sets obtained at the three minimum flows. The low flow model was calibrated to velocities measured at the 5.3 cfs release, and the medium and high flow models were calibrated to velocities measured at the 8.5 cfs and 15 cfs releases, respectively.

After each velocity simulation was run, the output was assessed for unusual results (e.g., a simulation flow in which the velocities in the individual cells along the transect differed from the general velocity patterns in the same cells at other simulation flows). When unusual results were encountered, they were reviewed and, when appropriate, adjusted so that simulated velocities represented realistic velocities based on field observations at each site and professional judgment. A list of any adjustments was kept in the project file notes and is available for review upon request.

Habitat Modeling: Weighted Usable Area

After completing hydraulic modeling, the HABTAE subroutine of PHABSIM was used to quantify the available fish habitat at each transect for each of the simulation flows. HABTAE specifically computes the available fish habitat in terms of "weighted usable area" (WUA) in the study reach at each simulation flow for each species/life stage. WUA is reported in units of square feet of habitat per 1000 linear feet of stream.

The final products from HABTAE were calculations of WUA in the study reach for each simulated flow, specific to each target fish species and life stage. These WUA results are referred to in this report as "habitat-flow relationships" or, when graphed by flow, as "WUA curves".

As described above, hydraulic and habitat modeling was done separately for each of the three calibration flows. The low, medium, and high flow WUA results were then merged into one continuous WUA curve over the entire flow range modeled by computing the geometric mean of the WUA values at flows where the simulations overlapped. The specific points of overlap/merger between two (or occasionally all three) model results were selected to produce the smoothest possible transition between the partial WUA results for each target species/life stage. The end result was a single, continuous WUA curve for each of the four target fish species/life stages. These four final WUA curves were subsequently applied in a habitat duration analysis as explained below in section 3.6. The habitat duration analysis was used to estimate the frequency and duration of WUA for each target species under expected daily flow conditions between May and October. A different metric of habitat availability (stream wetted perimeter) was used for the months of November through April as explained further in the next section.

Habitat Modeling: Wetted Perimeter

The hydraulic modeling portion of PHABSIM provided the metric of wetted perimeter at each transect over the range of flow simulations. Wetted perimeter was reported by PHABSIM in units of feet. A simple relationship was developed between the average wetted perimeter of the thirteen transects and the three flows. This relationship was analyzed for the inflection point, or the flow that produced the greatest incremental increase in wetted perimeter. Additionally, the inflection points of individual transects were examined and discussed.

3.7 HABITAT DURATION ANALYSIS

A habitat duration analysis was performed to assess the percentage of time that habitat levels (based on WUA) in the East Fork bypass reach would be equaled or exceeded under alternative flow regimes. The flow-habitat relationships for WUA were used to evaluate habitat frequency and duration under a number of assumed flow regimes, including: (1) the unimpaired flow[3] regime, also referred to as the tailrace reroute scenario[4]; (2) the current baseline regime of a minimum flow of 0.8 cfs; and (3) alternative flow regimes that assume minimum flow levels ranging from 1 cfs to 10 cfs. Model results were used to conduct a habitat duration analysis to illustrate various flow alternatives compared to baseline conditions over the course of each season. The following subsections describe the steps of the analysis.

3.7.1 Hydrology

A historic flow record is necessary to develop (synthesize) the alternative flow regimes and complete a habitat duration analysis. A record of daily average flows between WY 1924 and WY 1983 exists for the East Fork bypass reach (USGS gage no. 1332500) and the power house tailrace (USGS gage no. 13324500). When daily average flows from the two sites are combined, an approximation of unimpaired flows can be developed for the East Fork Wallowa River. Accordingly, the USGS developed reporting station 13325001 which combined the data from the two gages. For this study, PacifiCorp selected daily unimpaired flows from 45 complete water years from reporting station 13325001, including WY 1924 to WY 1952 and WY 1967 to WY 1983. A reliable data record was not available at both gages between WY 1953 and WY 1966, so these years were omitted from the analysis.

The record of estimated flows was used to synthesize nine alternative flow regimes. These alternatives included assumed minimum flow levels of 0.8 cfs (current baseline conditions), 1 cfs, 2 cfs, 3 cfs, 4 cfs, 5 cfs, 6 cfs, 8 cfs, and 10 cfs. Minimum flow alternatives greater than or equal to 8 cfs were explored to help define trends, but are not considered by PacifiCorp to be realistic minimum flow alternatives from an operational and environmental perspective. For

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[3] Unimpaired flow is a standard hydrologic term, which in this case is the estimated flow regime that assumes no Project-related diversions from the East Fork at any time. However, it otherwise assumes the existence of the current channel configuration and runoff conditions. Therefore, the definition of unimpaired flow is distinct from (and may differ from) “natural” or “pre-project historic” flows.

[4] During the June 2013 IFIM stakeholder meeting, PacifiCorp proposed rerouting the tailrace of the powerhouse from the West Fork Wallowa River to the East Fork bypass reach, as an alternative flow scenario. The rerouted tailrace would discharge to the bypass reach 2,600 feet upstream of the confluence of the East Fork and West Fork Wallowa River. This alternative would restore historical flows to the lower 2600 feet of the East Fork bypass reach. Up to 16 cfs would be rerouted from the West Fork and returned to the bypass reach during the spring runoff months. Approximately 10 cfs to 13 cfs would be rerouted from the West Fork to the bypass during the autumn spawning months, when natural flows are low. The scenario would reduce flows in the West Fork by over 40% during the spawning season, but habitat effects of flow reduction on the West Fork fish community, including spawning kokanee and migrating/spawning bull trout, are beyond the scope of this study.

example, such minimum flow alternatives are unrealistic because they are (a) substantially greater than any frequently recurrent unimpaired low flow, and (b) cannot be maintained throughout the winter and thereby introduce an unnecessary desiccation risk to incubating bull trout eggs and alevin. Additionally PacifiCorp is concerned that higher minimum instream flows may cause a reduction in holding habitat due to the higher velocities incurred.

3.7.2 Habitat Time Series Analysis

The unimpaired flow record and the nine alternative flow records were converted to daily habitat values according to the flow-habitat relationship produced by PHABSIM for each of the four target species/life stages. The four WUA curves, applied to the ten flow records, generated 40 separate data sets, or habitat time series.

To compress 40 data sets to a more manageable size, habitat duration curves were developed from the habitat time series. Habitat duration curves display the relationship between a value of WUA and the percentage of time it is equaled or exceeded. The duration curves still comprised a large amount of data that was difficult to objectively analyze. Each duration curve was further simplified by integrating the area under the curve within the percentiles of 10 and 90. This calculation provided a single index value of habitat duration, called total WUA, and enabled straightforward comparisons of total WUA between two or more flow alternatives. A more detailed description is provided by Waddle (2012). Habitat duration, in the form of total WUA, was assessed for each individual month between May and October.

4.0 RESULTS

4.1 STREAM HABITAT SURVEY

The lower bypass is comprised principally of riffle-type habitat features that are differentiated only by gradient. The predominant habitat type in the lower bypass reach is fast turbulent rapid (53 percent). The U.S. Forest Service (2009) defines a fast turbulent rapid as “a riffle with stream gradient greater than 3% but less than 10 percent”. The secondary habitat type is fast, turbulent, riffle (29 percent), defined as a riffle with a gradient of less than 3 percent. Fast, turbulent, cascades, which are riffles with gradients greater than 10 percent, comprise 16 percent of habitat in the lower bypass reach. The remaining 2 percent of the bypass reach is comprised of slow scour plunge pools, typically associated with human-built flow obstructions or transverse substrate bars.

The dominant substrate within the lower bypass reach includes boulder (46 percent) and cobble (27 percent). Gravel and sand comprise fifteen percent and nine percent of the substrate, respectively. The remaining three percent of substrate consists of fines, such as silt or organic material. The relatively small proportion of substrate finer than cobble may be associated with the Wallowa Falls dam and forebay, which tend to impede sediment transport to the bypass reach.

The habitat survey provided several important details for the PHABSIM modeling. First, the survey provided the study team with an opportunity to select a study reach in which transects could be established that were consistent with PHABSIM assumptions[5]. Second, the survey results indicated that equal transect weighting should be applied during modeling, due to the prevalence of the riffle habitat type throughout the bypass reach. Finally, the survey results implied that substrate would not be a useful parameter for habitat modeling, due to the pervasive distribution of boulder and cobble size categories.

4.2 Weighted Usable Area versus Flow

The relationships between flow and habitat WUA for the four target species/life stages are illustrated in Figure 3. The results are expressed as a percentage of the maximum WUA (i.e. WUA values have been "normalized" to eliminate distortions caused by graphing very different magnitudes of data on the same scale). Tables containing the numeric values of the WUA results are provided in Appendix D. The following points summarize the four WUA versus flow relationships:

- WUA for adult bull trout is characterized by a steep increase in habitat between flows of 0.8 cfs and 5 cfs. A more gradual, curvilinear increase occurs between 5 cfs and 17 cfs. As flows increase above 17 cfs, WUA declines gradually and steadily.
- WUA levels for juvenile bull trout increase rapidly as flows rise from 0.8 cfs to 2 cfs. The rate of WUA increase becomes more gradual between 2 cfs and 4 cfs, and reaches a peak between 5 cfs and 6 cfs. WUA declines steadily between flows 6 cfs and 40 cfs.
- Spawning bull trout experience WUA levels that increase rapidly as flows increase from 0.8 cfs to 7 cfs. A distinct peak in WUA occurs at 8 to 9 cfs. As flows increase above 9 cfs, a steady decline in WUA occurs.
- For spawning kokanee, WUA increases sharply with flow between 0.8 cfs and approximately 5 cfs, then more gradually until peak habitat is reached at 10 cfs. Habitat decreases rapidly as flows increase between 11 cfs and approximately 19 cfs. The rate of habitat decline with increasing flow is more gradual at flows between 20 cfs and 40 cfs. Unimpaired flows of this magnitude are not likely to occur during the period of maximum kokanee spawning in September and October.

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[5] PHABSIM assumes that the water surface level is even across each transect. The study reach needed to be located in a section of stream that was not dominated by channel features that created visible differences in the water surface level normal to the direction of flow, such as mid-channel lateral steps or transverse substrate bars.

4.3 HABITAT DURATION ANALYSIS

4.3.1 Hydrology

Hydrograph synthesis was the necessary first step to performing the habitat duration analysis. As discussed in section 3.7, hydrographs were synthesized using daily unimpeded flows from 45 complete water years from reporting station in the East Fork bypass reach. The 45 years of historic flows in the East Fork bypass reach are summarized as the “unimpaired” data series in Figure 4. Also included are the synthesized hydrographs for each minimum flow alternative. A logarithmic scale is applied to the y-axis for clarity.

The months of May through July are referred to as the spring runoff season in this report. Flows during these months are high, variable, and typically much greater than the power plant capacity of 16 cfs. During most of the spring runoff season, the various minimum flow alternatives are inundated by excess flows spilled at Wallowa Falls dam. As a result, the nine synthesized alternative hydrographs have identical daily average flows between mid-May and mid-July.

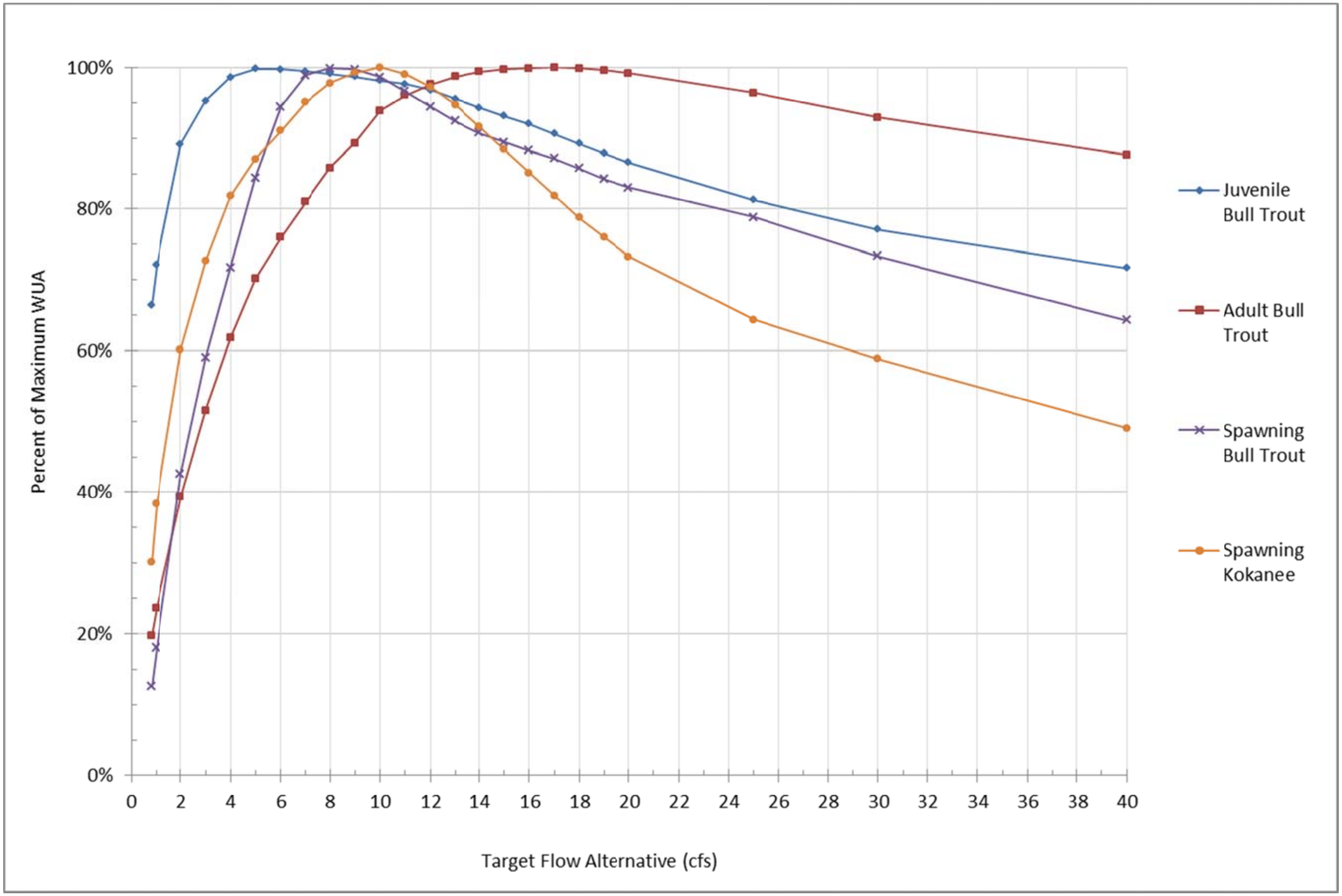

Figure 3. Normalized (% of maximum) WUA curve for all target species and life stages of fish in East Fork Wallowa bypass reach.

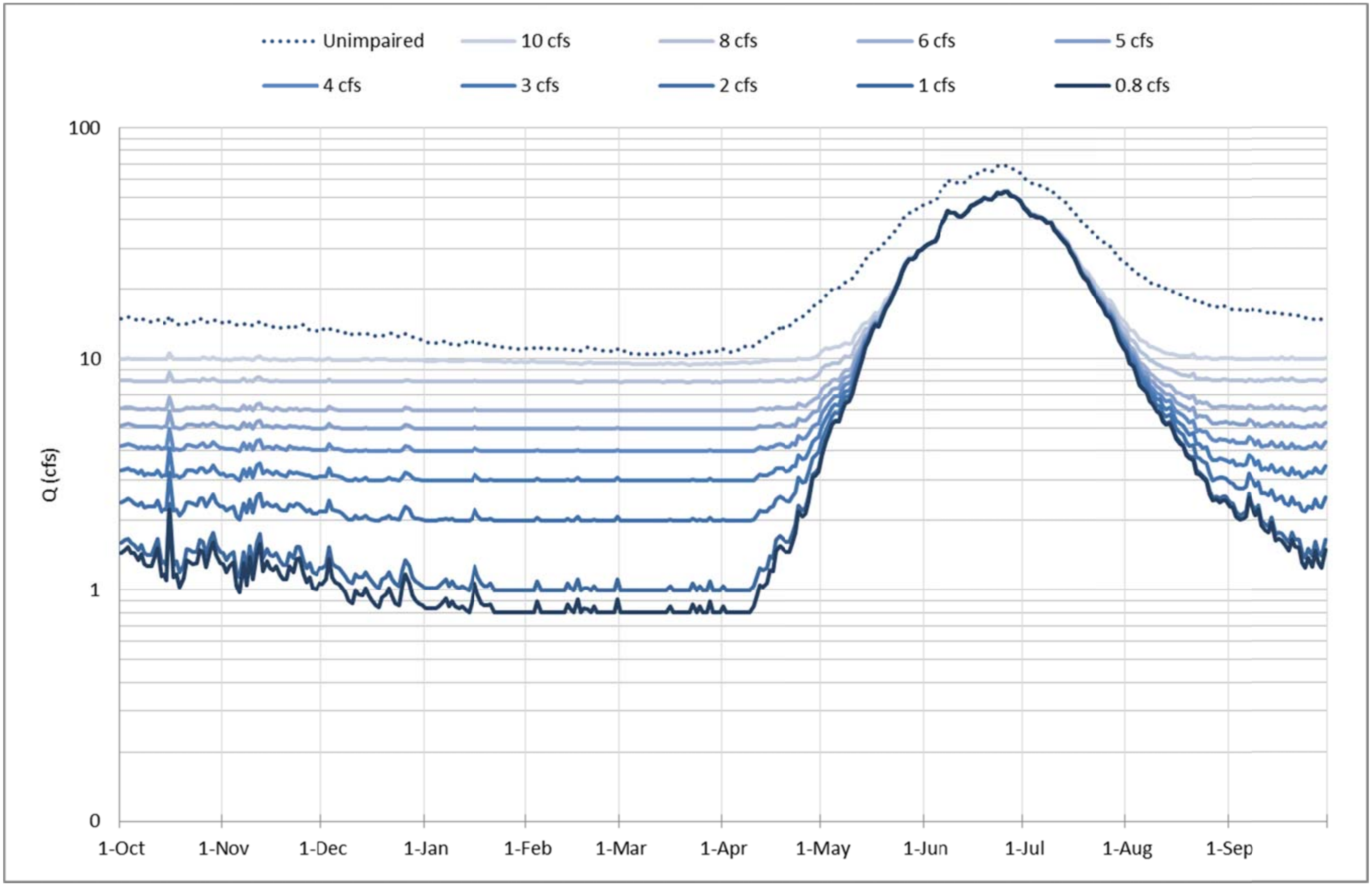

Figure 4. Hydrographs of historic daily average flows ("unimpaired") and synthesized minimum flow alternatives in East Fork bypass.

4.3.2 Habitat Time Series Analysis

Total WUA, which is basically a summation of habitat, was calculated for each minimum flow alternative during the time periods of May through October, and total wetted perimeter was calculated for each minimum flow during the winter baseflow period of November through April. Total WUA is a useful index statistic that represents, in a single quantitative value, the integration of the numerous data points that comprise a habitat duration curve. Thus, using the total WUA index value, a straightforward comparison can be graphically presented between various flow alternatives. However, total WUA values tend to be very large numbers. To create a more useful style of presentation, the total WUA values for each flow were standardized as percent increase over the total WUA value for existing, baseline conditions. The usefulness of this standardization is that it transforms very large values of total WUA into more manageable statistics, and eliminates distortions of scale.

Juvenile Bull Trout

Of the minimum flow alternatives explored, total WUA levels for juvenile bull trout were lowest at the existing minimum flow (0.8 cfs) during August, September, and October. In May, June, and July, the lowest total WUA levels were provided by the unimpaired, or tailrace reroute, alternative. Peak total WUA levels occurred every month, except June, at minimum flows of 5 cfs and 6 cfs. Minimum flows of 4 cfs provided total WUA levels that were 99 percent of peak each month, also with the exception of June. The naturally high runoff flows in June inundated the effects of the various flow alternatives. The monthly total WUA values are provided in Table 3 and are normalized to existing, baseline conditions in Figure 5.

During the spring runoff season (May through July), minimum flow alternatives had a minimal influence on total WUA. Figure 5 illustrates the minor influence of the various flow alternatives on total WUA during these months. Every alternative provides less than a 10 percent increase in total WUA over baseline conditions, and the tailrace reroute alternative is associated with a reduction in total WUA over existing baseline conditions.

The tailrace reroute scenario is associated with moderate total WUA increases over baseline conditions in August, September, and October. Under this scenario, bull trout are exposed to total WUA levels that are less than those provided by 2 cfs August, and less than those provided by 3 cfs in September and October.

The seasonal habitat duration curves and tables used to develop the summarized results are provided in Appendix E-1 and Appendix F-1.

Adult Bull Trout

The lowest total WUA levels for adult bull trout occurred at the existing minimum flow of 0.8 cfs in every month except June, during which the lowest WUA levels were associated with the unimpaired flows of the tailrace reroute scenario. There are no peak values of total WUA to report because total WUA increased continuously over the range of minimum flows analyzed in every month except June. In June, total WUA values increased at 2 cfs and remained constant until levels were diminished by the unimpaired flow scenario. The total WUA values provided by the various flow alternatives for each month are found in Table 4.

Baseline habitat conditions during the spring runoff period were not appreciably affected by any minimum flow alternative due to the overriding influence of the high seasonal flows. As runoff diminished in August, total WUA demonstrated gradual, steady increases with increasing minimum flows. During the low flow months of September and October, the various minimum flow alternatives had considerable influence on total WUA. As minimum flows were increased, the total WUA trends during these two months are characterized by large, continuous increases. These increases represent substantial increases in habitat availability over baseline conditions. Total WUA increased by nearly 100 percent at minimum flows in the range of 2 cfs (October) and 3 cfs (September). The magnitude of the WUA-flow relationships, particularly in September and October, is more clearly characterized in Figure 6.

The habitat duration analysis for adult bull trout are provided in Appendix E-2 and Appendix F-2.

Spawning Bull Trout

Total WUA during the bull trout spawning months of September and October was lowest under the existing minimum flow of 0.8 cfs. Peak total WUA for spawning bull trout was provided by 8 cfs during both months (Table 5). Increases to minimum flows resulted in substantial increases in total WUA over baseline conditions. In September, total WUA exceeded a 100 percent increase over baseline conditions at 3 cfs, and in October, a total WUA increase in excess of 100 percent of baseline was proved by 2 cfs. Although the unimpaired flow scenario was associated with total WUA levels that were on the declining limb of the total WUA curve, this scenario still provided large increases in total WUA levels over existing conditions. During both months, unimpaired flows provided total WUA levels similar to those provided by 5 cfs to 6 cfs. Figure 7 illustrates the magnitude of total WUA increase provided by each alternative flow over the existing minimum flow of 0.8 cfs. The habitat duration tables and curves developed for spawning bull trout during the months of September and October are provided in Appendix E-3 and Appendix F-3.

Spawning Kokanee

Total WUA for spawning kokanee were lowest at minimum flows of 0.8 cfs, and increased continuously over the range of analyzed minimum flows (Table 6). Unimpaired flows resulted in decreased total WUA values, relative to the preceding trend. Unimpaired flows were associated with total WUA levels similar to those provided by 3 cfs in August, 5 cfs in September and 6 cfs in October. The summary of these data, provided Figure 8, illustrates that during each of these three months total WUA increased continuously as alternative minimum flows were increased.

Figure 8 displays the percent increase in total WUA over baseline conditions provided by each alternative minimum flow. During August, habitat availability is not as strongly influenced by increases in minimum flows because natural flows remain relatively high during the first half of the month due to high-elevation runoff from melting snow. This graphic emphasizes the appreciable effect that relatively small increases in minimum flows can have on habitat availability during periods of seasonally low flows. In September and October, increases in total WUA of 100% over baseline conditions are predicted at minimum flows of approximately 4 cfs and 3 cfs, respectively.

Habitat duration tables and curves for spawning kokanee during the months of August, September, and October are provided in Appendix E-4 and Appendix F-4.

Table 3. Total WUA (in millions of square feet per 1,000 linear feet) provided by selected minimum flow alternatives for juvenile bull trout.

Month	0.8 cfs	1 cfs	2 cfs	3 cfs	4 cfs	5 cfs	6 cfs	8 cfs	10 cfs	Unimpaired
May	3.92	3.93	4.11	4.18	4.24	4.26	4.26	4.25	4.23	3.65
Jun	3.34	3.34	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.16
Jul	3.68	3.68	3.78	3.82	3.85	3.86	3.86	3.86	3.85	3.44
Aug	3.66	3.76	4.17	4.35	4.47	4.51	4.51	4.48	4.44	4.05
Sep	3.22	3.37	3.95	4.18	4.32	4.37	4.37	4.34	4.30	4.05
Oct	3.08	3.30	4.05	4.31	4.47	4.52	4.52	4.49	4.44	4.26

Table 4. Total WUA (in millions of square feet per 1,000 linear feet) provided by selected minimum flow alternatives for adult bull trout.

