Kelly Bar Off-Channel Fisheries and Riparian Habitat Enhancement Project

Preliminary Basis of Design Report

October 2015

Prepared for:

Salmon River Restoration Council
PO Box 1089
25631 Sawyers Bar Road
Sawyers Bar, CA 96027

California Department of Fish and Wildlife
Fisheries Restoration Grants Program (P1310303)

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October 2015

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Appendices

1 INTRODUCTION

1.1 Project Area and Need

The Kelly Bar project area is located along the North Fork Salmon River (NF Salmon River) approximately 14 river miles upstream of its confluence with the South Fork Salmon River near Forks of Salmon, California (Figure 1-1). The project area includes (1) the confluence of Kelly Gulch with the river , a perennial tributary within the project area; Kelly Bar, (2) a wide overbank bar complex on river right upstream of the Kelly Gulch confluence; and (3) the West Bar, a bar complex on river left across from the Kelly Gulch confluence (Figure 1-2). The entire project area is located on United States Forest Service (USFS) lands, within the Klamath National Forest. There are two active gold mining claims that encompass the entire project area.

The Salmon River is one of the most biologically intact sub-basins of the Klamath River and has been identified by the Klamath National Forest as the watershed with the best anadromous fisheries habitat in the Forest. The Salmon River hosts all the native anadromous fish runs present in the Klamath River watershed, including coho, spring and fall-run Chinook, summer and winter steelhead, Pacific lamprey, and green sturgeon; yet they face a high risk of extinction. These salmonids are either protected under the state or federal Endangered Species Act or listed by the state and federal government as a sensitive species that is "of concern" and "at-risk of extinction".

Problems facing salmonids and other aquatic species on the Salmon River include invasive exotic species, barriers to fish passage, depleted large woody debris, high sediment loads from the extensive road system, timber harvesting and hydraulic gold mining impacts, large wildfires, limited riparian function, unstable spawning gravels, and temperature impairment (NMFS, 2014). Remnant mine tailings and riparian disturbance continue to affect coho salmon habitat in the Salmon River and mined-over floodplains and terraces have remained poorly vegetated many decades after large-scale mining has ended.

The NMFS SONCC Coho Salmon Recovery Plan (NMFS, 2014) states that summertime water temperatures and lack of winter rearing habitat are the greatest stressors for juvenile coho in the Salmon River. The highest priority for recovery of coho on the Salmon River was identified to be improving the quality and extent of rearing habitat and refugia, including improving connectivity to existing off-channel habitat, constructing of new off-channel habitat, increasing large woody debris, and protecting or enhancing potential cold-water refugia areas.
The Kelly Bar project area was identified as having High Intrinsic Potential in the Draft NMFS SONCC Coho Salmon Recovery Plan and rearing coho juveniles have been found in at least nine tributaries to the river by Karuk Tribe and SRRC presence/absence surveys, including both above and below the Kelly Bar project area (NMFS, 2014). The project area contains several high-flow side channels, a perennial cool water stream, and an off-channel pond fed by the cool water stream.

1.2 Off-Channel Habitat Utilization by Rearing Coho Salmon

Studies have shown the importance of channel margins and groundwater-fed off-channel and side channel habitats for fry and rearing juvenile coho salmon, which prefer slower water velocities than steelhead or Chinook salmon (Lestelle, 2007; Roni et al., 2006; and Blackwell, et al., 1999; among many). Off-channel habitats may provide both summer and winter rearing habitat. Seasonally groundwater-fed off channel habitat, particularly channels and ponds with cooler temperatures in the summer and warmer temperature in the winter, have been called "hotspots of production" for aquatic species (Stanford and Ward, 1993). It has been observed by Lestelle (2007) that SONCC coho salmon utilize groundwater channels more than any other salmonid species in the summer months due to their particularly low velocity and cooler water temperatures in the summer. During winter high flows, coho have been found to move into and overwinter in river margin features such as backwater alcoves and groundwater-fed off-channel habitat features, which are often warmer than the main river. Juvenile coho that over-winter in these areas commonly experience survival rates substantially greater than those that rear in main channel habitats due to less energy expenditure and warmer water temperatures, as summarized in Lestelle (2007). This survival difference can have a tremendous influence on whether a population, either in its entirety or some of its components, is sustainable under prevailing environmental conditions.

Coho salmon also prefer the presence of complex wood more than other salmonid species. Due to their poorer swimming capability, they have been found to favor the slow water in the scour pools and the cover provided by large wood that reduces predation (Lestelle, 2007).