Month	0.8 cfs	1 cfs	2 cfs	3 cfs	4 cfs	5 cfs	6 cfs	8 cfs	10 cfs	Unimpaired
May	2.91	2.91	2.97	3.04	3.12	3.21	3.27	3.40	3.55	3.54
Jun	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.30	3.19
Jul	3.22	3.22	3.24	3.25	3.29	3.31	3.34	3.39	3.48	3.41
Aug	1.62	1.68	1.99	2.26	2.51	2.73	2.90	3.22	3.51	3.68
Sep	0.98	1.06	1.50	1.87	2.23	2.53	2.75	3.10	3.39	3.58
Oct	0.79	0.91	1.48	1.92	2.31	2.62	2.84	3.20	3.51	3.69

Table 5. Total WUA (in millions of square feet per 1,000 linear feet) provided by selected minimum flow alternatives for spawning bull trout.

Month	0.8 cfs	1 cfs	2 cfs	3 cfs	4 cfs	5 cfs	6 cfs	8 cfs	10 cfs	Unimpaired
Sep	1.30	1.48	2.55	3.33	4.02	4.73	5.30	5.61	5.54	5.00
Oct	0.85	1.12	2.50	3.42	4.16	4.89	5.47	5.79	5.72	5.27

Table 6. Total WUA (in millions of square feet per 1,000 linear feet) provided by selected minimum flow alternatives for spawning kokanee.

Month	0.8 cfs	1 cfs	2 cfs	3 cfs	4 cfs	5 cfs	6 cfs	8 cfs	10 cfs	Unimpaired
Aug	6.30	6.68	8.00	8.84	9.54	10.01	10.39	11.12	11.36	9.17
Sep	4.46	4.99	6.87	8.02	9.00	9.58	10.01	10.76	11.00	9.52
Oct	3.69	4.48	6.89	8.26	9.30	9.90	10.35	11.12	11.37	10.27

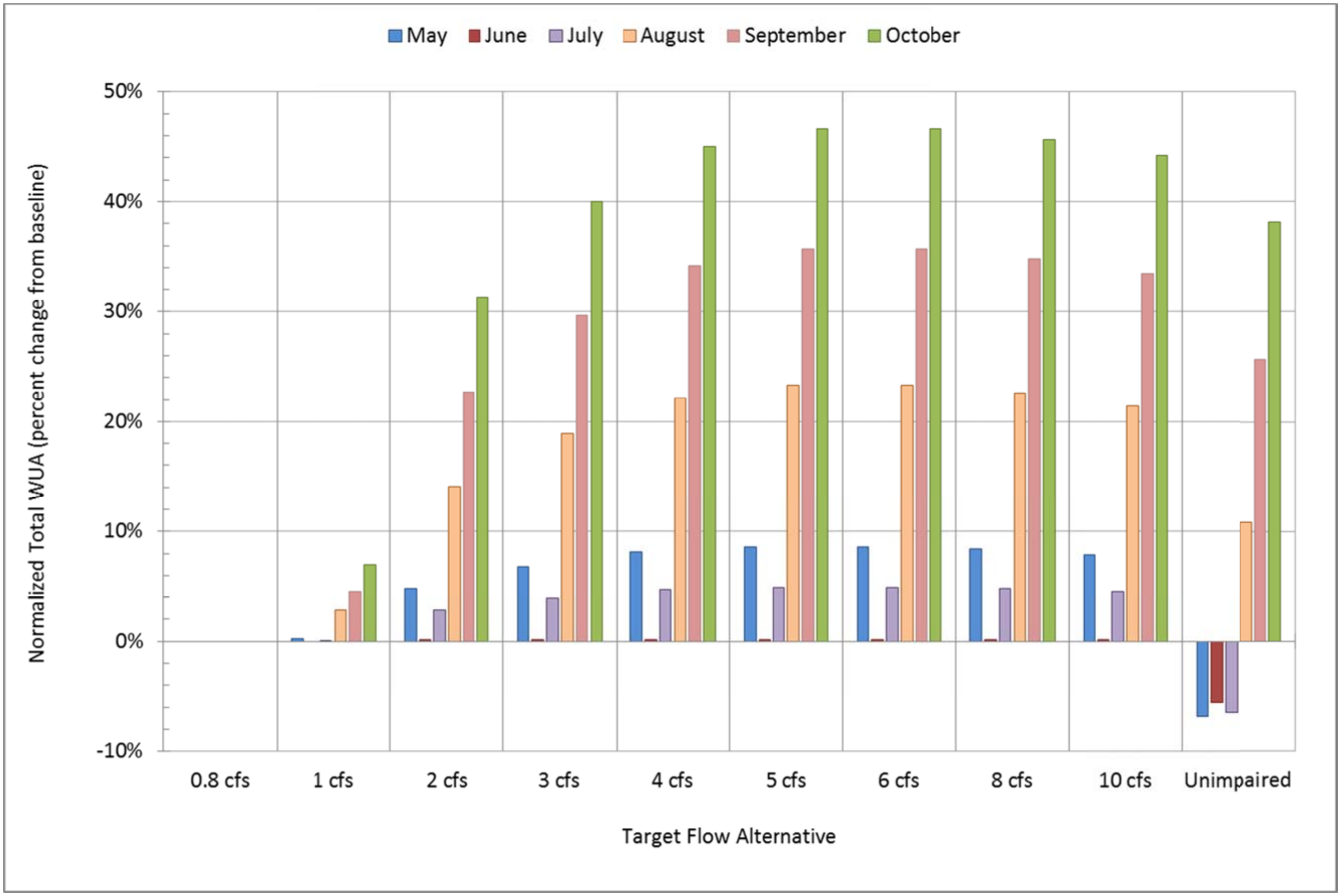

Figure 5. Total WUA, normalized as percent change over existing conditions (baseline minimum flow of 0.8 cfs), provided by selected minimum flow alternatives for juvenile bull trout.

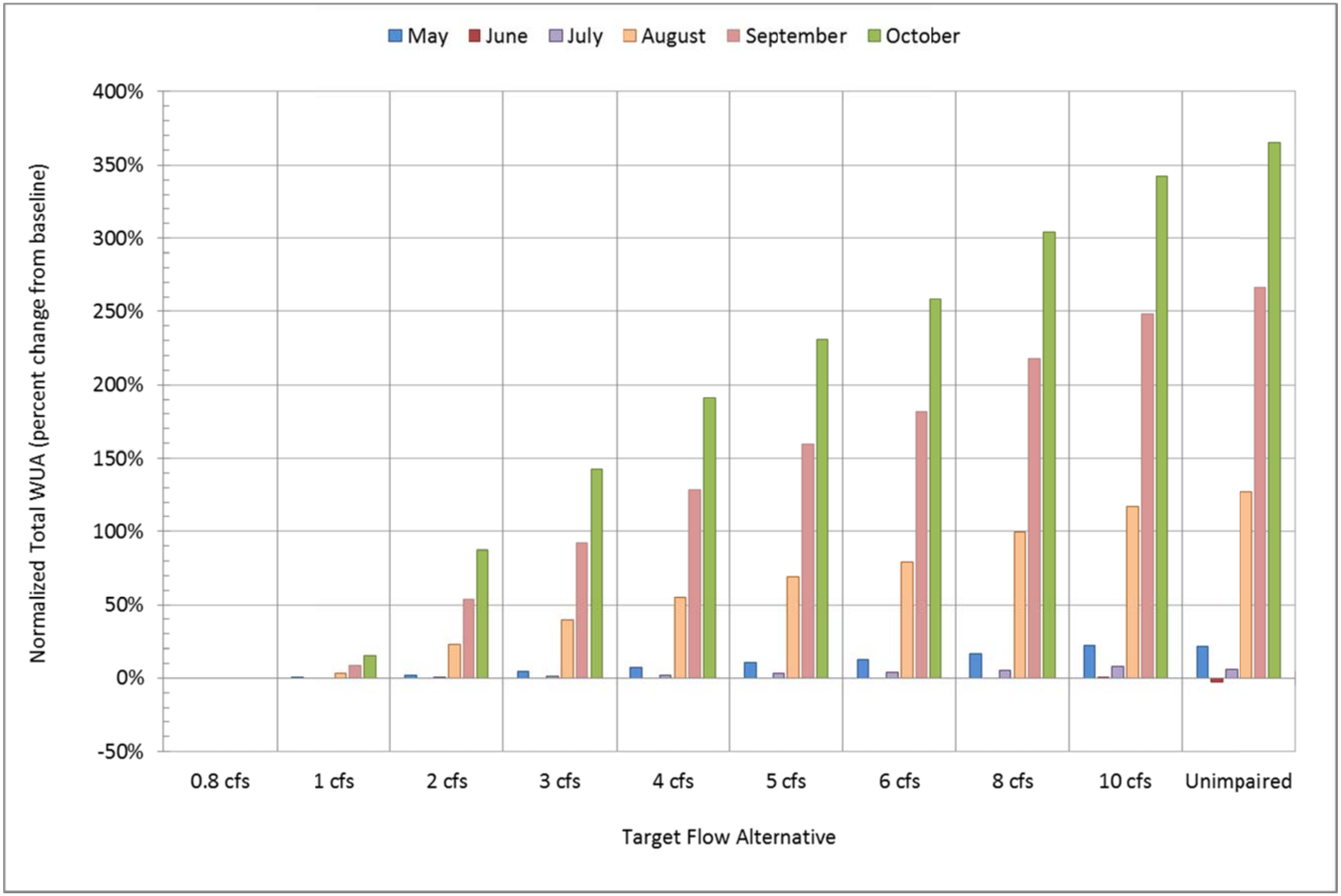

Figure 6. Total WUA, normalized as percent change over existing conditions (baseline minimum flow of 0.8 cfs), provided by selected minimum flow alternatives for adult bull trout.

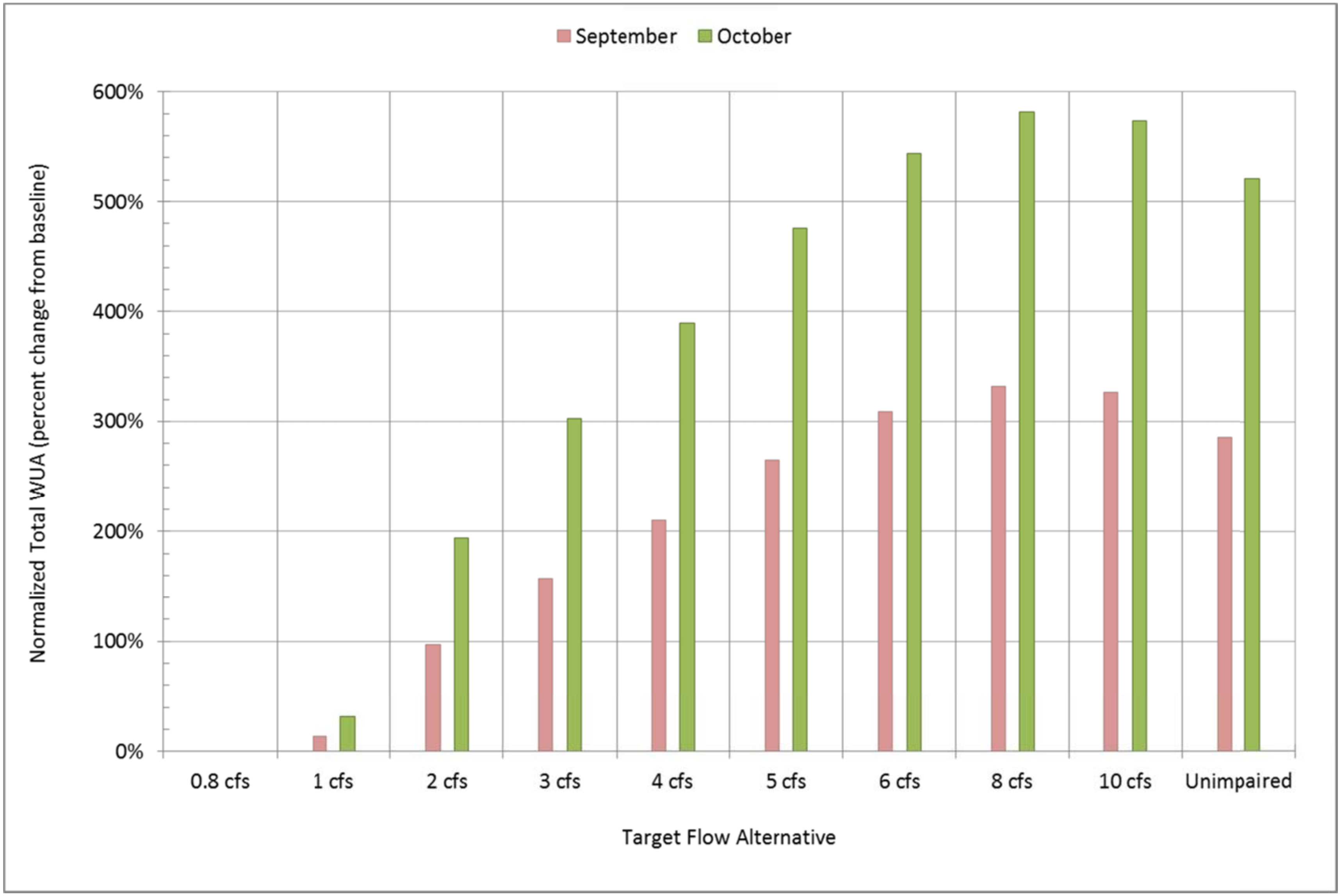

Figure 7. Total WUA, normalized as percent change over existing conditions (baseline minimum flow of 0.8 cfs), provided by selected minimum flow alternatives for spawning bull trout.

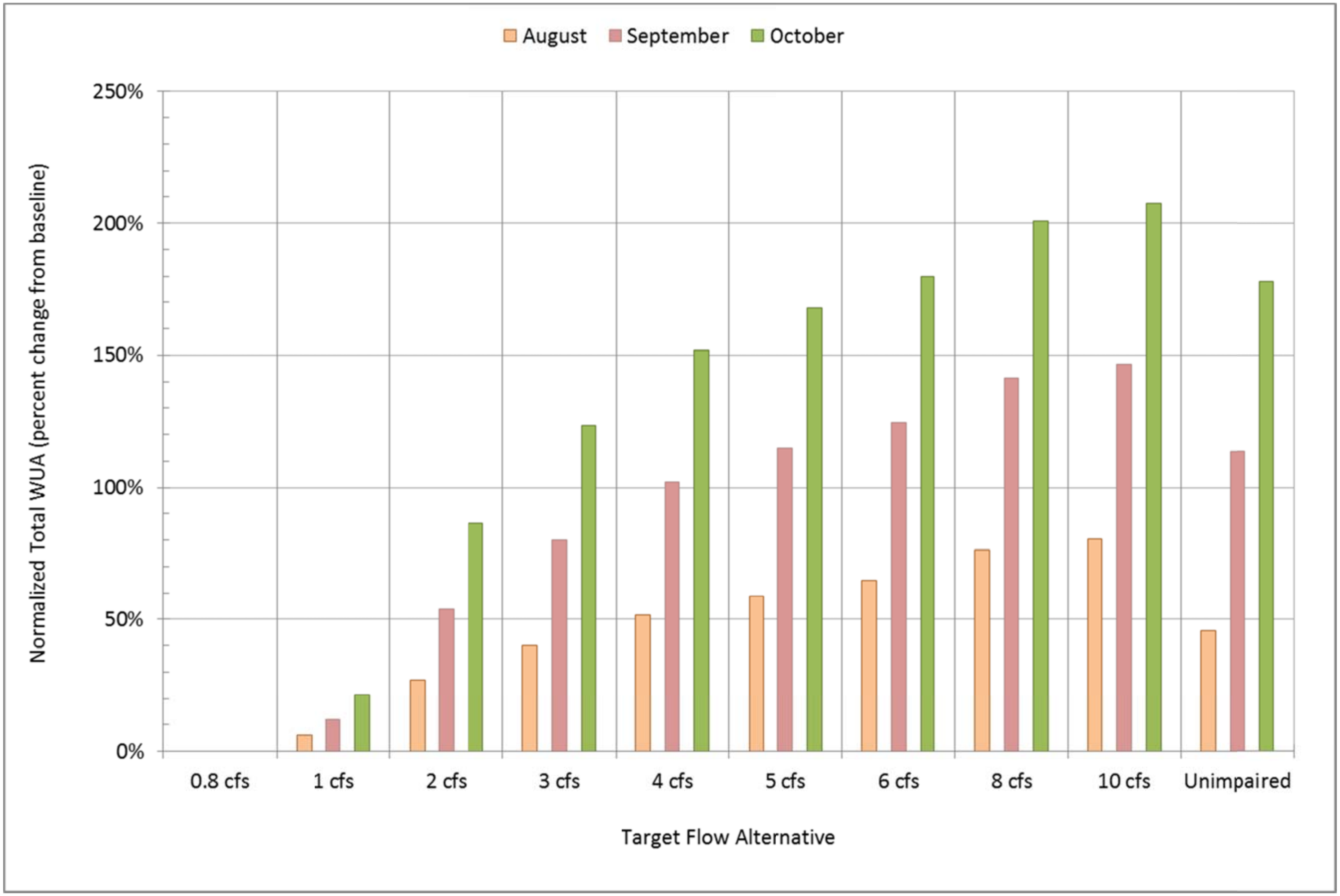

Figure 8. Total WUA, normalized as percent change over existing conditions (baseline minimum flow of 0.8 cfs), provided by selected minimum flow alternatives for spawning kokanee.

4.4 Wetted Perimeter versus Flow

Wetted perimeter increased most between minimum flows of 0.8 cfs and 2 cfs. As flows increased above 2 cfs, gains in wetted perimeter became progressively more gradual. The relationship between average wetted perimeter and flow in the study reach is illustrated in Figure 9. Although wetted perimeter was modeled up to flows of 40 cfs, Figure 9 displays wetted perimeter for flows up to 20 cfs. This upper limit was chosen because 20 cfs is approximately the maximum flow that is likely to occur during the baseflow months of November through April, when wetted perimeter is the relevant habitat metric.[6] The complete results for wetted perimeter, including the values for individual transects, are provided in Appendix G.

An important metric in the evaluation of wetted perimeter is the inflection point, or the flow at which the greatest incremental gain in wetted perimeter occurs. This point of diminishing returns represents the flow which fills the bottom of the stream channel. In principle, flows at or slightly above the inflection point flows provide conditions favorable to the winter ecology of bull trout discussed previously in the methods section 3.6 (wetted perimeter).

The average inflection point of the 13 transects occurred at 2 cfs (Figure 10). This flow represented an increase of 14 percent in average wetted perimeter, from 9.9 feet at 1 cfs to 11.2 feet at 2 cfs. Incremental gains in average wetted perimeter remained relatively high at flows of 3 cfs and 4 cfs, where the average incremental increases were 4.5 percent (0.5 feet) and 5.0 percent (0.6 feet), respectively. Incremental increases diminished steadily as flows increased, indicative of submersion of the channel margins and interstitial spaces.

On an individual transect basis, ten of the transects had inflection points at a flow of 2 cfs, one had an inflection point at 3 cfs, one had an inflection point at 4 cfs, and one had an inflection point at 5 cfs. The minimum inflection point occurred at transect number 13, where a two percent increase resulted when the wetted perimeter increased from 12.8 feet at 1 cfs to 13.1 feet at 2 cfs. The maximum individual inflection point occurred at transect number seven, where a 34 percent increase resulted when the wetted perimeter increased from 8.1 feet at 1 cfs to 10.9 feet at 2 cfs. Graphs of incremental gains in wetted perimeter are available for the individual transects in Appendix H.

Although 2 cfs provides the average inflection point for wetted perimeter, flows in the range of 3 cfs to 4 cfs are more likely to insure that stream wetted margins and substrate remain submerged throughout the study reach. Flows of 5 cfs or greater generally provide minimal additional increases to wetted perimeter, as the water surface is no longer flowing over previously-dry margins, but is rising up the banks. This principle is illustrated in Appendix I, where the profiles of the thirteen cross sections and selected simulations of water surface level are presented.

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[6] During the months of November through April, 20 cfs represents the 99th percentile of recorded, unimpaired flows, per the 45-year flow record utilized in this study. Flows greater than 20 cfs are likely to occur only 1 percent of the time, and therefore do not accurately portray the maximum wetted perimeter.

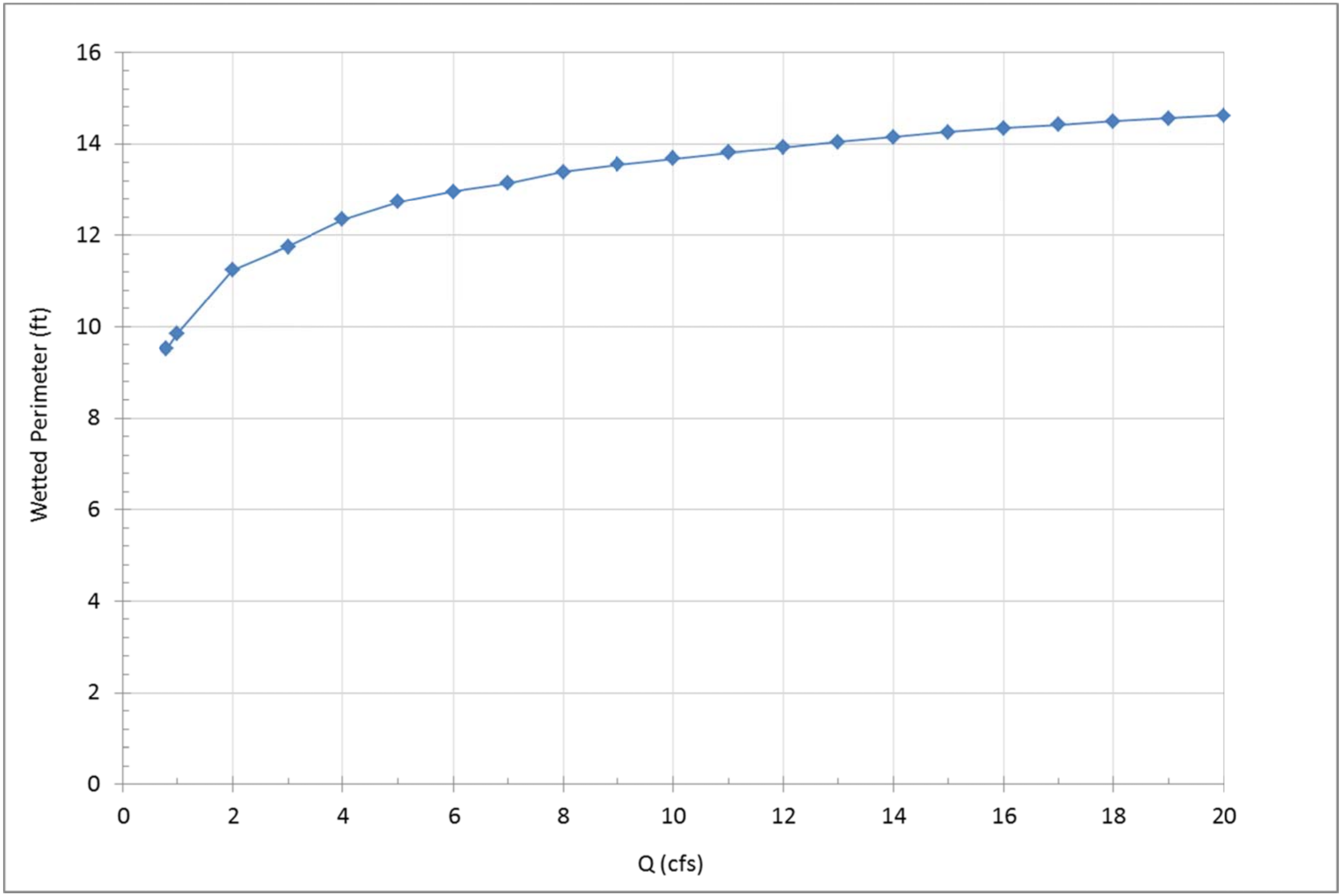

Figure 9. Average wetted perimeter of all transects versus flow in the Fork Wallowa bypass reach.

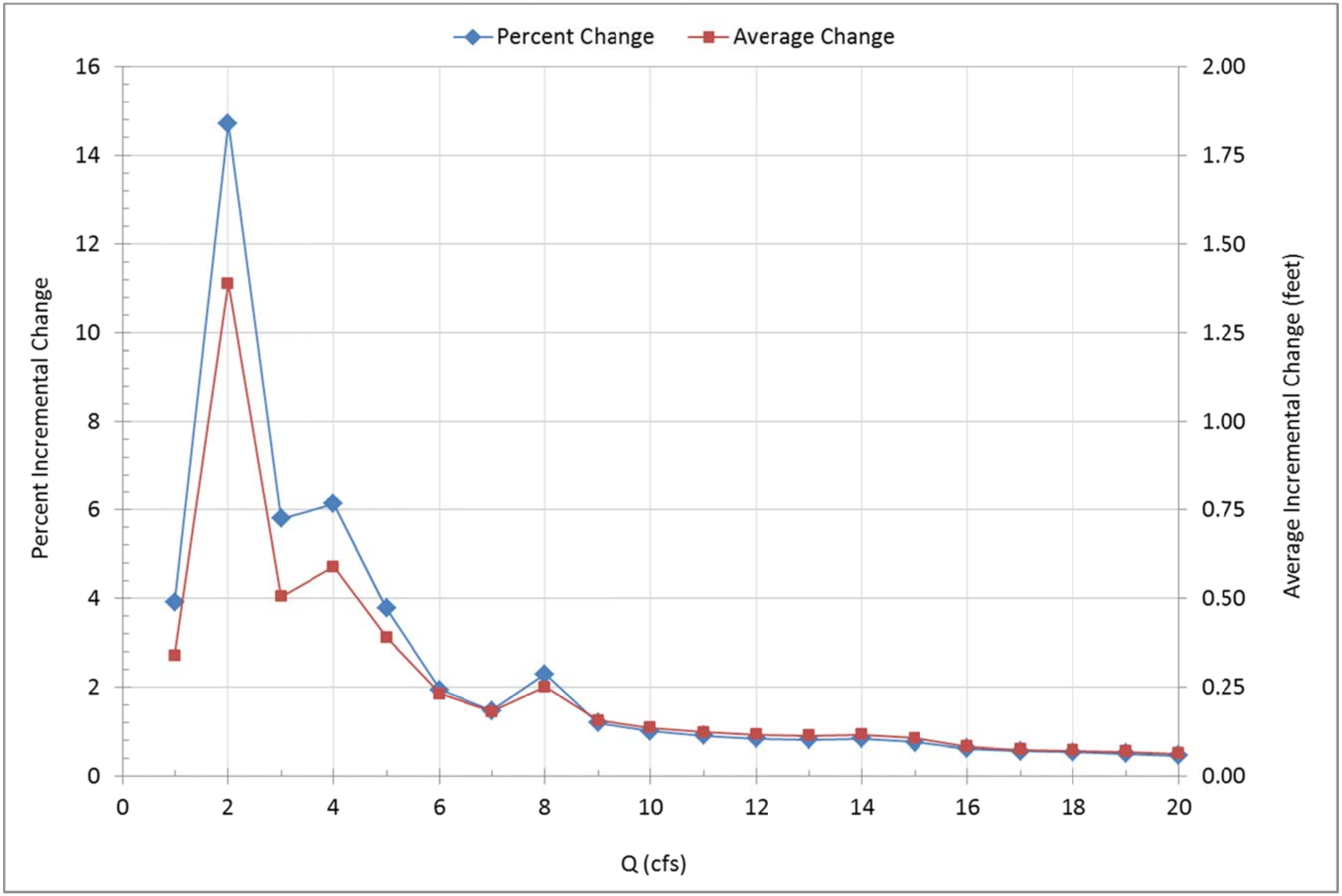

Figure 10. Average of percent increase in wetted perimeter per incremental increase in flow (note that the first increment of 0.8 cfs to 1 cfs represents a 0.2 cfs increase, whereas all remaining increments represent a 1.0 cfs increase).

5.0 CONCLUSIONS

The information collected from the IFIM study and professional judgment suggest the following regarding habitat for target species of bull trout and kokanee in the East Fork Wallowa bypass reach:

1. Channel morphology and steep gradient in the East Fork bypass reach create a velocity-driven system, where flow changes appear to be primarily a function of column velocity much more so than changes in water depth.
2. Mesohabitat consists primarily of riffle/rapid complex with large substrate. Habitat features such as pools, overhead cover, and spawning-sized substrate are rare.
3. Under existing minimum flow conditions, the total WUA index values are lowest for all four species/life stages evaluated. Total WUA for all four species/life stages would benefit from any increase above the existing minimum flow level.
4. For every lifestage examined, the total WUA inflection point (i.e. the target flow at which the rate in habitat increase began to decrease) occurred at 2 cfs.
5. For each of the species evaluated, increases in total WUA are most pronounced in October and September when natural flows are the lowest.
6. For adult and juvenile bull trout, total WUA changes in response to the various minimum flow alternatives are least pronounced during peak annual flows in June, when improvements over baseline are low or non-existent. Total WUA is also minimally influenced by the minimum flow alternatives in May and July.
7. A tailrace reroute scenario:
    a. results in total WUA levels that are greater than existing conditions during August, September, and October (particularly for adult bull trout, for which the unimpaired flows provide peak habitat);
    b. creates a high-velocity environment during the runoff months, which decreases total WUA over exiting conditions for juvenile bull trout (May, June, and July) and adult bull trout (June only), and presumably bull trout fry, although fry habitat was not evaluated in this study.
8. Spawning habitat for kokanee and bull trout stands to gain the most from increases in minimum flows, but lack of suitable substrate may be a limiting factor to spawning success.
9. Minimum flows between 4 and 5 cfs during September and October (the period of maximum spawning) can be sustained with certainty during the six-month period of baseflow, which will insure that incubating eggs, alevin, and fry of bull trout that are present upstream of the proposed tailrace discharge remain viable.
10. IFIM results cannot be applied directly to the area upstream of the proposed tailrace discharge point, due to the substantial differences in slope and channel geomorphology. However, the results may provide some indication of how WUA changes with flow upstream of the proposed tailrace discharge point. It is possible that

the inflection point also occurred at 2 cfs upstream of the proposed tailrace discharge point. By extension, it is also possible that a target flow of 4 cfs will provide WUA levels that differ little from those provided by a minimum flow of 5 cfs. A target flow of 4 cfs is proposed upstream of the tailrace discharge point for the following reasons:

a. Relatively low incremental increases in WUA are furnished by the additional 1 cfs for juvenile and adult bull trout;
b. Incremental increases furnished by the additional 1 cfs for spawning bull trout may be relatively higher, but there is a paucity of spawning gravel in the bypass reach, which is believed to limit spawning; and
c. Spawning kokanee are not able to access reaches of the stream above the proposed tailrace discharge point, and their habitat will not benefit from the additional 1 cfs.
d. Due to the steep gradient, confined channel, and abundance of exposed bedrock in this section of the bypassed reach, it is anticipated that additional flow of 1-2 cfs above the proposed target flow 4 cfs would not increase wetted width but simply increase turbulence and velocity.

11. Minimum flows during winter that range from 3 cfs to 5 cfs exceed the wetted perimeter inflection point, thereby protecting habitat of the overwintering life stages of bull trout. Flows greater than 5 cfs also exceed the wetted perimeter inflection point, but cannot be sustained with certainty during the winter. Therefore, minimum flows greater than 5 cfs may introduce an unnecessary risk of desiccation to incubating eggs, alevin and fry.

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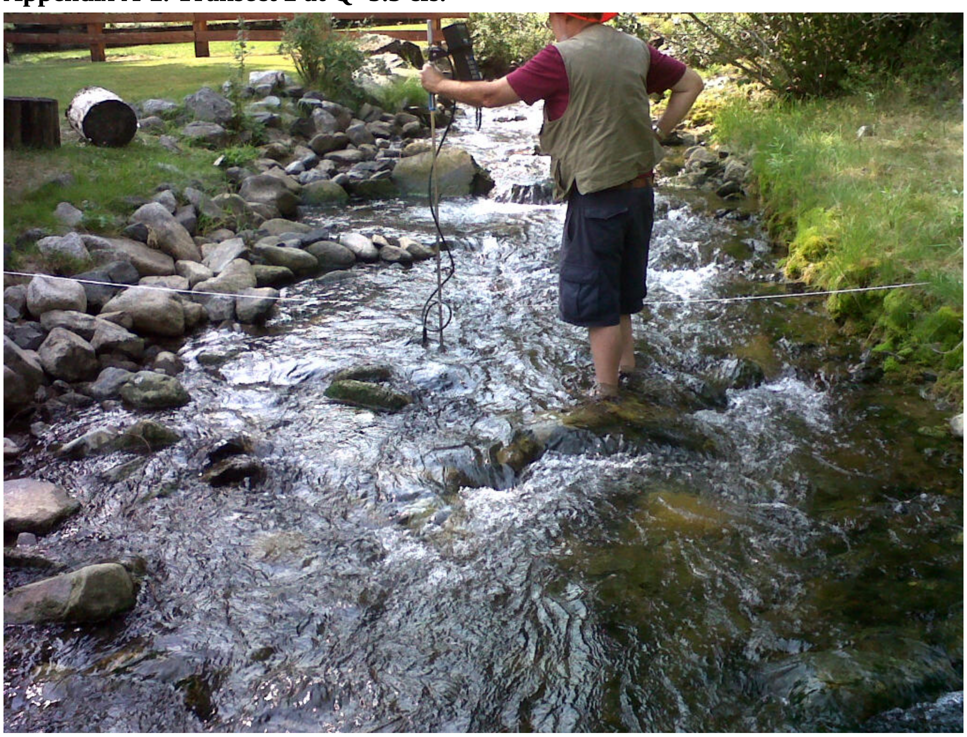
Appendix A. Images of Study Transects

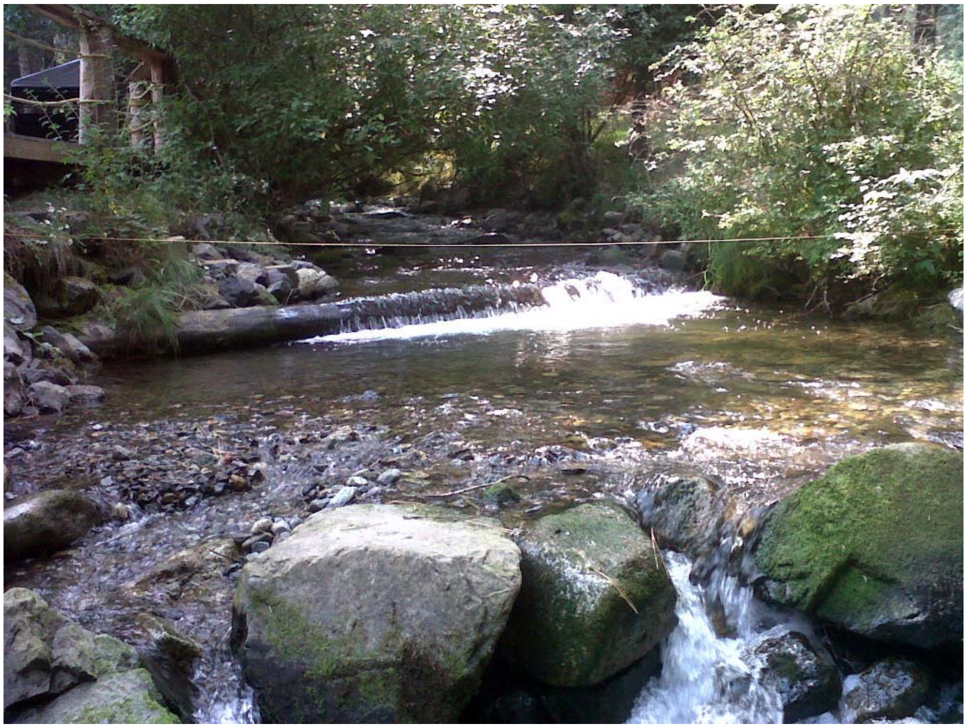
Appendix A-1. Transect 1 at Q=5.3 cfs.

Appendix A-2. Transect 2 at Q=5.3 cfs.



Appendix A-3. Transect 3 at Q=5.3 cfs.

Appendix A-4. Transect 4 at Q=5.3 cfs. Channel-spanning log blocks upstream access by Kokanee.



Appendix A-5. Transect 5 at Q=5.3 cfs.

Appendix A-6. Transect 6 at Q=5.3 cfs.

Appendix A-7. Transects 7 (foreground) and 8 (background) at 5.3 cfs.

Appendix A-8. Transect 9 at 5.3 cfs.

Appendix A-9. Transect 10 at 5.3 cfs.

Appendix A-10. Transect 11 at 5.3 cfs (photo taken looking downstream).

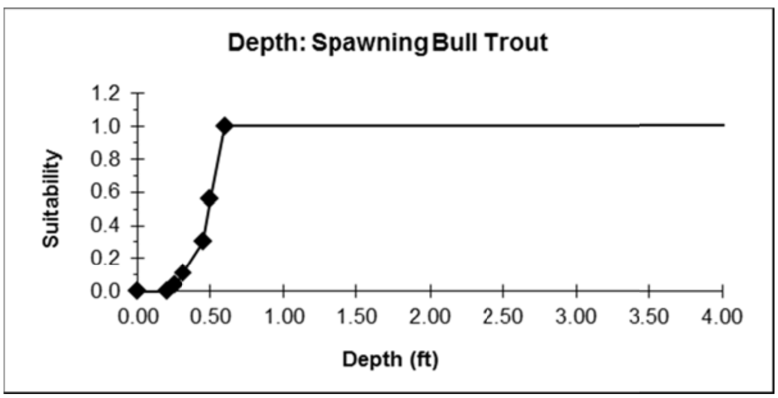
Appendix A-11. Transect 12 at 5.3 cfs.

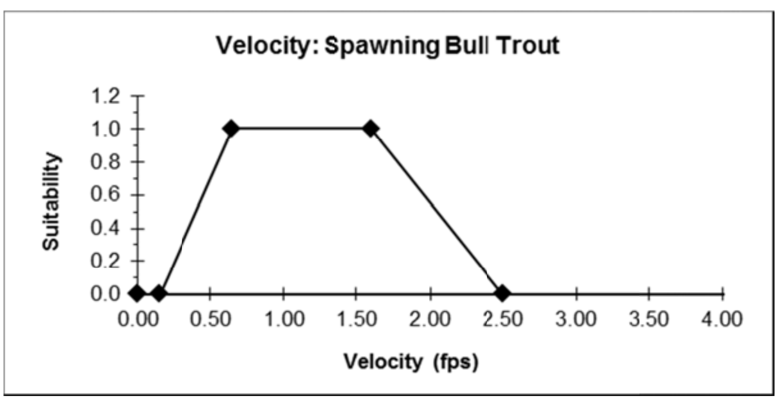
Appendix A-12. Transect 13 at 5.3 cfs.

Appendix A-13. Transect 14 at 5.3 cfs.

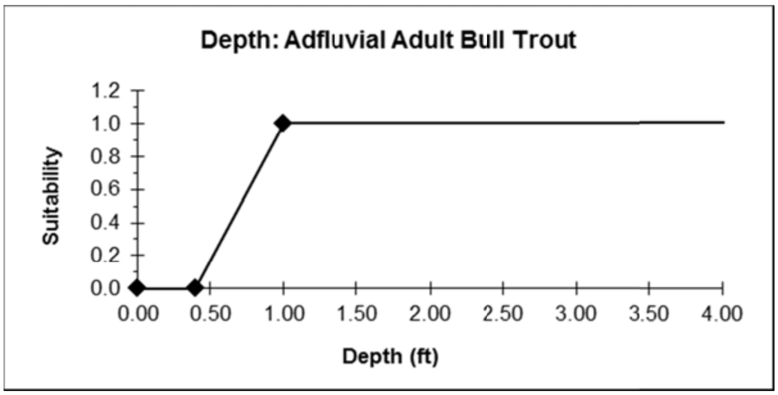
Appendix B. Habitat Suitability Criteria

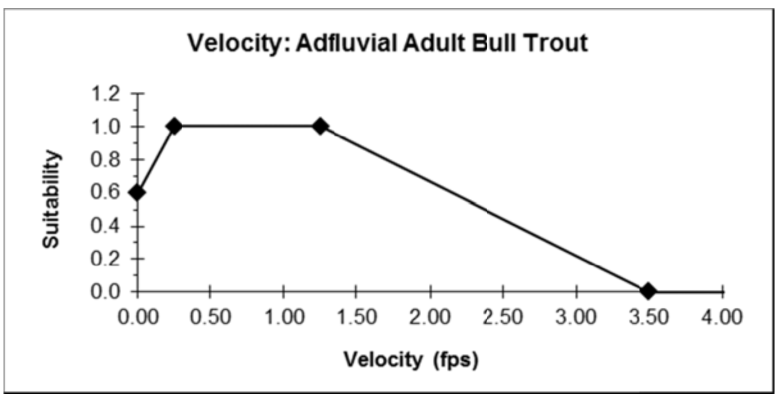
Bull Trout: Spawning			
DEPTH		**VELOCITY**	
Feet	**Suitability**	**FPS**	**Suitability**
0.00	0.00	0.00	0.00
0.20	0.00	0.15	0.00
0.25	0.04	0.65	1.00
0.31	0.11	1.60	1.00
0.45	0.30	2.50	0.00
0.50	0.56	4.50	0.00
0.60	1.00	10.00	0.00
100.00	1.00	0	0



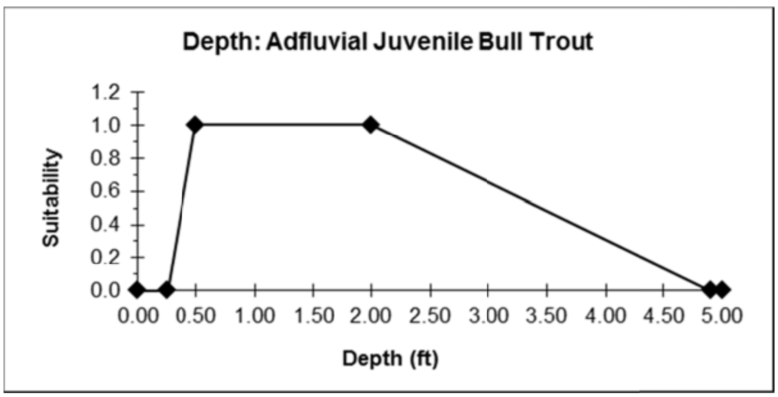


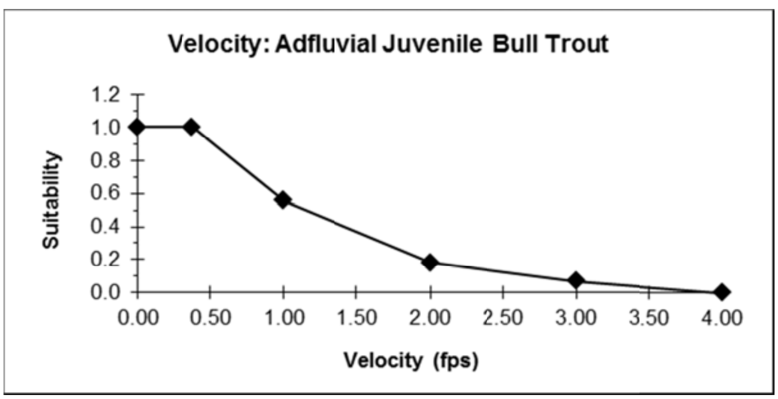
Bull Trout: Adult			
DEPTH		**VELOCITY**	
Feet	Suitability	FPS	Suitability
0.00	0.00	0.00	0.60
0.40	0.00	0.25	1.00
1.00	1.00	1.25	1.00
100	1	3.50	0.00
0.00	0.00	100.00	0.00



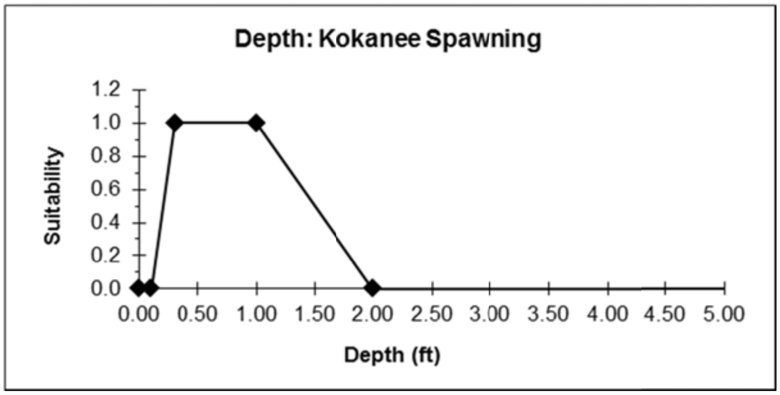


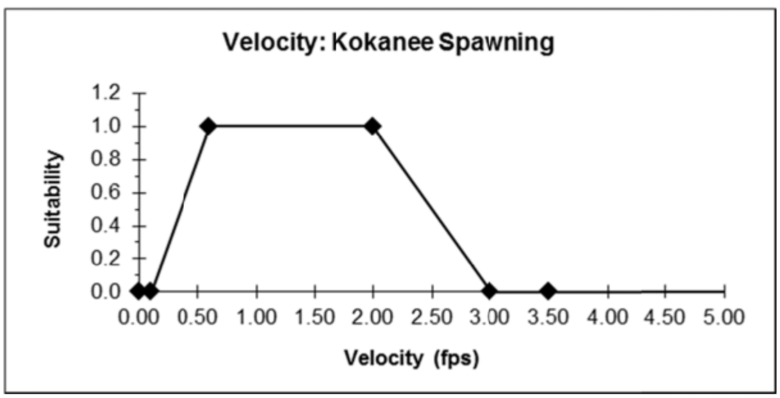
Bull Trout: Juvenile			
DEPTH		**VELOCITY**	
Feet	**Suitability**	**FPS**	**Suitability**
0.00	0.00	0.00	1.00
0.25	0.00	0.38	1.00
0.50	1.00	1.00	0.56
2.00	1.00	2.00	0.18
4.90	0.00	3.00	0.07
5.00	0.00	4.00	0.00
100.00	0.00	100.00	0.00





Kokanee: Spawning			
DEPTH		**VELOCITY**	
Feet	**Suitability**	**FPS**	**Suitability**
0.00	0.00	0.00	0.00
0.10	0.00	0.10	0.00
0.30	1.00	0.60	1.00
1.00	1.00	2.00	1.00
2.00	0.00	3.00	0.00
100.00	0.00	3.50	0.00
0	0	100.00	0.00





Appendix C. Water Surface Level (WSL) Calibration Results

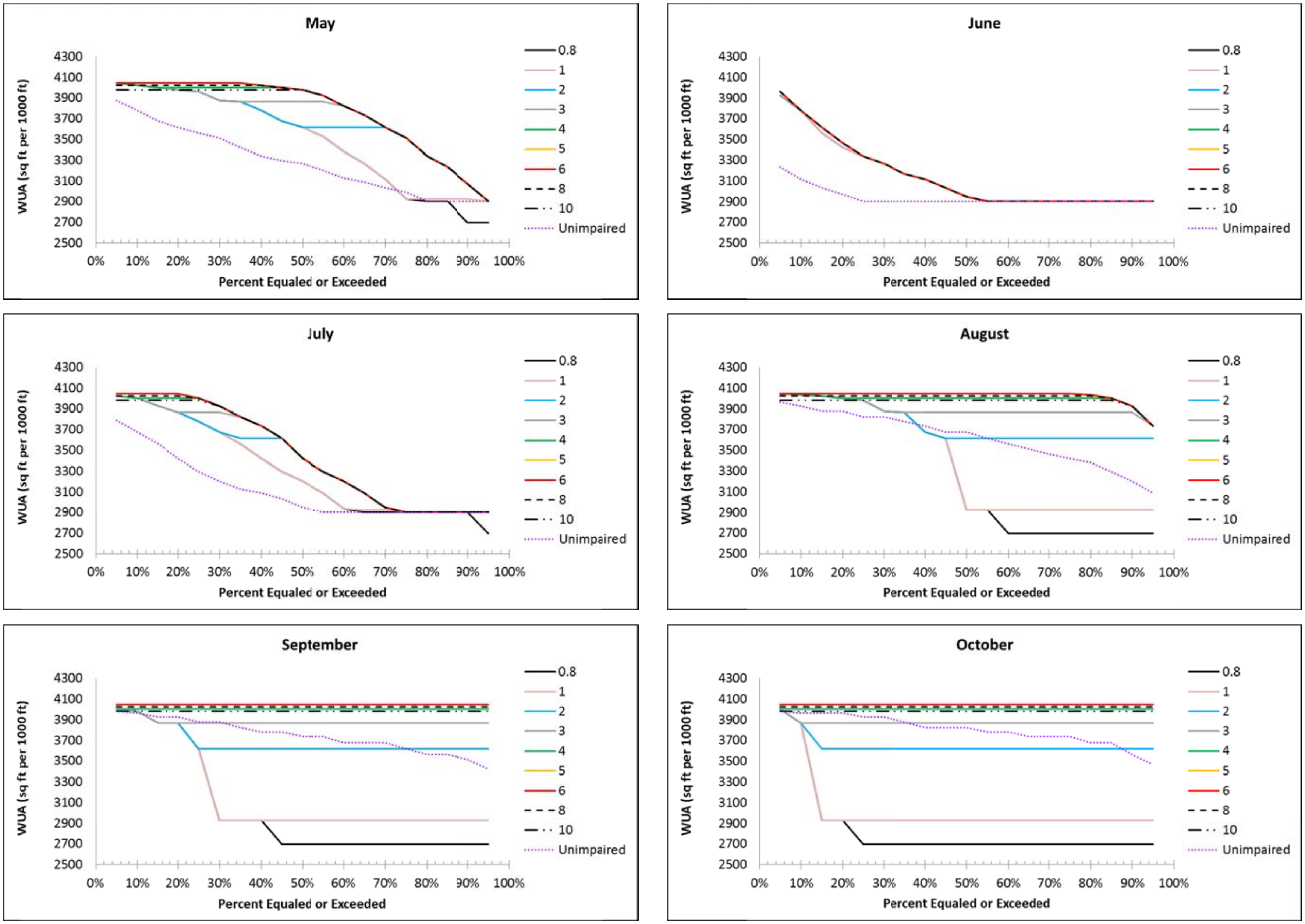
Transect No.	Calibration Q: 5.3 cfs			Calibration Q: 8.5 cfs			Calibration Q: 15 cfs		
	Obs. WSL (ft)	Cal. WSL (ft)	$\Delta_{(Cal-Obs)}$	Obs. WSL (ft)	Cal. WSL (ft)	$\Delta_{(Cal-Obs)}$	Obs. WSL (ft)	Cal. WSL (ft)	$\Delta_{(Cal-Obs)}$
1	4468.215	4468.204	-0.011	4468.265	4468.283	0.018	4468.400	4468.394	-0.006
2	4468.425	4468.420	-0.004	4468.530	4468.539	0.009	4468.710	4468.706	-0.004
3	4473.680	4473.665	-0.016	4473.745	4473.770	0.024	4473.920	4473.912	-0.008
4	4477.850	4477.854	0.004	4477.970	4477.961	-0.009	4478.105	4478.110	0.005
5	4480.750	4480.735	-0.015	4480.810	4480.833	0.023	4480.970	4480.963	-0.007
6	4484.225	4484.207	-0.019	4484.250	4484.274	0.024	4484.370	4484.365	-0.005
7	4484.170	4484.180	0.010	4484.290	4484.288	-0.002	4484.440	4484.443	0.003
8	4484.910	4484.902	-0.008	4485.030	4485.045	0.015	4485.250	4485.243	-0.007
9	4506.555	4506.544	-0.011	4506.626	4506.612	-0.014	4506.705	4506.700	-0.005
11	4510.000	4509.989	-0.011	4510.080	4510.099	0.019	4510.257	4510.250	-0.007
12	4514.490	4514.509	0.019	4514.580	4514.597	0.017	4514.720	4514.713	-0.007
13	4522.280	4522.280	0.000	4522.350	4522.379	0.029	4522.515	4522.515	0.000
14	4532.825	4532.811	-0.015	4532.850	4532.907	0.057	4533.035	4533.038	0.002