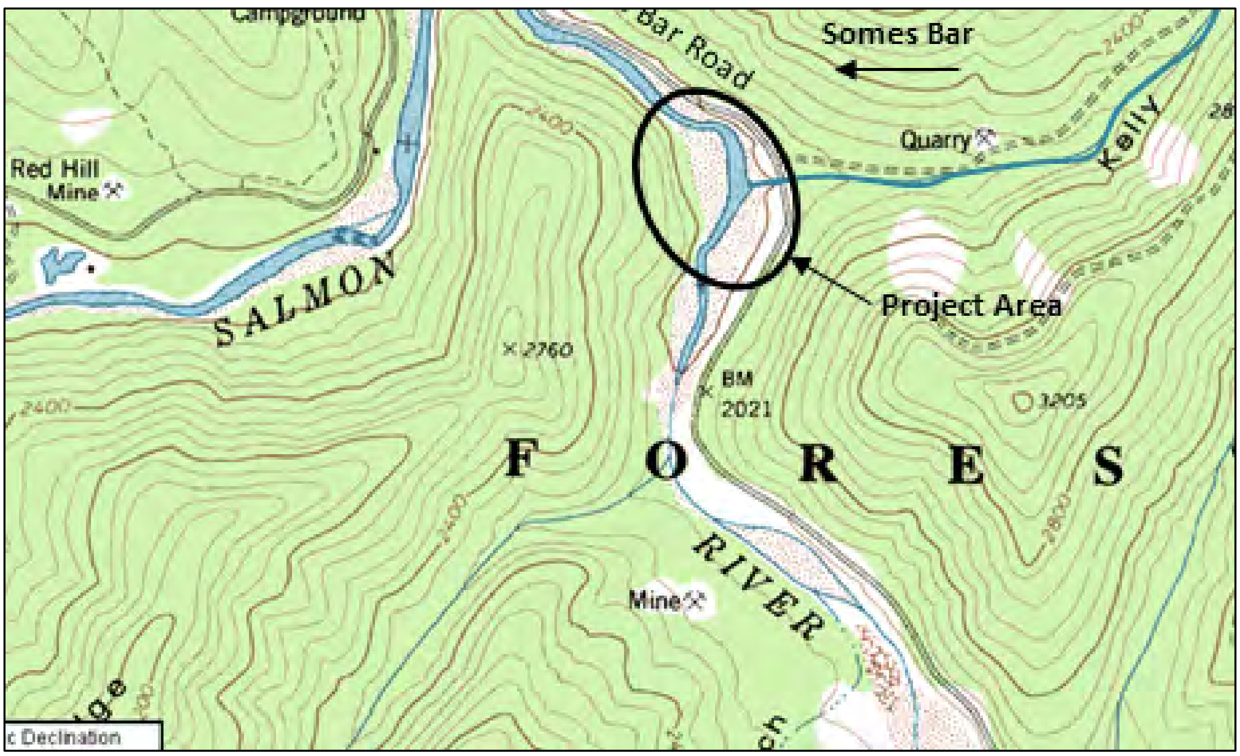
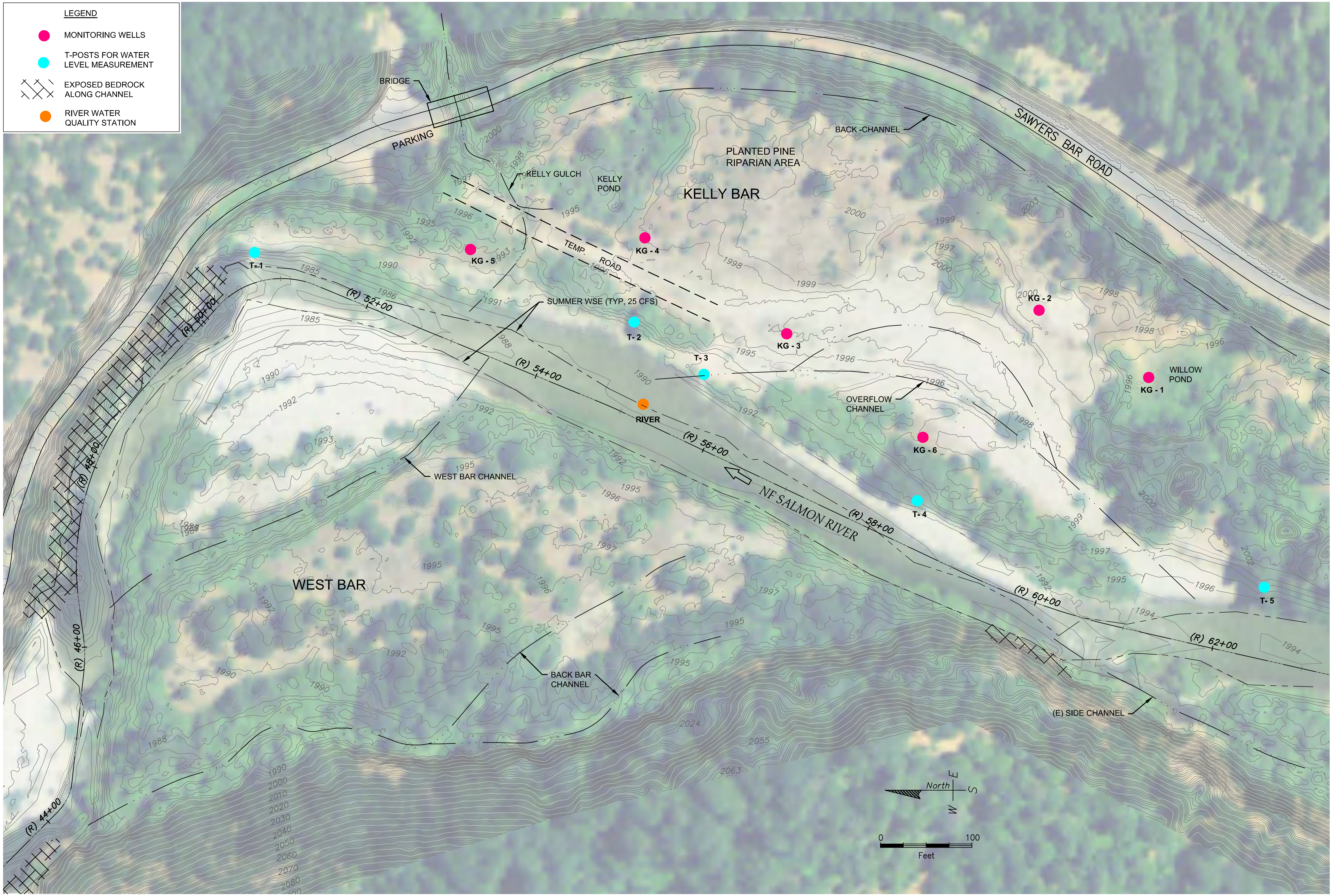