Appendix D. WUA vs. Flow Relationships

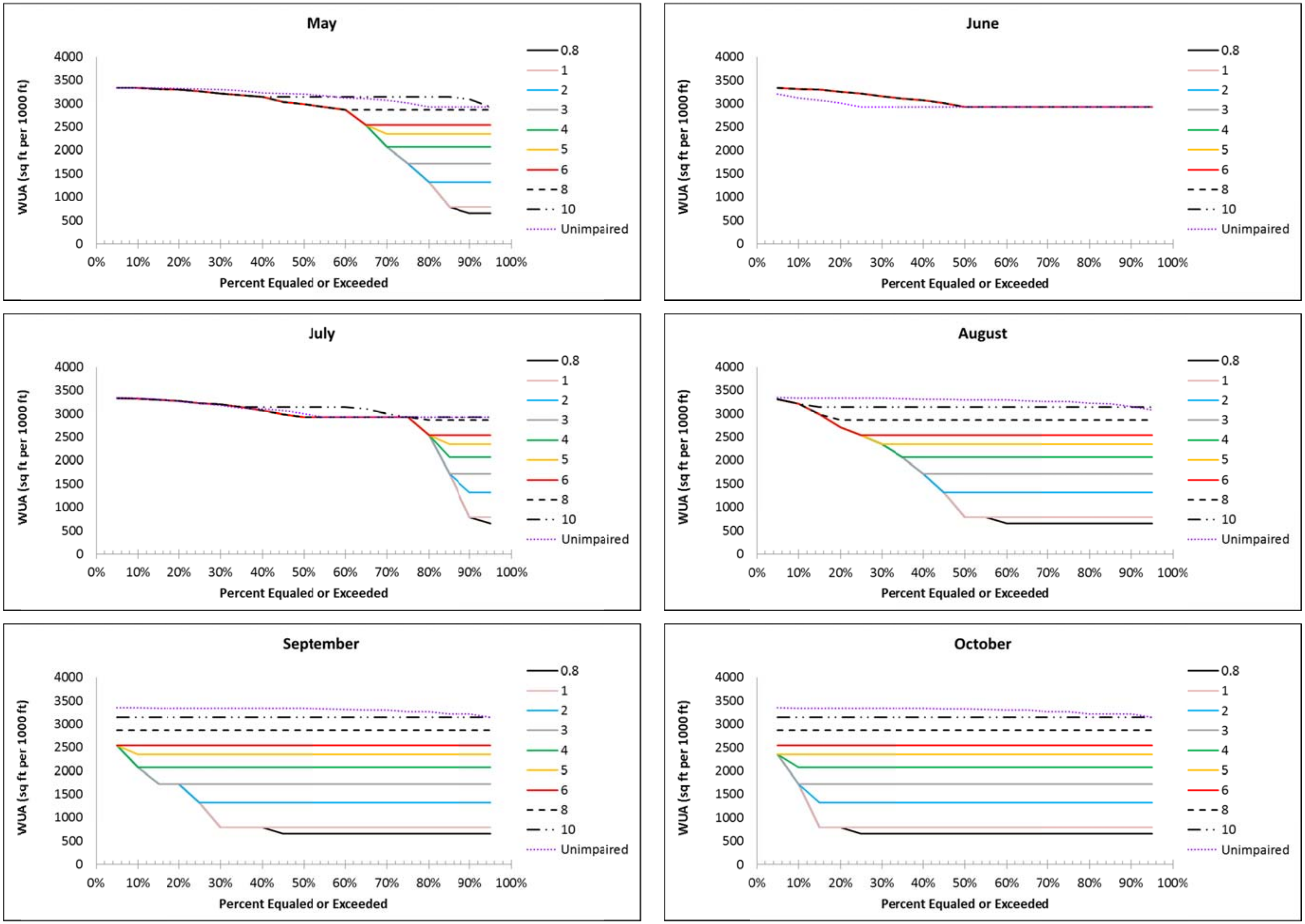
Q (cfs)	WUA (ft^2 per 1000 ft):			
	Adult Bull Trout	Juvenile Bull Trout	Spawning Bull Trout	Spawning Kokanee
0.8	662	2697	653	3076
1	790	2926	955	3869
2	1317	3618	2206	5988
3	1724	3866	3069	6938
4	2066	4003	3725	7790
5	2346	4049	4384	8523
6	2543	4069	4905	9272
7	2711	4036	5137	9684
8	2840	4022	5191	9962
9	2947	4004	5182	10112
10	3033	3982	5126	10188
11	3150	3963	5020	10090
12	3204	3929	4906	9910
13	3241	3878	4803	9650
14	3265	3825	4714	9337
15	3279	3779	4645	9004
16	3343	3733	4586	8671
17	3346	3677	4525	8342
18	3341	3619	4455	8022
19	3334	3565	4373	7738
20	3319	3514	4314	7463
25	3226	3298	4095	6557
30	3109	3127	3811	5998
40	2931	2906	3339	4992

Appendix E. Habitat Duration Curves

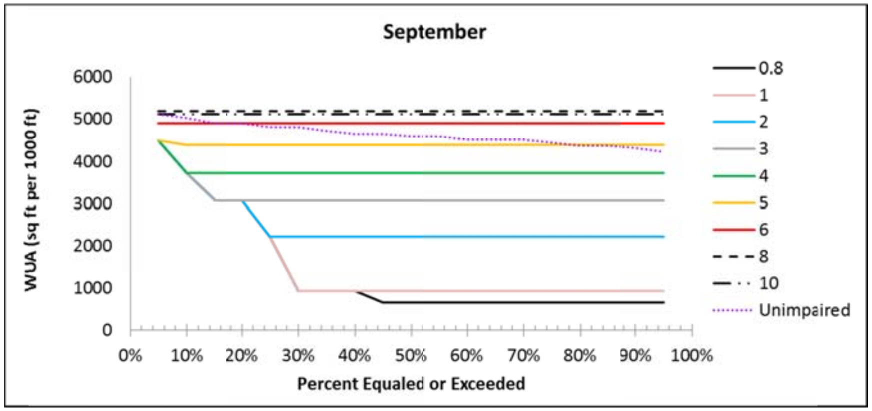
Appendix E-1. Habitat duration curves for juvenile bull trout.

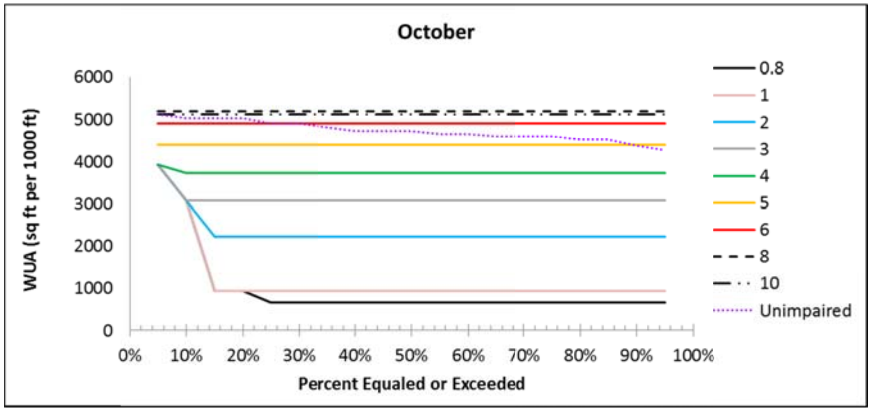


Appendix E-2. Habitat duration curves for adult bull trout.

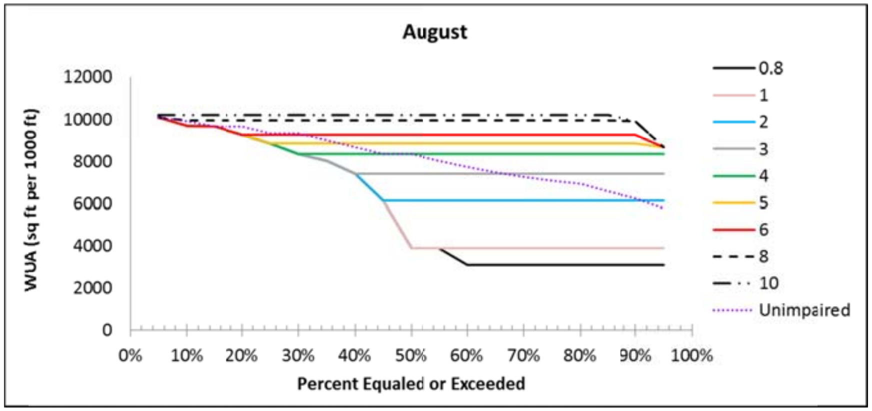


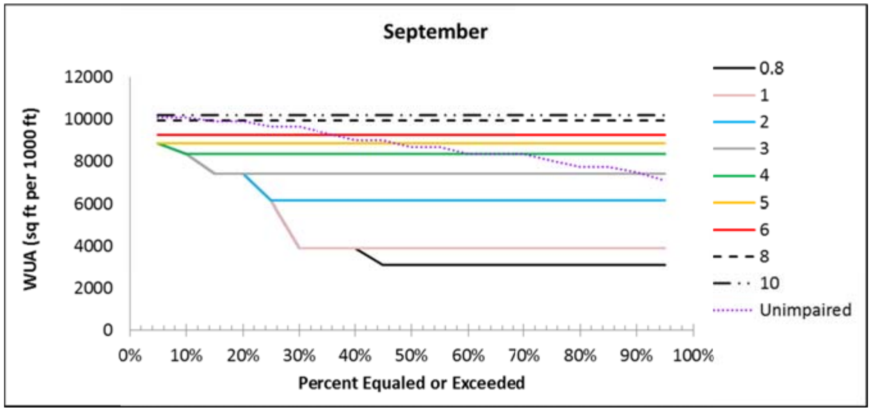
Appendix E-3. Habitat duration curves for spawning bull trout.

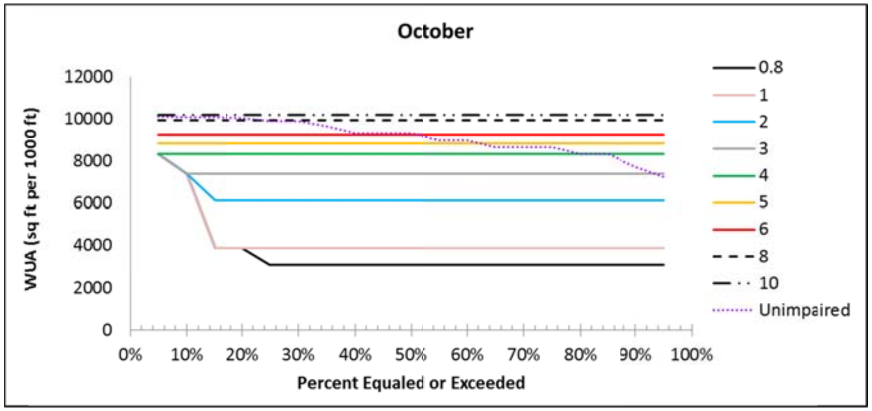




Appendix E-4. Habitat duration curves for spawning kokanee.







Appendix F. Habitat Duration Tables

Appendix F-1. Habitat duration tables for juvenile bull trout.

Month: 5		1395	(n)								
	Exceedence	0.8 cfs	1 cfs	2 cfs	3 cfs	4 cfs	5 cfs	6 cfs	8 cfs	10 cfs	Unimpaired
	5%	4048	4048	4048	4048	4048	4049	4048	4022	3982	3878
	10%	4022	4022	4022	4022	4022	4049	4048	4022	3982	3779
	15%	4004	4004	4004	4004	4004	4049	4048	4022	3982	3677
	20%	3982	3982	3982	3982	4003	4049	4048	4022	3982	3619
	25%	3963	3963	3963	3963	4003	4049	4048	4022	3982	3565
	30%	3878	3878	3878	3878	4003	4049	4048	4022	3982	3514
	35%	3866	3866	3866	3866	4003	4048	4048	4022	3982	3422
	40%	3779	3779	3779	3866	4003	4022	4022	4022	3982	3341
	45%	3677	3677	3677	3866	4003	4004	4004	4004	3982	3298
	50%	3618	3618	3618	3866	3982	3982	3982	3982	3982	3269
	55%	3529	3529	3618	3866	3929	3929	3929	3929	3929	3203
	60%	3381	3381	3618	3825	3825	3825	3825	3825	3825	3127
	65%	3269	3269	3618	3733	3733	3733	3733	3733	3733	3088
	70%	3117	3117	3618	3619	3619	3619	3619	3619	3619	3037
	75%	2926	2926	3514	3514	3514	3514	3514	3514	3514	2990
	80%	2906	2926	3341	3341	3341	3341	3341	3341	3341	2906
	85%	2906	2926	3235	3235	3235	3235	3235	3235	3235	2906
	90%	2697	2926	3072	3072	3072	3072	3072	3072	3072	2906
	95%	2697	2906	2906	2906	2906	2906	2906	2906	2906	2906

Month: 6		1350	(n)								
	Exceedence	0.8	1	2	3	4	5	6	8	10	Unimpaired
	5%	3929	3929	3929	3929	3963	3963	3963	3963	3963	3235
	10%	3779	3779	3779	3779	3779	3779	3779	3779	3779	3115
	15%	3565	3565	3618	3619	3619	3619	3619	3619	3619	3037
	20%	3422	3422	3466	3466	3466	3466	3466	3466	3466	2968
	25%	3341	3341	3341	3341	3341	3341	3341	3341	3341	2906
	30%	3269	3269	3269	3269	3269	3269	3269	3269	3269	2906
	35%	3172	3172	3172	3172	3172	3172	3172	3172	3172	2906
	40%	3115	3115	3115	3115	3115	3115	3115	3115	3115	2906
	45%	3036	3036	3037	3037	3037	3037	3037	3037	3037	2906
	50%	2946	2946	2946	2946	2946	2946	2946	2946	2946	2906
	55%	2906	2906	2906	2906	2906	2906	2906	2906	2906	2906
	60%	2906	2906	2906	2906	2906	2906	2906	2906	2906	2906
	65%	2906	2906	2906	2906	2906	2906	2906	2906	2906	2906
	70%	2906	2906	2906	2906	2906	2906	2906	2906	2906	2906
	75%	2906	2906	2906	2906	2906	2906	2906	2906	2906	2906
	80%	2906	2906	2906	2906	2906	2906	2906	2906	2906	2906
	85%	2906	2906	2906	2906	2906	2906	2906	2906	2906	2906
	90%	2906	2906	2906	2906	2906	2906	2906	2906	2906	2906
	95%	2906	2906	2906	2906	2906	2906	2906	2906	2906	2906

Month: 7		1395	(n)								
	Exceedence	0.8	1	2	3	4	5	6	8	10	Unimpaired
	5%	4022	4022	4022	4022	4022	4049	4048	4022	3982	3793
	10%	4003	4003	4003	4003	4003	4049	4048	4022	3982	3677
	15%	3929	3929	3929	3929	4003	4049	4048	4022	3982	3565
	20%	3866	3866	3866	3866	4003	4048	4048	4022	3982	3422
	25%	3779	3779	3779	3866	4003	4004	4004	4004	3982	3298
	30%	3677	3677	3677	3866	3929	3929	3929	3929	3929	3203
	35%	3565	3565	3618	3825	3825	3825	3825	3825	3825	3127
	40%	3422	3422	3618	3733	3733	3733	3733	3733	3733	3088
	45%	3298	3298	3618	3619	3619	3619	3619	3619	3619	3037
	50%	3203	3203	3422	3422	3422	3422	3422	3422	3422	2946
	55%	3088	3088	3298	3298	3298	3298	3298	3298	3298	2906
	60%	2938	2938	3203	3203	3203	3203	3203	3203	3203	2906
	65%	2906	2926	3088	3088	3088	3088	3088	3088	3088	2906
	70%	2906	2926	2946	2946	2946	2946	2946	2946	2946	2906
	75%	2906	2906	2906	2906	2906	2906	2906	2906	2906	2906
	80%	2906	2906	2906	2906	2906	2906	2906	2906	2906	2906
	85%	2906	2906	2906	2906	2906	2906	2906	2906	2906	2906
	90%	2906	2906	2906	2906	2906	2906	2906	2906	2906	2906
	95%	2697	2906	2906	2906	2906	2906	2906	2906	2906	2906

Month:	8		1395	(n)							
		Exceedence	0.8	1	2	3	4	5	6	8	10	Unimpaired
		5%	4048	4048	4048	4048	4048	4049	4048	4022	3982	3963
		10%	4036	4036	4036	4036	4036	4049	4048	4022	3982	3929
		15%	4022	4022	4022	4022	4022	4049	4048	4022	3982	3878
		20%	4003	4003	4003	4003	4003	4049	4048	4022	3982	3878
		25%	3982	3982	3982	3982	4003	4049	4048	4022	3982	3825
		30%	3878	3878	3878	3878	4003	4049	4048	4022	3982	3825
		35%	3866	3866	3866	3866	4003	4049	4048	4022	3982	3779
		40%	3677	3677	3677	3866	4003	4049	4048	4022	3982	3733
		45%	3618	3618	3618	3866	4003	4049	4048	4022	3982	3677
		50%	2926	2926	3618	3866	4003	4049	4048	4022	3982	3677
		55%	2926	2926	3618	3866	4003	4049	4048	4022	3982	3619
		60%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3565
		65%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3514
		70%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3466
		75%	2697	2926	3618	3866	4003	4048	4048	4022	3982	3422
		80%	2697	2926	3618	3866	4003	4036	4036	4022	3982	3381
		85%	2697	2926	3618	3866	4003	4004	4004	4004	3982	3298
		90%	2697	2926	3618	3866	3929	3929	3929	3929	3929	3203
		95%	2697	2926	3618	3733	3733	3733	3733	3733	3733	3088

Month:	9		1350	(n)							
		Exceedence	0.8	1	2	3	4	5	6	8	10	Unimpaired
		5%	4004	4004	4004	4004	4004	4049	4048	4022	3982	3982
		10%	3982	3982	3982	3982	4003	4049	4048	4022	3982	3963
		15%	3866	3866	3866	3866	4003	4049	4048	4022	3982	3929
		20%	3866	3866	3866	3866	4003	4049	4048	4022	3982	3929
		25%	3618	3618	3618	3866	4003	4049	4048	4022	3982	3878
		30%	2926	2926	3618	3866	4003	4049	4048	4022	3982	3878
		35%	2926	2926	3618	3866	4003	4049	4048	4022	3982	3825
		40%	2926	2926	3618	3866	4003	4049	4048	4022	3982	3779
		45%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3779
		50%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3733
		55%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3733
		60%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3677
		65%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3677
		70%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3677
		75%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3619
		80%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3565
		85%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3565
		90%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3514
		95%	2697	2926	3618	3866	4003	4048	4048	4022	3982	3422

Month:	10		1395	(n)							
		Exceedence	0.8	1	2	3	4	5	6	8	10	Unimpaired
		5%	4003	4003	4003	4003	4003	4049	4048	4022	3982	3982
		10%	3866	3866	3866	3866	4003	4049	4048	4022	3982	3963
		15%	2926	2926	3618	3866	4003	4049	4048	4022	3982	3963
		20%	2926	2926	3618	3866	4003	4049	4048	4022	3982	3963
		25%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3929
		30%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3929
		35%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3878
		40%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3825
		45%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3825
		50%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3825
		55%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3779
		60%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3779
		65%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3733
		70%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3733
		75%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3733
		80%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3677
		85%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3677
		90%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3565
		95%	2697	2926	3618	3866	4003	4049	4048	4022	3982	3466

Appendix F-2. Habitat duration tables for adult bull trout.

Month:	5		1395	(n)								
		Exceedence	0.8 cfs	1 cfs	2 cfs	3 cfs	4 cfs	5 cfs	6 cfs	8 cfs	10 cfs	Unimpaired
		5%	3341	3341	3341	3341	3341	3341	3341	3341	3341	3343
		10%	3334	3334	3334	3334	3334	3334	3334	3334	3334	3341
		15%	3319	3319	3319	3319	3319	3319	3319	3319	3319	3338
		20%	3302	3302	3302	3302	3302	3302	3302	3302	3302	3326
		25%	3266	3266	3266	3266	3266	3266	3266	3266	3266	3319
		30%	3221	3221	3221	3221	3221	3221	3221	3221	3221	3299
		35%	3183	3183	3183	3183	3183	3183	3183	3183	3183	3280
		40%	3143	3143	3143	3143	3143	3143	3143	3143	3143	3226
		45%	3034	3034	3034	3034	3034	3034	3034	3034	3143	3221
		50%	2988	2988	2988	2988	2988	2988	2988	2988	3143	3202
		55%	2931	2931	2931	2931	2931	2931	2931	2931	3143	3169
		60%	2870	2870	2870	2870	2870	2870	2870	2870	3143	3126
		65%	2543	2543	2543	2543	2543	2543	2543	2870	3143	3107
		70%	2066	2066	2066	2066	2066	2346	2543	2870	3143	3070
		75%	1724	1724	1724	1724	2066	2346	2543	2870	3143	3015
		80%	1317	1317	1317	1724	2066	2346	2543	2870	3143	2931
		85%	790	790	1317	1724	2066	2346	2543	2870	3143	2931
		90%	662	790	1317	1724	2066	2346	2543	2870	3096	2931
		95%	662	790	1317	1724	2066	2346	2543	2870	2931	2931

Month:	6		1350	(n)								
		Exceedence	0.8	1	2	3	4	5	6	8	10	Unimpaired
		5%	3338	3338	3338	3338	3338	3338	3338	3338	3338	3202
		10%	3319	3319	3319	3319	3319	3319	3319	3319	3319	3126
		15%	3299	3299	3299	3299	3299	3299	3299	3299	3299	3070
		20%	3260	3260	3260	3260	3260	3260	3260	3260	3260	3015
		25%	3221	3221	3221	3221	3221	3221	3221	3221	3221	2931
		30%	3164	3164	3164	3164	3164	3164	3164	3164	3164	2931
		35%	3109	3109	3109	3109	3109	3109	3109	3109	3143	2931
		40%	3070	3070	3070	3070	3070	3070	3070	3070	3109	2931
		45%	3015	3015	3015	3015	3015	3015	3015	3015	3070	2931
		50%	2931	2931	2931	2931	2931	2931	2931	2931	2997	2931
		55%	2931	2931	2931	2931	2931	2931	2931	2931	2931	2931
		60%	2931	2931	2931	2931	2931	2931	2931	2931	2931	2931
		65%	2931	2931	2931	2931	2931	2931	2931	2931	2931	2931
		70%	2931	2931	2931	2931	2931	2931	2931	2931	2931	2931
		75%	2931	2931	2931	2931	2931	2931	2931	2931	2931	2931
		80%	2931	2931	2931	2931	2931	2931	2931	2931	2931	2931
		85%	2931	2931	2931	2931	2931	2931	2931	2931	2931	2931
		90%	2931	2931	2931	2931	2931	2931	2931	2931	2931	2931
		95%	2931	2931	2931	2931	2931	2931	2931	2931	2931	2931

Month:	7		1395	(n)								
		Exceedence	0.8	1	2	3	4	5	6	8	10	Unimpaired
		5%	3341	3341	3341	3341	3341	3341	3341	3341	3341	3341
		10%	3326	3326	3326	3326	3326	3326	3326	3326	3326	3334
		15%	3302	3302	3302	3302	3302	3302	3302	3302	3302	3317
		20%	3280	3280	3280	3280	3280	3280	3280	3280	3280	3266
		25%	3226	3226	3226	3226	3226	3226	3226	3226	3226	3226
		30%	3202	3202	3202	3202	3202	3202	3202	3202	3202	3183
		35%	3143	3143	3143	3143	3143	3143	3143	3143	3143	3126
		40%	3070	3070	3070	3070	3070	3070	3070	3070	3143	3107
		45%	2988	2988	2988	2988	2988	2988	2988	2988	3143	3070
		50%	2931	2931	2931	2931	2931	2931	2931	2931	3143	2997
		55%	2931	2931	2931	2931	2931	2931	2931	2931	3143	2931
		60%	2931	2931	2931	2931	2931	2931	2931	2931	3143	2931
		65%	2931	2931	2931	2931	2931	2931	2931	2931	3107	2931
		70%	2931	2931	2931	2931	2931	2931	2931	2931	2997	2931
		75%	2931	2931	2931	2931	2931	2931	2931	2931	2931	2931
		80%	2543	2543	2543	2543	2543	2543	2543	2870	2931	2931
		85%	1724	1724	1724	1724	2066	2346	2543	2870	2931	2931
		90%	790	790	1317	1724	2066	2346	2543	2870	2931	2931
		95%	662	790	1317	1724	2066	2346	2543	2870	2931	2931

Month: 8	1395	(n)								
Exceedence	0.8	1	2	3	4	5	6	8	10	Unimpaired
5%	3319	3319	3319	3319	3319	3319	3319	3319	3319	3346
10%	3213	3213	3213	3213	3213	3213	3213	3213	3213	3343
15%	2988	2988	2988	2988	2988	2988	2988	2988	3143	3341
20%	2711	2711	2711	2711	2711	2711	2711	2870	3143	3338
25%	2543	2543	2543	2543	2543	2543	2543	2870	3143	3334
30%	2346	2346	2346	2346	2346	2346	2543	2870	3143	3334
35%	2066	2066	2066	2066	2066	2346	2543	2870	3143	3326
40%	1724	1724	1724	1724	2066	2346	2543	2870	3143	3319
45%	1317	1317	1317	1724	2066	2346	2543	2870	3143	3319
50%	790	790	1317	1724	2066	2346	2543	2870	3143	3302
55%	790	790	1317	1724	2066	2346	2543	2870	3143	3302
60%	662	790	1317	1724	2066	2346	2543	2870	3143	3299
65%	662	790	1317	1724	2066	2346	2543	2870	3143	3280
70%	662	790	1317	1724	2066	2346	2543	2870	3143	3266
75%	662	790	1317	1724	2066	2346	2543	2870	3143	3266
80%	662	790	1317	1724	2066	2346	2543	2870	3143	3226
85%	662	790	1317	1724	2066	2346	2543	2870	3143	3213
90%	662	790	1317	1724	2066	2346	2543	2870	3143	3164
95%	662	790	1317	1724	2066	2346	2543	2870	3143	3089

Month: 9	1350	(n)								
Exceedence	0.8	1	2	3	4	5	6	8	10	Unimpaired
5%	2543	2543	2543	2543	2543	2543	2543	2870	3143	3346
10%	2066	2066	2066	2066	2066	2346	2543	2870	3143	3346
15%	1724	1724	1724	1724	2066	2346	2543	2870	3143	3343
20%	1724	1724	1724	1724	2066	2346	2543	2870	3143	3343
25%	1317	1317	1317	1724	2066	2346	2543	2870	3143	3341
30%	790	790	1317	1724	2066	2346	2543	2870	3143	3341
35%	790	790	1317	1724	2066	2346	2543	2870	3143	3338
40%	790	790	1317	1724	2066	2346	2543	2870	3143	3338
45%	662	790	1317	1724	2066	2346	2543	2870	3143	3334
50%	662	790	1317	1724	2066	2346	2543	2870	3143	3334
55%	662	790	1317	1724	2066	2346	2543	2870	3143	3326
60%	662	790	1317	1724	2066	2346	2543	2870	3143	3319
65%	662	790	1317	1724	2066	2346	2543	2870	3143	3302
70%	662	790	1317	1724	2066	2346	2543	2870	3143	3302
75%	662	790	1317	1724	2066	2346	2543	2870	3143	3266
80%	662	790	1317	1724	2066	2346	2543	2870	3143	3266
85%	662	790	1317	1724	2066	2346	2543	2870	3143	3213
90%	662	790	1317	1724	2066	2346	2543	2870	3143	3213
95%	662	790	1317	1724	2066	2346	2543	2870	3143	3143

Month: 10	1395	(n)								
Exceedence	0.8	1	2	3	4	5	6	8	10	Unimpaired
5%	2346	2346	2346	2346	2346	2346	2543	2870	3143	3346
10%	1724	1724	1724	1724	2066	2346	2543	2870	3143	3343
15%	790	790	1317	1724	2066	2346	2543	2870	3143	3343
20%	790	790	1317	1724	2066	2346	2543	2870	3143	3343
25%	662	790	1317	1724	2066	2346	2543	2870	3143	3341
30%	662	790	1317	1724	2066	2346	2543	2870	3143	3338
35%	662	790	1317	1724	2066	2346	2543	2870	3143	3338
40%	662	790	1317	1724	2066	2346	2543	2870	3143	3334
45%	662	790	1317	1724	2066	2346	2543	2870	3143	3326
50%	662	790	1317	1724	2066	2346	2543	2870	3143	3326
55%	662	790	1317	1724	2066	2346	2543	2870	3143	3319
60%	662	790	1317	1724	2066	2346	2543	2870	3143	3302
65%	662	790	1317	1724	2066	2346	2543	2870	3143	3302
70%	662	790	1317	1724	2066	2346	2543	2870	3143	3266
75%	662	790	1317	1724	2066	2346	2543	2870	3143	3266
80%	662	790	1317	1724	2066	2346	2543	2870	3143	3213
85%	662	790	1317	1724	2066	2346	2543	2870	3143	3213
90%	662	790	1317	1724	2066	2346	2543	2870	3143	3213
95%	662	790	1317	1724	2066	2346	2543	2870	3143	3143

Appendix F-3. Habitat duration tables for spawning bull trout.

Month: 8	1350	(n)								
Exceedence	0.8 cfs	1 cfs	2 cfs	3 cfs	4 cfs	5 cfs	6 cfs	8 cfs	10 cfs	Unimpaired
5%	5182	5182	5182	5182	5182	5182	5182	5191	5126	4803
10%	5137	5137	5137	5137	5137	5137	5137	5191	5126	4645
15%	5020	5020	5020	5020	5020	5020	5020	5191	5126	4525
20%	4906	4906	4906	4906	4906	4906	4906	5191	5126	4455
25%	4803	4803	4803	4803	4803	4803	4905	5191	5126	4373
30%	4645	4645	4645	4645	4645	4645	4905	5191	5126	4314
35%	4525	4525	4525	4525	4525	4525	4905	5191	5126	4222
40%	4384	4384	4384	4384	4384	4384	4905	5191	5126	4124
45%	4271	4271	4271	4271	4271	4384	4905	5182	5126	4095
50%	4124	4124	4124	4124	4124	4384	4905	5126	5126	4025
55%	3976	3976	3976	3976	3976	4384	4905	4906	4906	3927
60%	3725	3725	3725	3725	3725	4384	4714	4714	4714	3811
65%	3483	3483	3483	3483	3725	4384	4586	4586	4586	3730
70%	3339	3339	3339	3339	3725	4384	4455	4455	4455	3631
75%	3062	3062	3062	3062	3725	4314	4314	4314	4314	3533
80%	2212	2212	2212	3062	3725	4124	4124	4124	4124	3339
85%	935	935	2212	3062	3725	3976	3976	3976	3976	3339
90%	653	935	2212	3062	3698	3700	3700	3700	3700	3339
95%	653	935	2212	3062	3339	3339	3339	3339	3339	3339

Month: 9	1350	(n)								
Exceedence	0.8	1	2	3	4	5	6	8	10	Unimpaired
5%	4803	4803	4803	4803	4803	4803	4905	5020	5020	3976
10%	4586	4586	4586	4586	4586	4586	4645	4645	4645	3779
15%	4373	4373	4373	4373	4373	4384	4455	4455	4455	3631
20%	4222	4222	4222	4222	4222	4271	4271	4271	4271	3483
25%	4095	4095	4095	4095	4095	4124	4124	4124	4124	3339
30%	3976	3976	3976	3976	3976	4025	4025	4025	4025	3339
35%	3867	3867	3867	3867	3867	3877	3877	3877	3877	3339
40%	3730	3730	3730	3730	3730	3779	3779	3779	3779	3339
45%	3582	3582	3582	3582	3631	3631	3631	3631	3631	3339
50%	3385	3385	3385	3385	3434	3434	3434	3434	3434	3339
55%	3339	3339	3339	3339	3339	3339	3339	3339	3339	3339
60%	3339	3339	3339	3339	3339	3339	3339	3339	3339	3339
65%	3339	3339	3339	3339	3339	3339	3339	3339	3339	3339
70%	3339	3339	3339	3339	3339	3339	3339	3339	3339	3339
75%	3339	3339	3339	3339	3339	3339	3339	3339	3339	3339
80%	3339	3339	3339	3339	3339	3339	3339	3339	3339	3339
85%	3339	3339	3339	3339	3339	3339	3339	3339	3339	3339
90%	3339	3339	3339	3339	3339	3339	3339	3339	3339	3339
95%	3339	3339	3339	3339	3339	3339	3339	3339	3339	3339

Appendix F-4. Habitat duration tables for spawning kokanee.

Month:	8		1395	(n)								
		Exceedence	0.8 cfs	1 cfs	2 cfs	3 cfs	4 cfs	5 cfs	6 cfs	8 cfs	10 cfs	Unimpaired
		5%	10090	10090	10090	10090	10090	10090	10090	10090	10188	10090
		10%	9684	9684	9684	9684	9684	9684	9684	9962	10188	9910
		15%	9650	9650	9650	9650	9650	9650	9650	9962	10188	9650
		20%	9272	9272	9272	9272	9272	9272	9272	9962	10188	9650
		25%	8870	8870	8870	8870	8870	8870	9272	9962	10188	9337
		30%	8337	8337	8337	8337	8337	8870	9272	9962	10188	9337
		35%	8022	8022	8022	8022	8337	8870	9272	9962	10188	9004
		40%	7401	7401	7401	7401	8337	8870	9272	9962	10188	8671
		45%	6132	6132	6132	7401	8337	8870	9272	9962	10188	8342
		50%	3907	3907	6132	7401	8337	8870	9272	9962	10188	8342
		55%	3907	3907	6132	7401	8337	8870	9272	9962	10188	8022
		60%	3076	3907	6132	7401	8337	8870	9272	9962	10188	7738
		65%	3076	3907	6132	7401	8337	8870	9272	9962	10188	7463
		70%	3076	3907	6132	7401	8337	8870	9272	9962	10188	7246
		75%	3076	3907	6132	7401	8337	8870	9272	9962	10188	7082
		80%	3076	3907	6132	7401	8337	8870	9272	9962	10188	6926
		85%	3076	3907	6132	7401	8337	8870	9272	9962	10188	6557
		90%	3076	3907	6132	7401	8337	8870	9272	9910	9910	6232
		95%	3076	3907	6132	7401	8337	8671	8671	8671	8671	5762

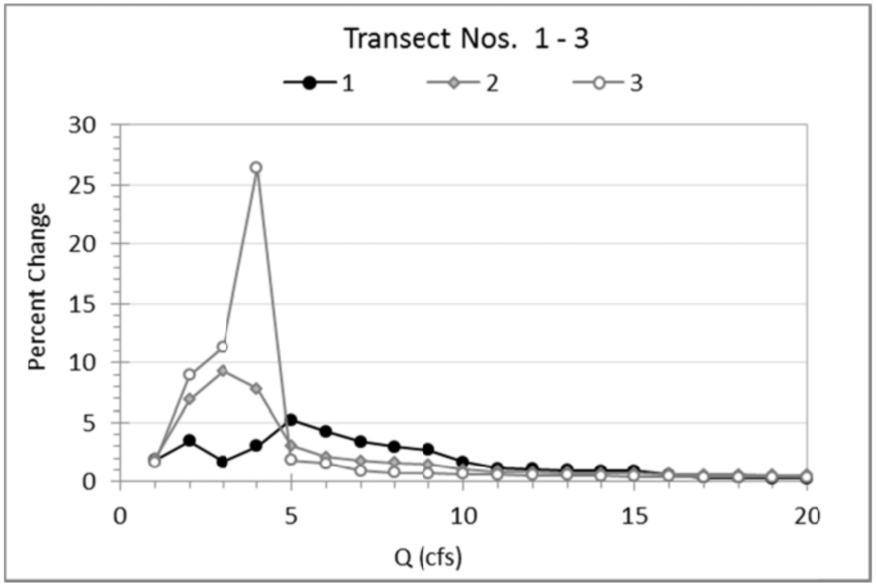
Month:	9		1350	(n)								
		Exceedence	0.8	1	2	3	4	5	6	8	10	Unimpaired
		5%	8870	8870	8870	8870	8870	8870	9272	9962	10188	10090
		10%	8337	8337	8337	8337	8337	8870	9272	9962	10188	10090
		15%	7401	7401	7401	7401	8337	8870	9272	9962	10188	9910
		20%	7401	7401	7401	7401	8337	8870	9272	9962	10188	9910
		25%	6132	6132	6132	7401	8337	8870	9272	9962	10188	9650
		30%	3907	3907	6132	7401	8337	8870	9272	9962	10188	9650
		35%	3907	3907	6132	7401	8337	8870	9272	9962	10188	9337
		40%	3907	3907	6132	7401	8337	8870	9272	9962	10188	9004
		45%	3076	3907	6132	7401	8337	8870	9272	9962	10188	9004
		50%	3076	3907	6132	7401	8337	8870	9272	9962	10188	8671
		55%	3076	3907	6132	7401	8337	8870	9272	9962	10188	8671
		60%	3076	3907	6132	7401	8337	8870	9272	9962	10188	8342
		65%	3076	3907	6132	7401	8337	8870	9272	9962	10188	8342
		70%	3076	3907	6132	7401	8337	8870	9272	9962	10188	8342
		75%	3076	3907	6132	7401	8337	8870	9272	9962	10188	8022
		80%	3076	3907	6132	7401	8337	8870	9272	9962	10188	7738
		85%	3076	3907	6132	7401	8337	8870	9272	9962	10188	7738
		90%	3076	3907	6132	7401	8337	8870	9272	9962	10188	7463
		95%	3076	3907	6132	7401	8337	8870	9272	9962	10188	7082

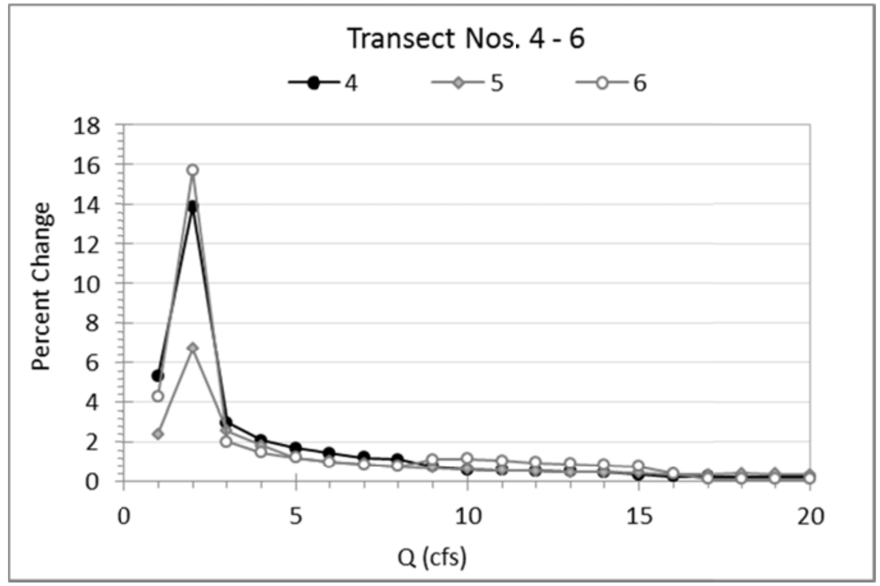
Month:	10		1395	(n)								
		Exceedence	0.8	1	2	3	4	5	6	8	10	Unimpaired
		5%	8337	8337	8337	8337	8337	8870	9272	9962	10188	10112
		10%	7401	7401	7401	7401	8337	8870	9272	9962	10188	10090
		15%	3907	3907	6132	7401	8337	8870	9272	9962	10188	10090
		20%	3907	3907	6132	7401	8337	8870	9272	9962	10188	10045
		25%	3076	3907	6132	7401	8337	8870	9272	9962	10188	9910
		30%	3076	3907	6132	7401	8337	8870	9272	9962	10188	9910
		35%	3076	3907	6132	7401	8337	8870	9272	9962	10188	9650
		40%	3076	3907	6132	7401	8337	8870	9272	9962	10188	9337
		45%	3076	3907	6132	7401	8337	8870	9272	9962	10188	9337
		50%	3076	3907	6132	7401	8337	8870	9272	9962	10188	9337
		55%	3076	3907	6132	7401	8337	8870	9272	9962	10188	9004
		60%	3076	3907	6132	7401	8337	8870	9272	9962	10188	9004
		65%	3076	3907	6132	7401	8337	8870	9272	9962	10188	8671
		70%	3076	3907	6132	7401	8337	8870	9272	9962	10188	8671
		75%	3076	3907	6132	7401	8337	8870	9272	9962	10188	8671
		80%	3076	3907	6132	7401	8337	8870	9272	9962	10188	8342
		85%	3076	3907	6132	7401	8337	8870	9272	9962	10188	8342
		90%	3076	3907	6132	7401	8337	8870	9272	9962	10188	7738
		95%	3076	3907	6132	7401	8337	8870	9272	9962	10188	7246

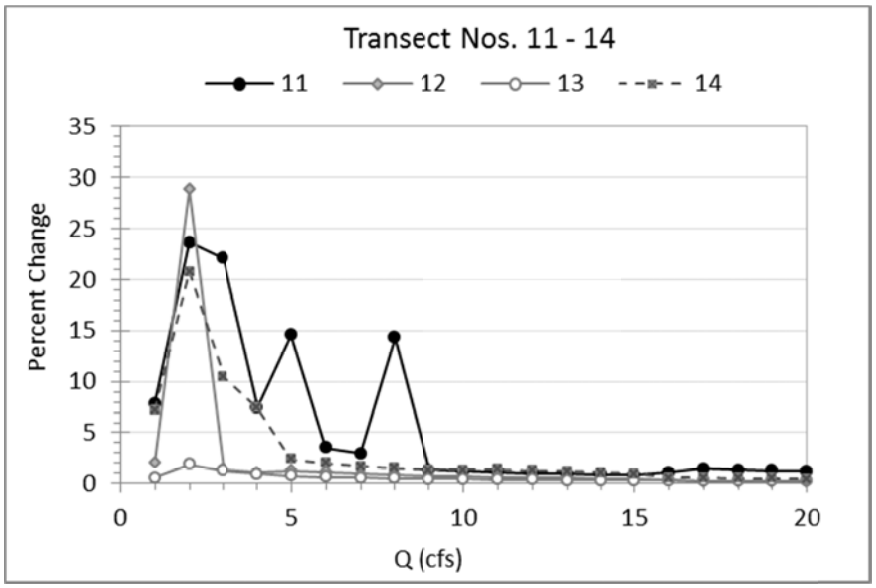
Appendix G. Wetted Perimeter vs. Flow Relationships

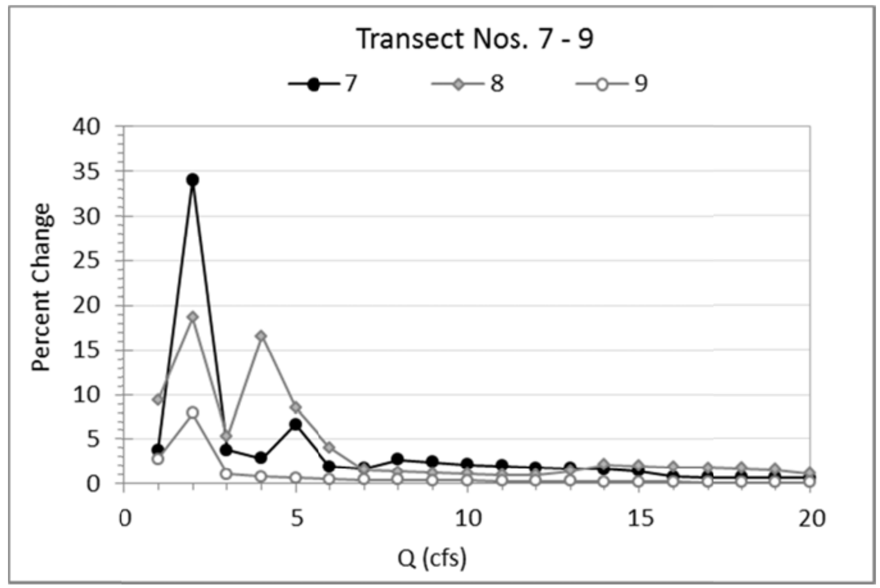
Q (cfs)	Wetted Perimeter (ft.) of Cross Section Number:													Average
	1	2	3	4	5	6	7	8	9	11	12	13	14	
0.8	10.3	7.1	7.1	13.8	8.7	12.6	7.8	6.5	12.1	4.0	12.3	12.8	8.7	9.5
1.0	10.4	7.2	7.2	14.6	8.9	13.1	8.1	7.1	12.5	4.3	12.6	12.9	9.3	9.9
2.0	10.8	7.7	7.8	16.6	9.5	15.1	10.9	8.5	13.5	5.3	16.2	13.1	11.3	11.2
3.0	11.0	8.4	8.7	17.1	9.8	15.4	11.3	8.9	13.6	6.5	16.4	13.3	12.4	11.8
4.0	11.3	9.1	11.0	17.5	10.0	15.7	11.6	10.4	13.7	6.9	16.6	13.4	13.4	12.3
5.0	11.9	9.3	11.2	17.8	10.1	15.9	12.4	11.3	13.8	7.9	16.8	13.5	13.7	12.7
6.0	12.4	9.5	11.4	18.0	10.2	16.0	12.6	11.8	13.9	8.2	17.0	13.6	13.9	13.0
7.0	12.8	9.7	11.5	18.2	10.3	16.2	12.9	11.9	13.9	8.5	17.1	13.7	14.2	13.1
8.0	13.2	9.9	11.6	18.4	10.4	16.3	13.2	12.1	14.0	9.7	17.3	13.7	14.4	13.4
9.0	13.6	10.0	11.7	18.6	10.4	16.5	13.5	12.3	14.1	9.8	17.4	13.8	14.6	13.5
10.0	13.8	10.1	11.7	18.7	10.5	16.7	13.8	12.4	14.1	9.9	17.5	13.9	14.8	13.7
11.0	14.0	10.2	11.8	18.8	10.6	16.9	14.1	12.5	14.1	10.0	17.7	13.9	15.0	13.8
12.0	14.1	10.3	11.9	18.9	10.6	17.0	14.4	12.7	14.2	10.2	17.8	14.0	15.2	13.9
13.0	14.2	10.4	11.9	19.0	10.7	17.2	14.6	12.8	14.2	10.3	17.9	14.0	15.4	14.0
14.0	14.4	10.4	12.0	19.1	10.7	17.3	14.9	13.1	14.3	10.3	18.0	14.1	15.5	14.2
15.0	14.5	10.5	12.0	19.2	10.8	17.4	15.1	13.4	14.3	10.4	18.0	14.1	15.7	14.3
16.0	14.6	10.6	12.1	19.2	10.8	17.5	15.2	13.6	14.3	10.5	18.1	14.1	15.8	14.3
17.0	14.6	10.6	12.1	19.3	10.9	17.5	15.3	13.9	14.3	10.7	18.1	14.2	15.9	14.4
18.0	14.7	10.7	12.2	19.3	10.9	17.6	15.4	14.1	14.4	10.8	18.2	14.2	15.9	14.5
19.0	14.7	10.8	12.2	19.3	10.9	17.6	15.5	14.3	14.4	11.0	18.2	14.2	16.0	14.6
20.0	14.8	10.8	12.3	19.4	11.0	17.6	15.6	14.5	14.4	11.1	18.2	14.3	16.1	14.6
25.0	15.0	11.1	12.5	19.6	11.2	17.7	16.1	14.7	14.5	11.7	18.4	14.4	16.4	14.9
30.0	15.1	11.3	12.6	19.7	11.3	17.8	16.5	15.0	14.6	12.2	18.5	14.6	16.7	15.1
40.0	15.4	11.7	12.9	20.0	11.6	17.9	17.3	15.4	14.7	13.2	18.7	14.8	17.2	15.4