Figure 1-1. Location of the Kelly Bar project area on the NF Salmon River upstream of Forks of Salmon in Siskiyou County, California.



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VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

Salmon River Restoration Council
KELLY BAR OFF-CHANNEL
FISHERIES AND RIPARIAN HABITAT DESIGN

BASE MAP OF PROJECT AREA AND LOCATIONS OF MONITORING STATIONS

DATE	OCT. 2015
SUBMITTAL	30% DESIGN
DESIGN	RS ML
DRAWN	NN
FIGURE	1-2

Q:\Kelly Bar\DWG\SHEETS\2_E-COND.dwg

1.3 Project Background

The Salmon River Restoration Council (SRRC) fisheries program coordinates the bulk of monitoring, assessment and restoration in the Salmon River for anadromous fisheries. In 2008, the SRRC received a grant to conduct an assessment that evaluated riparian conditions and fisheries habitat throughout the Salmon River, and to develop conceptual designs for sites prioritized for restoration.

SRRC contracted Pacific Watershed Associates (PWA) to develop conceptual designs for restoration of riparian conditions and salmonid habitat at two high priority sites on a key reach of the NF Salmon River. One of these sites was the Kelly Bar project area. As part of the project, PWA prepared two conceptual alternatives for restoration of side channel habitat at Kelly Gulch (PWA, 2012). These alternatives involved enhancement of two existing high-flow side channels on Kelly Bar to create self-maintaining perennial channels. The study also recommended excavating through the existing cobble bar a defined channel for Kelly Gulch, which was observed to go subsurface through the dryer months, disconnecting fish ingress and egress from Kelly Gulch during those times.

SRRC obtained funding through the California Department of Fish and Wildlife (CDFW) Fisheries Restoration Grant Program (FRGP) Agreement No. P1310303 to prepare preliminary through final (100%) engineering plans for constructing self-sustainable side-channel habitat on Kelly Bar. SRRC retained Michael Love & Associates, Inc. (MLA) and PWA to perform the field investigations and prepare the engineering designs for the project. This report summarizes the results of the field investigations, alternatives evaluation, and basis of design for the proposed project.
Preliminary design plans for the project are in Appendix A.