Appendix H. Percent Incremental Increase in Wetted Perimeter vs. Flow

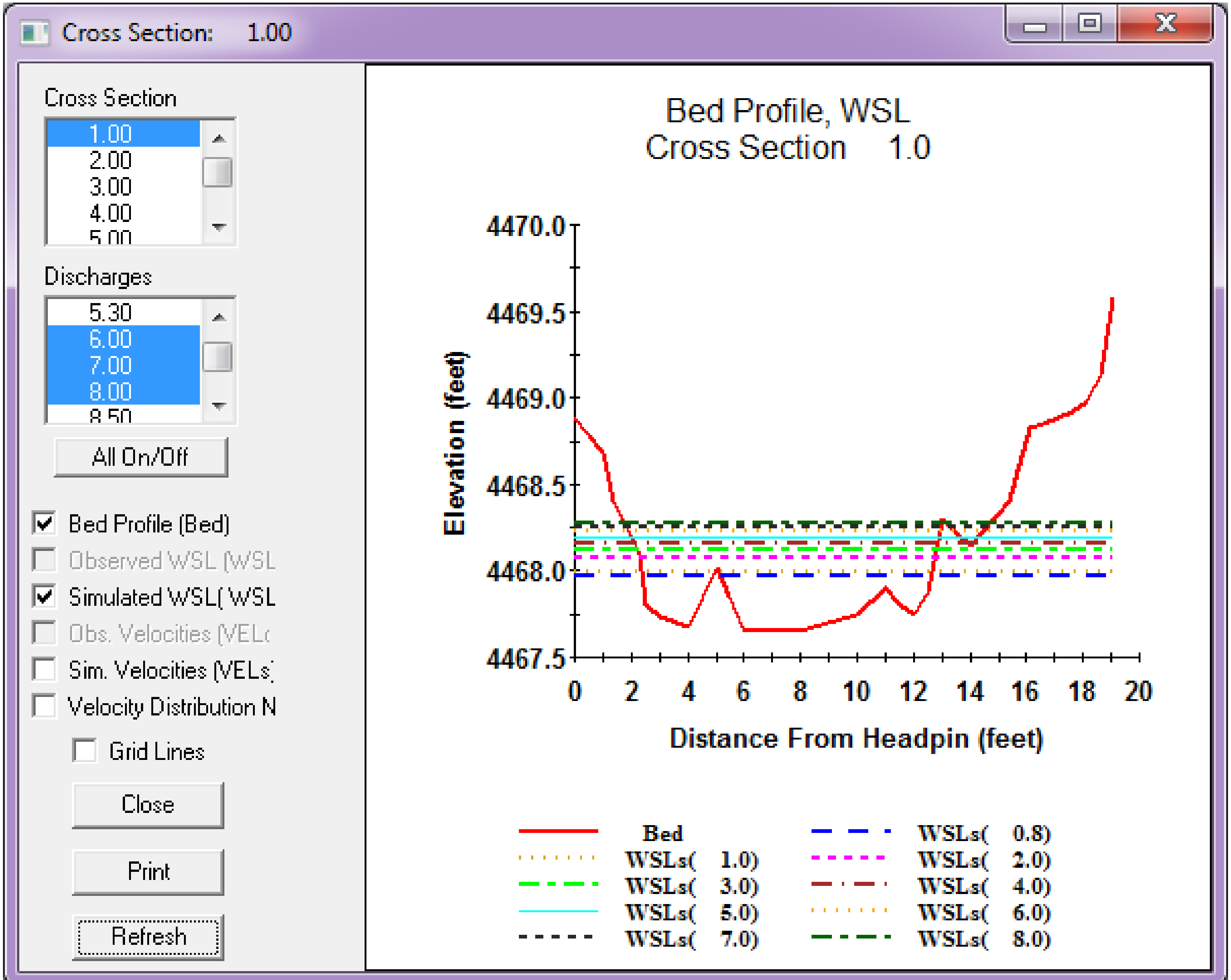








Appendix I. Channel Profiles and Selected WSL Simulations



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Distance From Headpin (feet)
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WSLs(0.8)
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WSLs(5.0)
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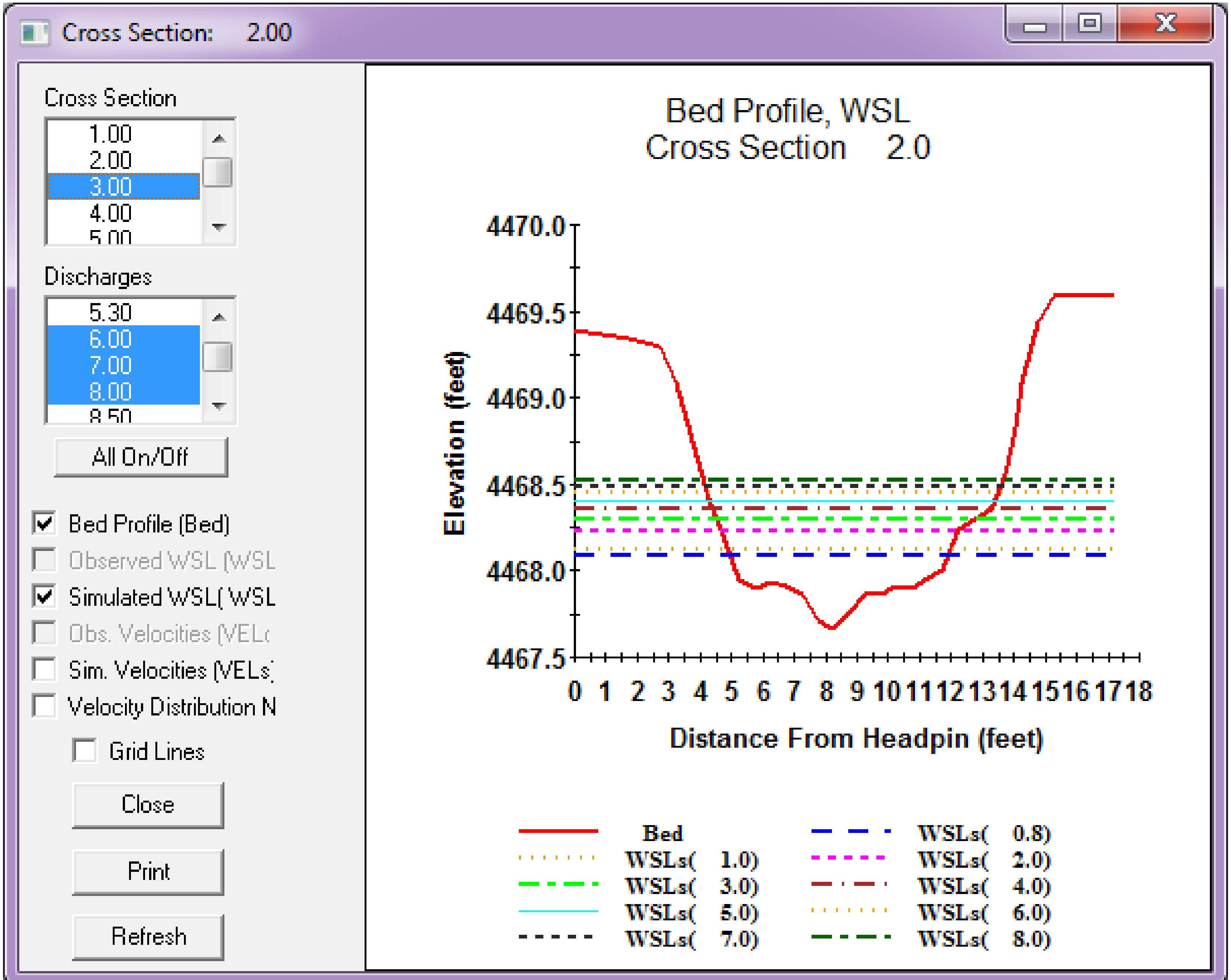
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Distance From Headpin (feet)
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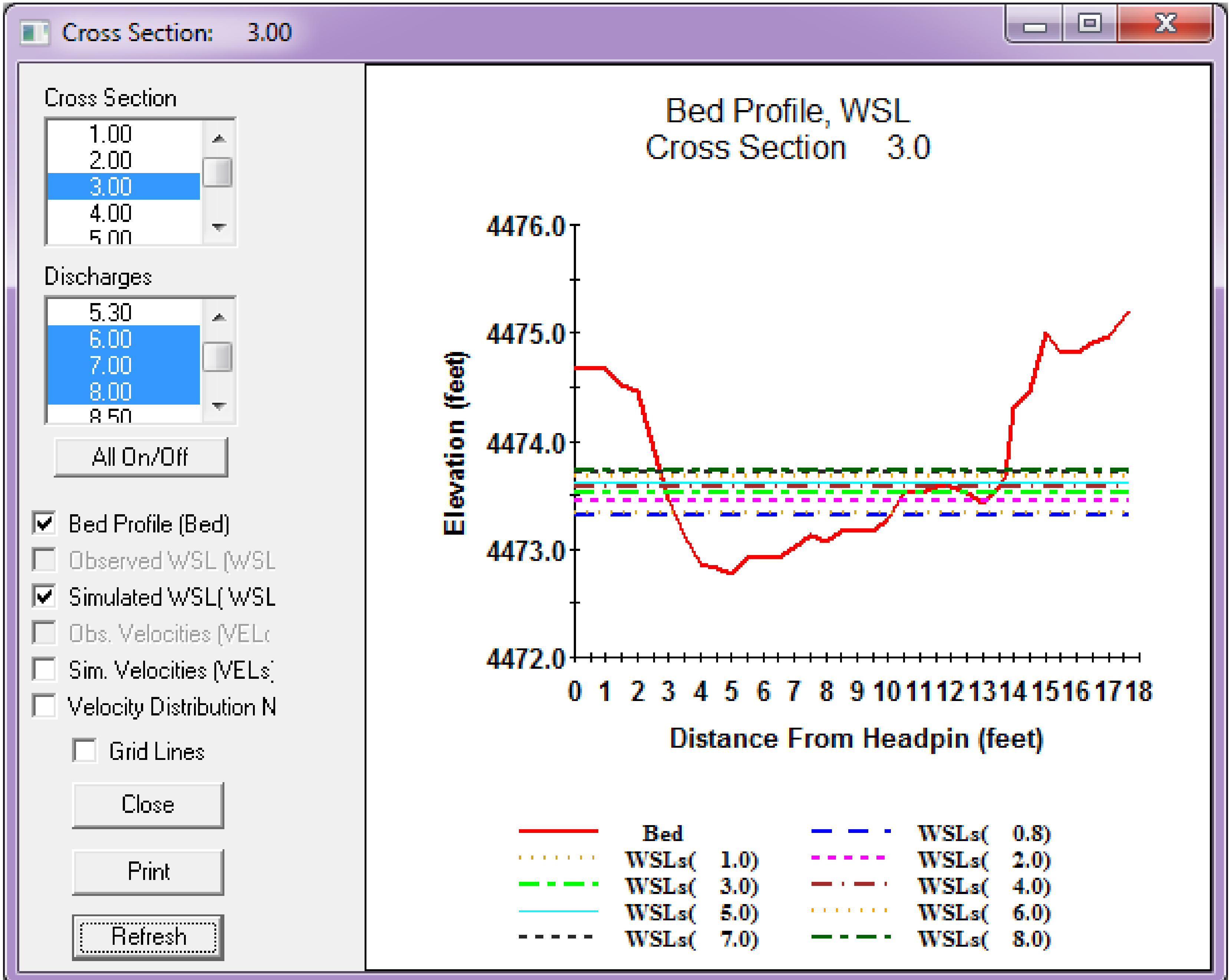
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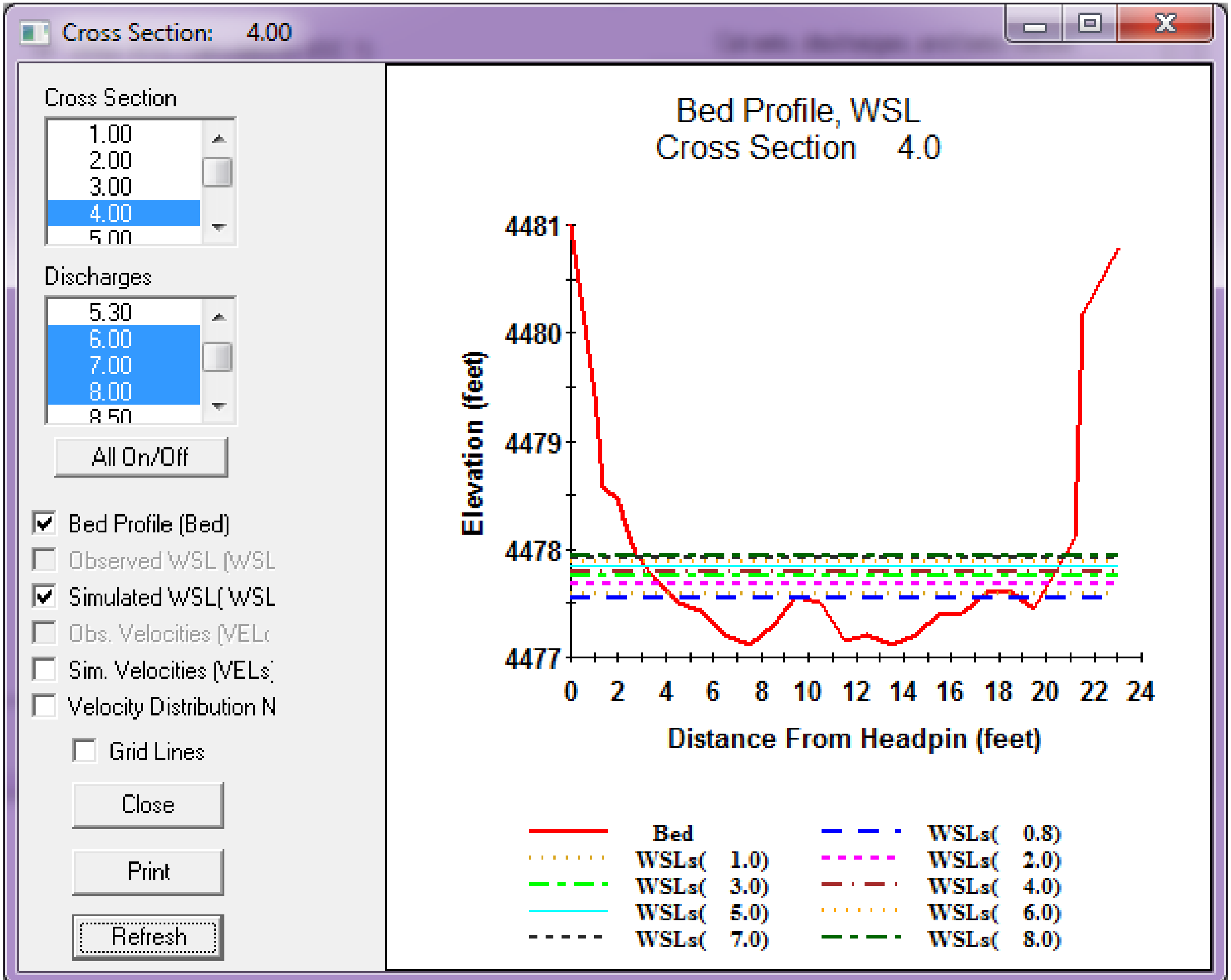
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Bed Profile, WSL
Cross Section 4.0
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Distance From Headpin (feet)
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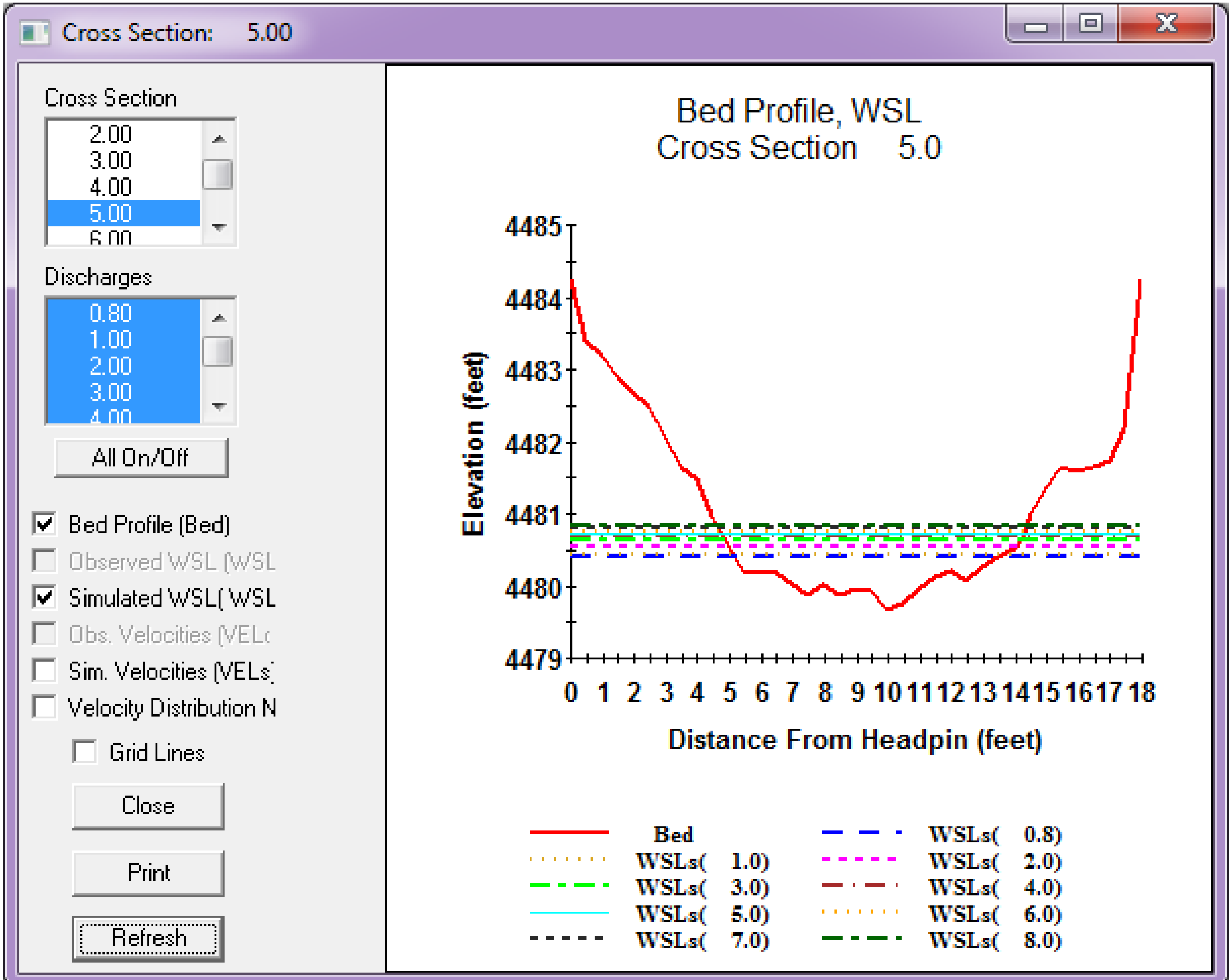

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Distance From Headpin (feet)
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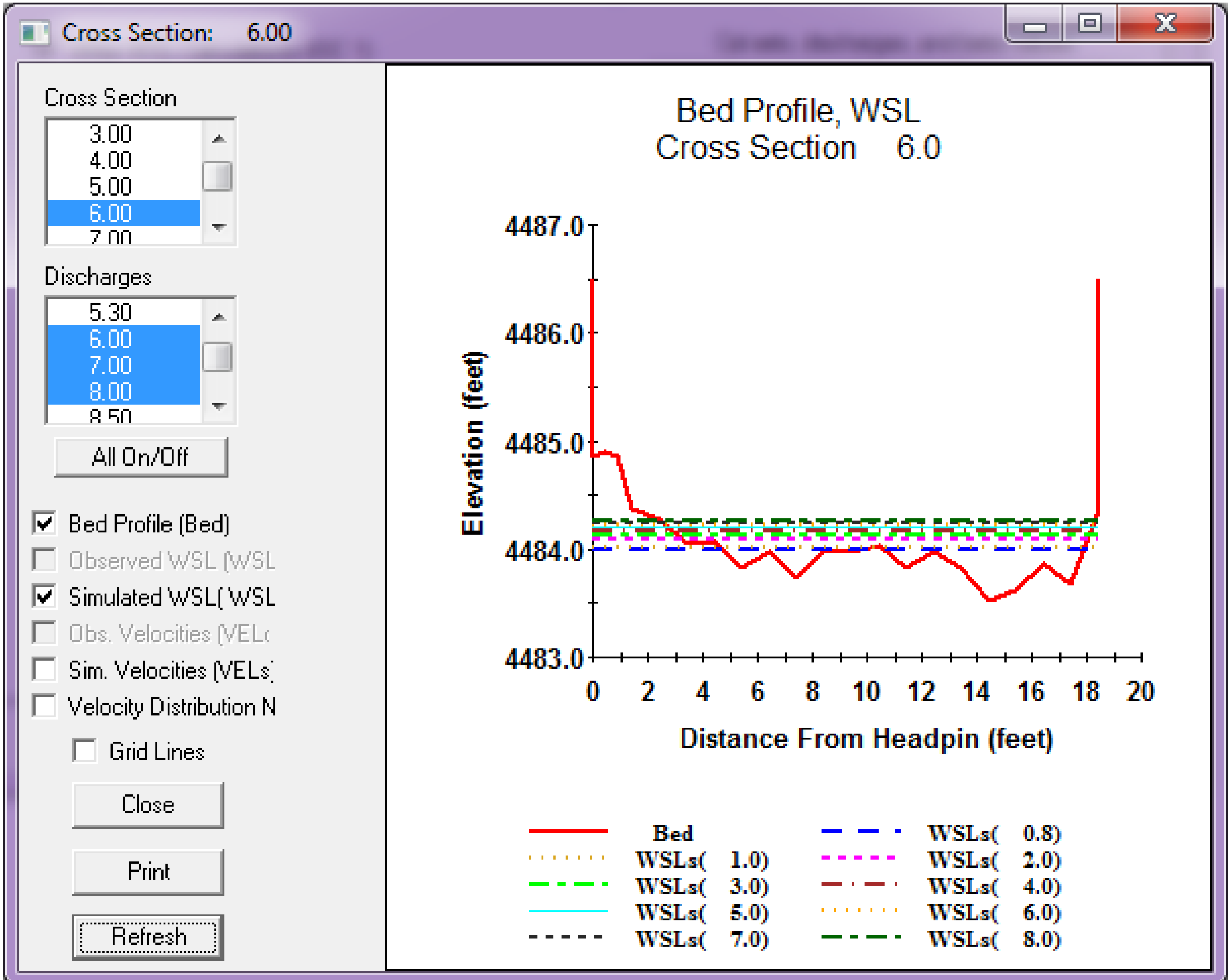
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Distance From Headpin (feet)
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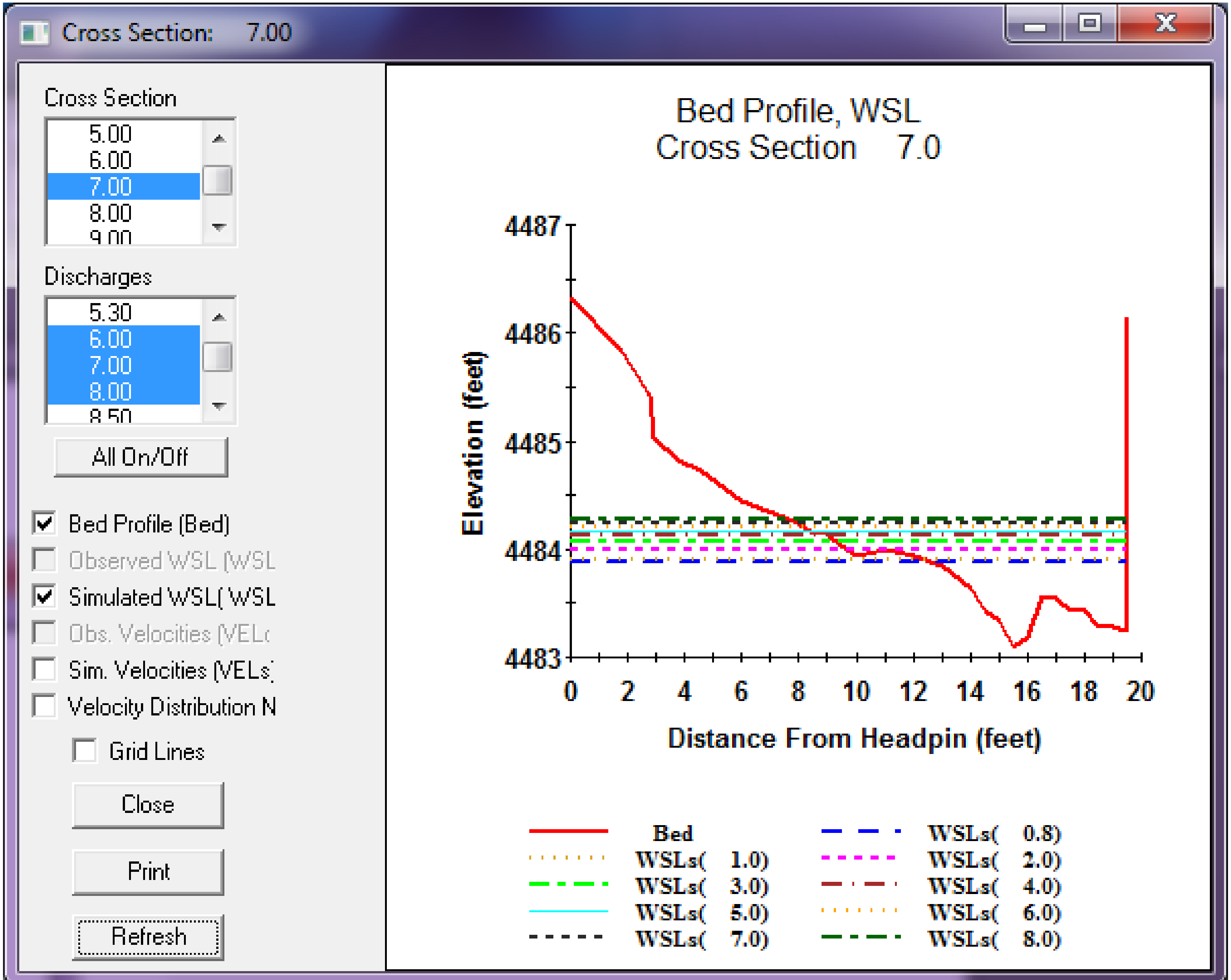
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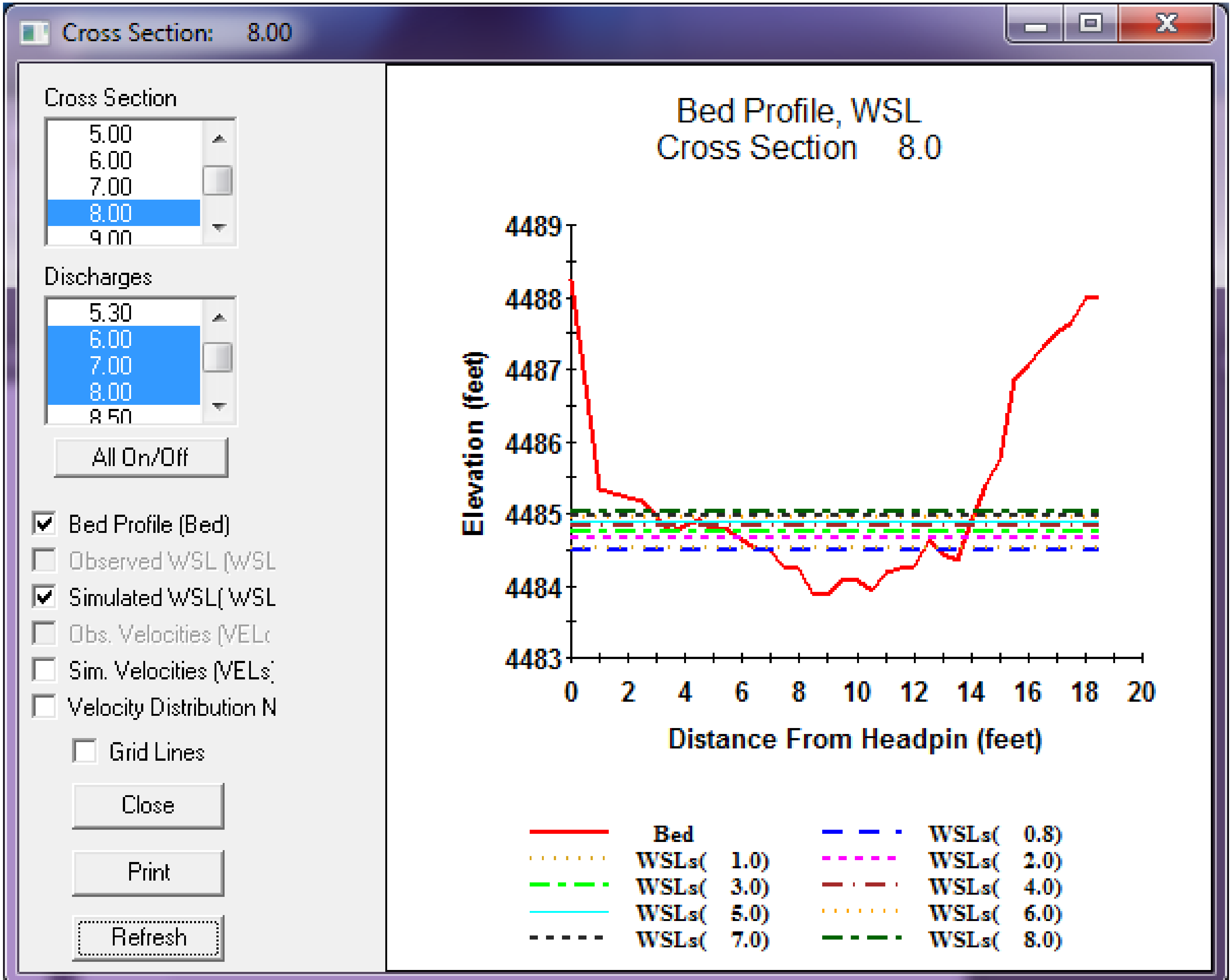
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Distance From Headpin (feet)
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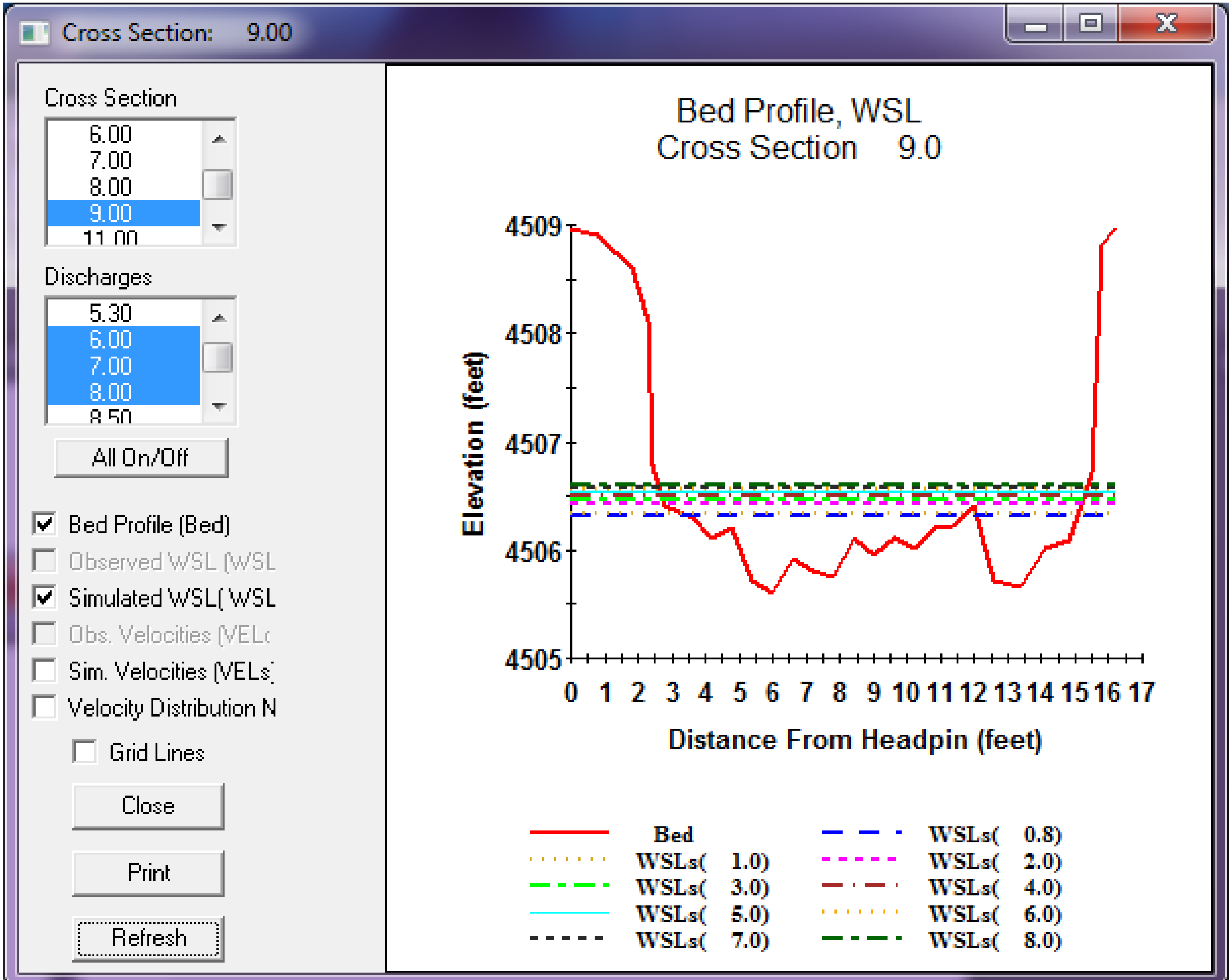
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Bed Profile (Bed)
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Elevation (feet)
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Distance From Headpin (feet)
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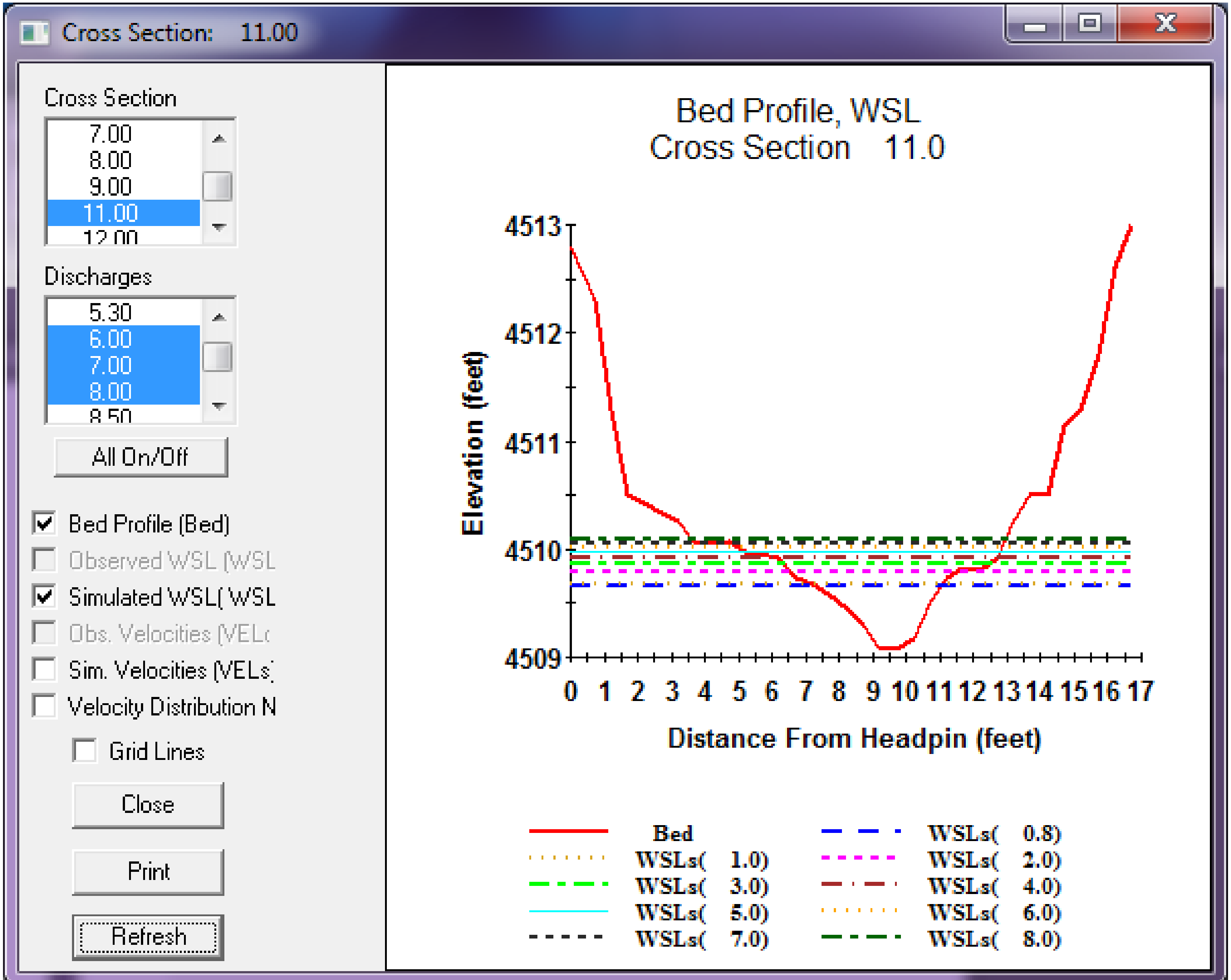

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Distance From Headpin (feet)
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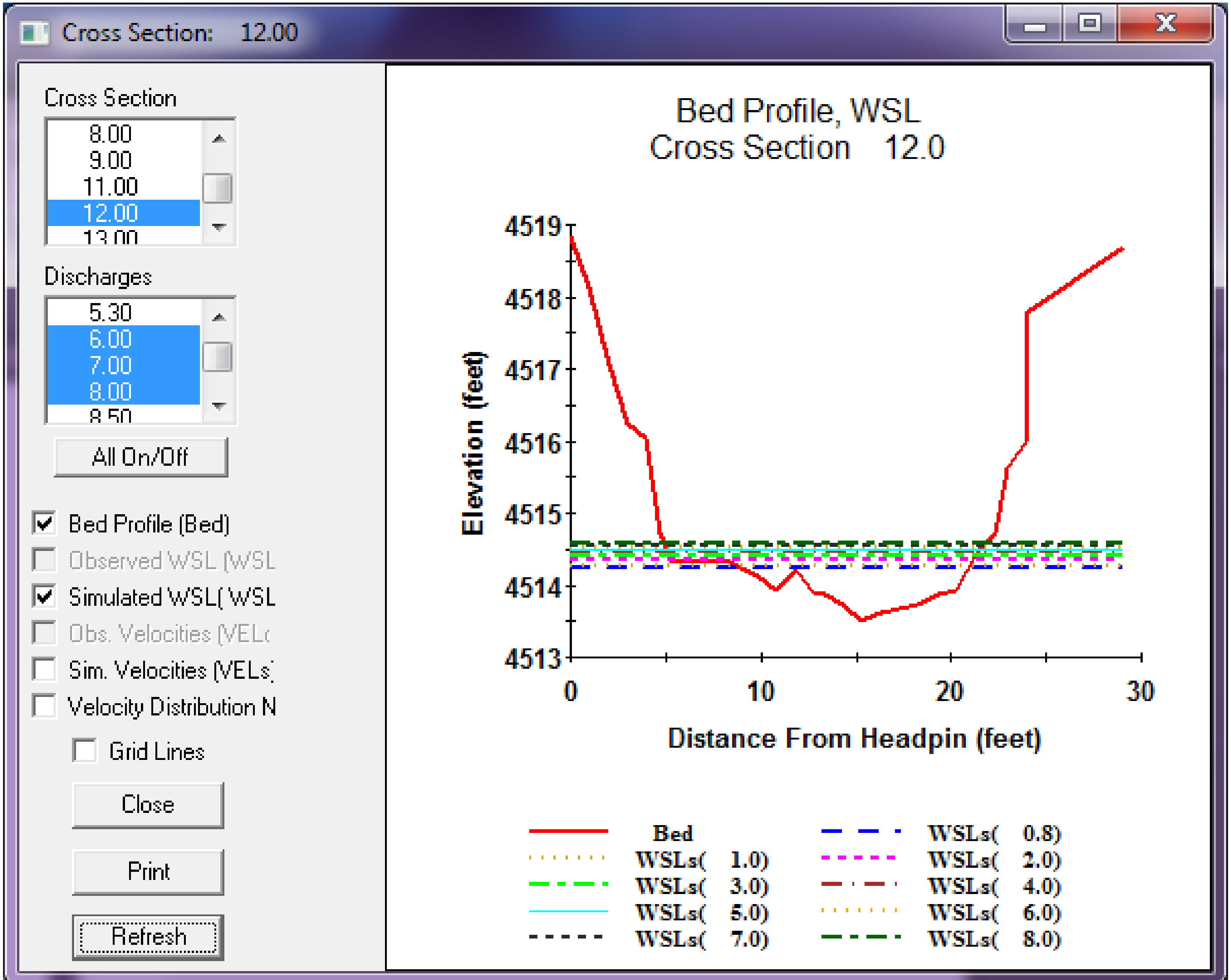
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Bed Profile, WSL
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Distance From Headpin (feet)
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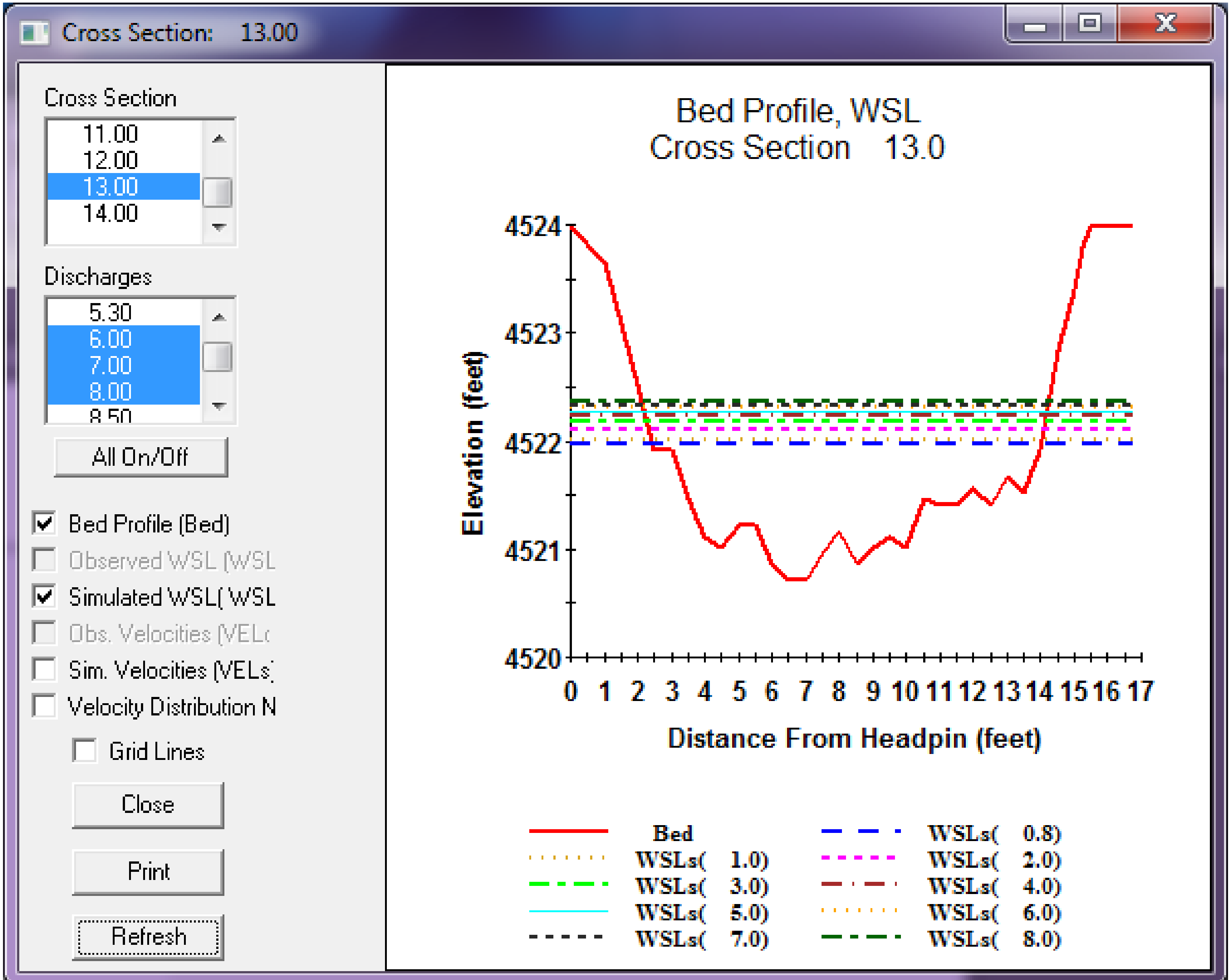
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Bed Profile, WSL
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0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
Distance From Headpin (feet)
Bed
WSLs(0.8)
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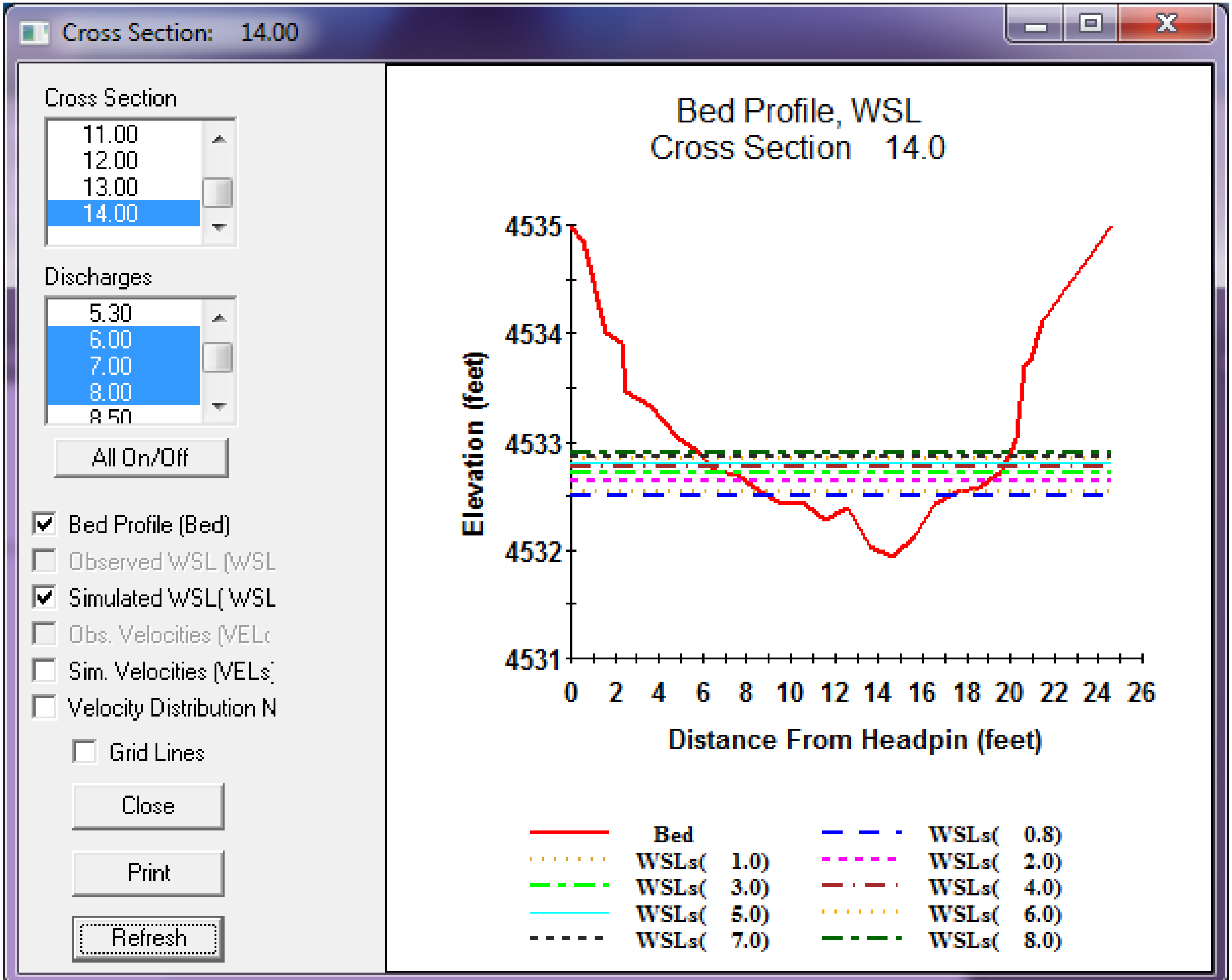
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Bed Profile, WSL
Cross Section 14.0
Elevation (feet)
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0 2 4 6 8 10 12 14 16 18 20 22 24 26
Distance From Headpin (feet)
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WSLs(0.8)
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Appendix J. Consultation Record

PacifiCorp's responses to stakeholder comments are provided in italics

MEMO
TO: Russ Howison, PacifiCorp FROM: ODFW, FWS, ODEQ, USFS DATE: MAY 22, 2013 SUBJECT: Follow-up comments from Instream Flow Report meeting on April 25, 2013 After review of the Wallowa Falls Habitat Modeling Results and discussion among the fish and water management stakeholders (ODFW, FWS, ODEQ, USFS), we provide the following comments:
Minimum flow recommendations:
General considerations: Fluvial adult bull trout occur in low numbers in East Fork Wallowa River (East Fork). We think they could occur in greater numbers with a higher minimum flow, thus we have incorporated bull trout adult as well as juvenile results into our rearing flow recommendations. We looked at the basic WUA vs. Q relationships as well as the habitat duration results. Our flow recommendations are based on both types of analysis.
It is agreed that modeling results from both the adult and the juvenile life stages and life histories should be incorporated into a minimum flow decision. To this end, an effort has been made to present results in a manner that did not promote the habitat gains of one life stage, at the expense of another.
August through October (spawning) – 8 cfs Rationale: Bull trout and kokanee both spawn in the East Fork. Kokanee use the East Fork only for spawning activities. Spawning habitat for bull trout elsewhere in the drainage is limited due to kokanee competition. The portion of the East Fork upstream of the kokanee barrier could be some of the only unoccupied spawning August through October (spawning) – 8 cfs
The statement that "spawning habitat for bull trout…is limited due to kokanee competition" has not been verified. *The recommendation for 8 cfs was retracted on July 10, 2013 (see Memo below). 8 cfs, as a spawning flow, cannot be sustained throughout the winter. Implementing high, unsustainable flows during the spawning season may encourage fish to spawn in areas that are subject to dewatering in the winter, resulting in egg and alevin mortality from desiccation and/or freezing. Although such events will happen naturally, it is generally agreed that it is not prudent to implement an artificial flow regime that could encourage some of the fish, from the presently small number of spawning pairs, to spawn in an*

area that won't be successful.
November through April (incubation and rearing) – 5 cfs Rationale: This flow considers both wetted perimeter and juvenile bull trout WUA. Wetted perimeter considers only keeping the substrate wet to support egg incubation. Resident bull trout are present in the East Fork during this 6 month period. Sub-adult fluvial bull trout likely use the East Fork for feeding as well. Therefore, flows should support all life-stages that will utilize the habitat.
This version of the draft technical report has been altered to better address the rationale for using wetted perimeter in the winter as a habitat index. Wetted perimeter indirectly addresses keeping the channel wetted to provide winter habitat for fish, recognizing that winter needs are different. Methods section 3.6 provides a detailed justification for the use of wetted perimeter in the winter months
May through July (rearing, migration) – 8 cfs Rationale: Under natural conditions, flow during this time period would normally be greater than or equal to the spawning flow to encourage fish to move into the system and begin staging for spawning. According to the flow record, during most years, flow will exceed the hydro project capacity and there will be spill over the dam. However, in occasional water years, there would be little or no spill during this season, so a minimum flow above the low winter bypass flow is needed. A flow greater than or equal to the spawning flow is recommended for migration and fluvial adult rearing habitat.
The recommendation for 8 cfs was retracted on July 10, 2013 (see Memo below).
Proposed Tailrace Reroute and Bull Trout Stranding
PacifiCorp discussed an operational concern which results in unintended and unplanned dewatering of the tailrace. Since this circumstance is unintentional and unplanned, fish salvage of the tailrace in a timely manner is not possible and fish become stranded in the tailrace during dewatering. Fish mortality has been observed during such events in the past, however species composition is unknown. Impacts to bull trout are an ESA consideration. The fish and water management stakeholders were asked to respond to two aspects related to this discussion. 1) The fish and water management stakeholders are concerned with potential stranding of fish in the tailrace from project activities (especially during unintended and unplanned dewatering events). We would like PacifiCorp to provide a range of potential options to address this issue for our review. If the options are related to the discharge location, we would like to see these analyzed for discharge into the East Fork and West Fork Wallowa River (West Fork). The analysis of options should provide advantages and disadvantages to both bull trout and kokanee habitat. The options should not rely on annual salvage of fish. 2) One potential option discussed at the meeting would entail re-routing the tailrace from the current discharge location in the West Fork to the East Fork. The result would mean that the East Fork would receive the full, unimpeded (i.e. 16 cfs, minimum flow, and spill) from the yet-to-be proposed new discharge location to the confluence with the West Fork. The fish and water management

stakeholders feel that this option could be acceptable, however there are concerns. The West Fork provides spawning habitat for kokanee throughout its length. The section from the tailrace discharge to the mouth of the East Fork is approximately 0.5 miles. This section supports high numbers of kokanee spawning. Kokanee spawning occurs from August to October during which flow in the system is limited. Re-routing the tailrace could reduce the flow in the West Fork from the tailrace discharge to the mouth of the East Fork by as much as 50% (J. Yanke, ODFW, pers. comm. 2013). This could result in major impact to kokanee spawning

This draft technical report addresses the habitat effects of a tailrace reroute within the East Fork bypass reach. Additional data will be presented in other reports or in the final technical IFIM report, including water temperatures in the West Fork, Kokanee spawning in the West Fork, and discharge in the West Fork. These data are currently under study or analysis, and will help all parties better understand the magnitude of impacts that the reroute could have on spawning kokanee and possibly spawning bull trout in the West Fork.

One stipulation presented by PacifiCorp during discussion on April 25, 2013 was that this solution would require a relatively low minimum flow (~2 cfs) for the project. The suitability of this flow for resident bull trout upstream of the potential East Fork discharge location is a concern and warrant further analysis and discussion.

Further discussion regarding a tailrace reroute, and all of its implications, is necessary.

Given the amount of channel modification and residential development, we recommend an evaluation of the suitability of the lower East Fork to handle the unimpeded flows.

The evaluation is provided in this draft technical report as requested.

Technical Comments

Overall, we concur that the PHABSIM study was done properly, insofar as transect numbers and placement, Habitat Suitability Criteria, hydraulic modeling, and production of WUA vs. flow results. Most of our comments are concerning the data interpretation and flow recommendations.

Combined Comments Related to Wetted Perimeter

We do not agree that wetted perimeter (WP) should be the exclusive or even primary means of assessing habitat conditions from November through April. WUA for juvenile bull trout should be the principal habitat metric for these months. WP was mentioned in ODFW comments (page 4 of comments on Proposed Study Plans, 11-4-2011), but only as a general indicator of macroinvertebrate health. Typically, the wetted perimeter method is applied to selected riffle transects, on the theory that keeping these broad transects wetted is important for macroinvertebrates and perhaps the biota in general. In this case, mesohabitat types were not clearly discernible in East Fork. PacifiCorp combined all 13 transects into an overall WP index, which is not the standard way to apply the method.

It is true that salmonids seek refuge in interstitial spaces in the substrate during winter - in the daytime.

But they typically move into the water column at night to feed, meaning that the WP criteria are not sufficient. Total WUA should be assessed in addition to WP. Juvenile and adult fish are in the river in winter, so egg incubation is not the only issue. Even if egg incubation were the only issue, there needs to be an explanation relating the spawning habitat that was used in the fall, to the incubation habitat, measured in terms of average WP as the surrogate.

The HSC used in this study were developed from spring/summer/autumn observations. Differential use of winter habitat by juvenile bull trout necessitates a different approach to the evaluation of habitat. The use of wetted perimeter was an effort to maximize the wetted channel width in conjunction with protecting low-velocity margin habitat. The stage-discharge relationships show that the water surface elevation essentially becomes flat around 4 cfs. Appendix I has been added to this version of the report to illustrate how little stage changes at flows increase. Therefore, only velocity would increase in response to increased flows. Methods section 3.6 provides a detailed justification for the use of wetted perimeter in the winter months. The remark that juvenile bull trout move into the water column at night implies that the fish exploit the same range of velocities in winter as in summer. This implication is not supported by the bull trout literature that explores diel habitat use. Bonneau and Dennis (1998) *performed a study of bull trout habitat use in a tributary to Lake Pend Oreille. The stream was of similar in size, gradient, and natural discharge to the East Fork Wallowa River. In the summer, they observed juvenile bull trout occupying velocities of about 0 to 0.7 fps in the day, and approximately 0.3 to 1.0 fps at night. These observations validate the HSC that were used in the Wallowa Falls IFIM for juvenile bull trout. However, their observations in the same study reach in the winter do not support the Wallowa juvenile bull trout HSC. Bull trout were almost exclusively observed in zero-velocity waters during the winter days, (typically below in the substrate) and velocities of approximately 0 to 0.4 fps during winter nights. The Wallowa HSC assign a reasonably high suitability index to velocities as high as 1 fps (SI = 0.56), and continue to assign diminishing suitability index values through about 3.5 fps. These criteria do not correspond with the winter observations of Bonneau and Dennis. Their study demonstrated that bull trout were never observed in velocities as high as 1 fps during the winter.[7] This seasonal shift in velocity use is associated with a reduced metabolic rate in the winter, and the need to minimize energy expenditures. As a result, nocturnal foraging occurs in the low-velocity stream margins, rather than the water columns (Bonneau and Dennis 1998, Muhlfeld, et al. 2003, CH2M Hill 1996).*

An analysis of wetted perimeter, as it applies to individual transects, has been added to Results section 4.4. The method of combining all 13 transects into an overall wetted perimeter index was utilized to maintain consistency with the transect weighting scheme used in the WUA calculations. All transects

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[7]*In a study of diel habitat shifts on the upper Flathead River, Muhlfeld (2003) observed that juvenile bull trout had a high probability of occupying velocities that ranged from 0 fps to approximately 1.3 fps during winter nights. However, the author cautioned that velocities were probably inflated. Bull trout usually occupy near-zero velocities on or near the substrate in the winter, but Muhlfeld's velocity measurements were collected at 15 cm above the stream bed, due to instrument limitations.*

were equally weighted, because stakeholders and PacifiCorp agreed that there was little distinction of mesohabitat throughout the study reach. The habitat survey revealed that the study reach almost entirely (95%) comprised of a riffle/rapid complex.
Wetted perimeter results should be provided for all separate transects in the report or appendices.
The individual transects have been added in Appendix G. Discussion regarding individual transects has been added to the results and conclusions sections.
WP counts all areas with a depth of at least 0.01 ft. as equally valuable. The HSC for juvenile bull trout require a depth of at least 0.4 ft., which is a much more realistic criterion for fish protection.
The following is a minor detail, should be corrected for the record: the interpolated HSC for juvenile bull trout indicate that depths less than 0.4 feet have positive suitability values, as displayed in the HSC table below. Depth — Suitability Index 0.25 — 0 0.3 — 0.2 (interpolated) 0.35 — 0.4 (interpolated) 0.4 — 0.6 (interpolated) 0.5 — 1.0
Other Comments
Habitat duration analysis counts removal of flows that are above the peak-WUA flow as a benefit to the fishery. ODFW commented in 2011 that this built-in assumption should be incorporated with caution. The built-in assumption is that flows to the "right" and "left" of the WUA peak are equally harmful to the fishery, but this assumption is not widely accepted by the instream flow community.
PacifiCorp understands that this statement is probably applicable in a natural channel. However, this report does not minimize the fact that much of the lower bypass reach has been channelized, armored with riprap, and as a result, is deeply incised. The "right" side of the WUA peak represents high velocities and shallow depths, because there are few natural energy-dispersing features in the bypass reach. The field data and modeling results show that higher discharges are associated with velocities that are not considered highly suitable, according to the HSC.
The report asserts that it "did not make logical sense to explore flow alternatives that were greater than any recurrent unimpeded low flow." This is not true. It is easily possible to explore higher minimum flow alternatives, and it is commonly done in most instream flow studies. The flow alternatives are simply developed with the proviso that such a minimum flow is provided, unless natural flow is too low at the time, in which case the project shuts down and the entire natural flow is bypassed.
PacifiCorp incorporates environmental, financial, and operational logistics, when determining whether a remote plant can be practicably operated under a minimum flow regime that requires seasonal shut-downs or multiple minimum flow changes over a year.

Combined Comments Regarding Baseline Conditions
The metric "percent increase in habitat availability over the baseline minimum flow of 0.8 cfs" is misleading and does not have biological relevance. Habitat conditions are of course very poor at 0.8 cfs. The first small increase in flow is bound to provide a big percentage habitat increase, because the denominator is so small. This metric is indicative of poor starting conditions, rather than high fishery benefits.
Per Federal Power Act Part I, Section 2, "the baseline consists of the existing condition of the waters and lands in the project area at the time of licensing proceeding." (*16 U.S.C. § 796,18 C.F.R. § 4.30(b)). To insure that readers are not misled, the presentation of total WUA has been simplified. All graphics in the draft report for agency review have been removed. They have been replaced with (1) tables showing the numeric value of total WUA for every flow alternative, including baseline; and (2) graphics in which the various alternatives have been normalized against baseline conditions. This approach provides readers with the actual, tabular values which have not been distorted by scale. It also allows the reader to view how each alternative enhances (or reduces) total WUA, relative to the conditions to which fish are currently exposed.*
Combined Comments Regarding Scale in Graphics, Tables
The scale is misleading in [former] Figure 5 and [former] Figure 9. Total WUA is apparently summed for May-July (3 months) but graphed on the same axis as the individual months of August, September, and October. As a result, the increases in total WUA between flow alternatives 2 to 5 are masked. These numbers should be normalized, or May-July plotted separately.
It is agreed that the May-July total WUA values were substantially larger than those of any individual month. This magnitude difference was the result of reporting the area under the three-month habitat duration curve, versus reporting the area under the single-month duration curve. To resolve the distortions caused by such great differences in scale, problem, the effort to analyze May, June, and July together has been discarded. In this version of the draft technical report, each month is analyzed individually. As a result, the total WUA values for each month are within the same order of magnitude.
[Former] Table 1, [former] Table 5 and [former] Figure 14: the incremental increase over the baseline condition of 0.8 cfs (which we feel is a misleading metric) should, if reported at all, be based on a common increment of flow. The first value reported is based on a flow increment of 0.2 cfs (from 0.8 to 1), while all the others are based on a flow increment of 1 cfs. The values in Table 1 in the 1 cfs column are not comparable to the other columns, and they distort the shape of the Figure 6 plots.
Tables of incremental increases have been omitted from this version of the draft technical report. A baseline of 0.8 cfs remains a valid baseline condition, per 16 U.S.C. § 796,18 C.F.R. § 4.30(b). Existing minimum flows are very low in the bypass reach, and as a result, WUA is also low. For decision-making purposes, it is useful to provide a metric that quantifies habitat percent increase for the various alternatives. For this reason, Figure 5 *through* Figure 8 *have been appended to this report.*

In [former] Table 2 [Table 5 in this version of the draft technical report], the amount of spawning habitat is still increasing at 7 cfs and beyond.
The new Table 5 extends the total WUA figures to 10 cfs and "unimpaired" flows to demonstrate that spawning habitat does not increase indefinitely.
Flow Regime Recommendations
In general, recommending a minimum bypass flow that is lower than any naturally-occurring flow is dubious from an ecological perspective. The 7Q10 (lowest 7-day flow in a ten-year period), which is widely regarded as an unacceptably low flow, is about 7.4 cfs in East Fork. PacifiCorp is proposing bypasses between 2 and 4 cfs. (Indicators of Hydrologic Alteration (IHA) was suggested during study plan development as a means for comparing alternative flow releases. ODFW performed preliminary runs with this model to compare unimpaired flows vs. 4 cfs bypass flow. Seventeen (17) of the 33 IHA metrics resulted in indicators of -1, the lowest possible score).
This version of the draft technical report has removed any direct recommendations for minimum flows. Neither IHA nor 7Q10 were discussed during the planning phase, although USFWS stated that the agency is moving in a direction that incorporates greater use of IHA. It is not appropriate to bring a new methodology into interpreting the results without a full discussion on the applicability. IHA does not seem to be a justified approach for assessing the PHABSIM analysis because it does not recognize that the degree to which the channel morphology has been altered. IHA examines hydrologic parameters, broadly grouped as: • *the magnitude of monthly flows;* • *the magnitude and duration of annual minimum and maximum flow events;* • *the timing of these annual extreme events;* • *frequency and duration of high and low pulses; and* • *the rate and frequency of flow changes* (Richter, Baumgartner, Powell, & Braun, 1996). *Richter et al. described the IHA as an ecosystem management tool that uses these biologically-relevant hydrologic parameters to compare a proposed and a natural flow regime. The parameters were chosen based on their importance in providing connectivity between the aquatic, riparian, and wetland components of a system. However, the IHA analysis does not recognize that the East Fork bypass reach is incised and armored to the point that it is generally disconnected from the riparian and wetland systems even at natural flows. Due to such altered channel morphology, we do not feel that IHA is an appropriate validation tool for this particular study.*
Flow regime recommendations were based in part on the observation that "the greatest increases in total WUA consistently occur at minimum flows of 2 cfs". As discussed above, the percent increase, pegged to a very low starting value, is seriously misleading.
PacifiCorp's statement is accurate. 2 cfs is, indeed, the inflection point, or the point of diminishing

returns, for increases in total WUA.
Flow recommendations for May-July need to be evaluated by something other than habitat duration. In normal or wet years, these months are dominated by spill, making the minimum bypass level irrelevant. The impact occurs in occasional dry years. A low minimum bypass in a dry year means that East Fork would be flat-lined all summer, which could have serious impacts on adult migration and holding habitat, and in turn could affect spawning in the fall. The minimum bypass flow for May-July should be at least equal to the spawning flow determined for August-October.
In this version of the report, the months of May - July months have been evaluated independently, rather than as a group.
In [former] Figure 15, habitat duration analysis is reported for May-October combined. As discussed in our previous memo to PacifiCorp, it is appropriate to combine May-July into one time period, but not May-October. Mixing the months (those with vs. without spill) masks the habitat-flow relationship in the non-spill months. Also, in Figure 15, spawning is displayed for May-October. Presumably, this is a typo, and the chart actually refers only to August-October. In addition to being separate from the May-July calculations, each month within the August-October period should itself be separate, in order to display the spawning WUA vs. flow relationship more clearly.
Figure 15 and the related discussion have been omitted and replaced with a conclusions section.
November-April: The Applicant acknowledges that a 3 cfs release might sometimes be needed to insure a minimum of 2 cfs in the river. The Applicant references an average diel variation of 0.7 cfs during periods of low base flow. Without a more detailed explanation of flow variation in the system, we can conclude only that a 3 cfs release insures 2 cfs in the river on average, as opposed to consistently. Also (see above), neither a 2 or 3 cfs minimum flow is adequate during this time period.
Recommended flows have been omitted in this version of the draft technical report.
Recommended Corrections (all corrections have been performed)
The titles for appendix C7 and C8 say adult bull trout, but the numbers are for juvenile bull trout. The chart shows that May-July WUA results for adult bull trout are the same for any bypass flow, except in very dry years. True, but because of this, it is important to provide a bypass flow higher than the proposed 2 or 3 cfs, in order to avoid the occasional drastic decrease in adult habitat. The title of Appendix C25 should say Wetted Perimeter duration for all transects combined, not habitat duration for all species combined. General/editorial: “Flow versus WUA” should be “WUA versus flow”, since WUA is on the Y axis.

MEMO

TO: Russ Howison, PacifiCorp

FROM: ODFW, FWS, ODEQ, USFS

DATE: JULY 10, 2013

SUBJECT: Response to meeting on June 13, 2013

In response to PacifiCorp's proposal for re-routing the tailrace to the East Fork Wallowa River, the fish and water management stakeholders (ODFW, FWS, ODEQ, USFS), provide the following comments:

We find that the proposal to re-route the tailrace to the East Fork Wallowa River (East Fork) may be an acceptable alternative that needs further examination and study.

The effects of a tailrace reroute scenario on habitat of the target species were explored. Results are presented in this report.

More information is needed to assess the impact of PacifiCorp's proposal on spawning kokanee in the West Fork Wallowa River (West Fork). Only anecdotal information currently exists on the importance of the reach from the mouth of the tailrace to the confluence with the East Fork. Historic flow information (attached) suggests that, the tailrace flow (approx. 12-16 cfs) could make up 1/4 to 1/2 of the flow in West Fork in August, September and October (more in low flow years), which could significantly impact available kokanee spawning habitat in the West Fork.

A kokanee spawning survey plan was developed and issued to stakeholders for review on August 8, 2013. The plan includes a field work schedule for the 2013 spawning season, and a final report date of January 2014.

We recommend the minimum flow provided be 5 cfs year-round. Under PacifiCorp's proposal, the reach impacted by this flow (i.e. above the proposed tailrace inflow) has the highest proportion of the bull trout population in the East Fork (according to PacifiCorp's Aquatic Resources Study Report (2012)). Therefore the minimum flow should be protective of every life stage that could potentially be present (i.e. adult, juvenile/resident and spawning bull trout). It is believed that the flow provided by the proposed tailrace re-route will increase habitat available to all life histories of bull trout, allowing them to potentially expand their distribution and connectivity upstream and downstream. Based on the Weighted Usable Area analysis, 5 cfs will better maintain and protect bull trout life histories, potentially increase distribution and connectivity, and support genetic diversity.

a) The PHABSIM results demonstrate that a tailrace reroute is not necessarily protective of all target species, life history types and/or life stages. The conclusions section of this report discusses the how a tailrace reroute provides minimal, sub-optimal, and maximum, levels of habitat, depending on the time of year and the species/life stages.

b) *The results of an IFIM habitat modeling study may only be used to evaluate how changes in flows influence habitat availability. The results cannot be extended to support conclusions or beliefs regarding increased connectivity, species distribution, or genetic diversity. As long as WUA values are greater than 0, the model is indicating that water of sufficient depth and velocity is available for fish habitation and movement (i.e. connectivity) within the study site and representative area.*

Tailrace flows to the lower East Fork could be beneficial to kokanee in the East Fork. Additional flow in the lower portion of the stream could potentially make available additional kokanee spawning habitat and expand distribution of spawning kokanee adults further upstream due to increased flows and cooler stream temperatures. However, due to limited habitat in the East Fork, these flows may not mitigate for the loss of kokanee spawning habitat in the West Fork as a result of the PacifiCorp's proposed tailrace re-route.

PHABSIM, as a modeling tool, does not address distribution, fish passage barriers, or stream temperatures. Based on modeling results, a tailrace reroute provides habitat levels for kokanee spawning similar to minimum flows of 3 cfs to 5 cfs. PacifiCorp acknowledges the comment that the removal of flows from the West Fork Wallowa River (a reduction of over 40% during peak spawning) may result in a loss of habitat for kokanee and any other fall-spawning species that currently use the stream.

To ensure that minimum flows are actualized in the impacted reach (above the proposed tailrace inflow, but below the fish barrier), we recommend that flow be monitored within this reach. This will allow calibration of PacifiCorp's proposed gaging station at the top of the East Fork to ensure that minimum flows are being met for protection of fish. This lower gaging station should be operated for 2 to 3 years after the FERC license is issued. The fish and water management stakeholders should be consulted on the location of this lower gaging station.

PacifiCorp has been attempting to gage the "impacted reach" for many years. Factors such as high gradients, turbulent flows, and a preponderance of boulders, tend to frustrate gaging attempts. Successful gaging will likely require the construction of a Parshall-flume in this segment of stream. PacifiCorp believes the habitat disturbance of such an installation could be minimized by shifting the expense to improving the existing compliance point below the dam. Construction of a flume or other gaging device below the dam would not impact bull trout or kokanee habitat, and it would provide substantially greater gaging accuracy at the compliance point.

The fish and water management stakeholders recognize that FWS is responsible for ESA consultation for the Wallowa Falls Hydroelectric relicensing project on federally threatened bull trout and critical habitat. We acknowledge that FWS strongly supports the proposal to re-route the tailrace to the East Fork Wallowa River to minimize take of bull trout associated with the potential for bull trout stranding in the tailrace from annual power outages and associated tailrace dewatering. This proposal will have long-term beneficial effects to bull trout critical habitat in the East Fork. Tailrace water (which originates in the East Fork) is cold and will be beneficial to bull trout in the East Fork from a

temperature and habitat/flow standpoint. In addition, we recognize that FWS is responsible for bull trout recovery plans with recovery actions to recover and/or protect the species. Four "recovery objectives" established for bull trout under the USFWS draft Bull Trout Recovery Plan are: 1) maintain current distribution of bull trout within bull trout Core Areas; 2) maintain stable or increasing trend in abundance; 3) restore and maintain suitable habitat conditions for all bull trout life history stages; 4) conserve bull trout genetic diversity and provide opportunity for genetic exchange. In the Wallowa River/Minam River Core Area (within which this project is located) demographic based targets that relate to this project also include: 1) expand distribution and increase connectivity between populations; and 2) maintain a variety of life history types, potentially increase fluvial populations.
PacifiCorp will note the above comments regarding Bull Trout recovery planning under the Endangered Species Act in future documents.