1.4 Project Goals and Objectives

Goals for the Kelly Gulch project are to increase the abundance of complex off-channel rearing habitat with high intrinsic potential for year-round rearing of juvenile salmonids by providing both high-flow and thermal refugia. Specific project objectives include:

- Create self-sustaining side-channels with off-channel alcoves for high-flow off-channel refugia
- Provide off-channel high-flow and thermal refugia using groundwater-fed ponds and exploiting hyporheic flows in alcoves
- Increase in-channel bed complexity using large wood features
- Create large wood complexity in off-channel habitats
- Increase riparian shading to reduce summer water temperatures
- Improve connectivity of Kelly Gulch with river for both immigration and outmigration
- Minimize removal of large riparian vegetation
- Balance cuts and fills within the boundary of each of the two mining claims within the project area.

1.5 Project Meetings

A kickoff meeting and two stakeholder meetings were held during the preliminary design development phase of the project.

1.5.1 September 22, 2014 Kickoff Meeting

An on-site kickoff meeting was held on September 22, 2014 to review the project site conditions and locate appropriate sites for groundwater monitoring wells, which were subsequently installed. In attendance was staff from SRRC, CDFW, USFS, MLA, and PWA. During this meeting and subsequent excavation for the groundwater monitoring wells, the area now referred to as the Willow Pond was identified as having high summer groundwater and a focus area for water quality monitoring.

1.5.2 March 9, 2015 Stakeholder Meeting

A stakeholder meeting was held at the SRRC offices and at the project site on March 9, 2015. In attendance was staff from SRRC, Karuk Tribal Fisheries, USFS, MLA and PWA. The results of the data collection and analyses performed for the project were presented, as well as five potential restoration alternatives for the project area. The group discussed the advantages and disadvantages of each alternative and the group provided recommendations to the design team.

At this meeting, the persistent water depths in the Kelly Pond were observed and it was agreed that the pond is a potential area in which both summer and winter off-channel habitat would be suitable. Though a groundwater well was not installed in this pond, it was agreed that standing water depths and water quality measurements would be taken until the end of the monitoring period.

Other items discussed at the meeting included an emphasis on riparian recolonization and concerns raised by the USFS District Fisheries Biologist that bullfrog may move into ponds with perennial open water. Project constraints associated with the two mining claim within the project area and desire to dispose of excavated material on the claim in which it originated.

1.5.3 April 2015 Stakeholder Meeting

A second stakeholder meeting via conference call on April 15, 2015 and was attended by SRRC, CDFW, Karuk Tribal Fisheries, USFS, MLA, PWA, and Stillwater Sciences. At this this meeting, the results of the data collection and analyses performed for the project were presented. The five alternatives developed for the first stakeholder meeting were presented, along with a sixth option to enhance the Kelly Pond and improve its connection to the river.

At this meeting, four of the six alternatives were selected for further design development. Other items discussed at the meeting was the need to identify the boundaries of the mining claims and for the USFS to coordinate with an adjacent landowner to eliminate unpermitted grazing in the project area. A fencing plan for the project area was also discussed.

2 DATA COLLECTION AND ANALYSIS

The project approach included topographic, geologic, hydrologic, and water quality characterizations of the Kelly Gulch project area. These activities provided an understanding of physical opportunities and limitations of the project area, and were used to develop the design for the project.

2.1 Topographic Survey

LIDAR-based topography obtained from SRRC was used for the base-mapping of the project area. The horizontal control for the LiDAR survey is North American Datum 1983 (NAD83) California State Plane, Zone 1, in feet and vertical control is North American Vertical Datum of 1988 (NAVD88) in feet. Graham Matthews and Associates (GMA) provided the survey control for the project area to correspond with the LiDAR datums.

The LIDAR topography did not contain details of the river channel due to the presence of flow in the channel when the LIDAR survey was completed. To supplement the LIDAR survey, MLA performed a field-run survey of the active channel of the river in September, 2014 using a total station. The survey included approximately 2,800 feet of the river, extending approximately 1,500 feet upstream and 1,300 feet downstream of the confluence of Kelly Gulch with the river. The survey included a thalweg survey, left and right edges of water, lower streambanks, bedrock outcrops, and the locations of water level monitoring stations.

MLA merged the field-run topography survey with the LIDAR topography to create a digital terrain model and base-map of the project area with 1-foot contours, as shown in Figure 1-2. A 2012 aerial photograph was overlain with the base-mapping for use in delineation of vegetated areas and to show the location of Sawyers Bar Road.

2.2 Geologic Investigation

PWA performed a geologic investigation of the project area (Appendix B, PWA, 2015). The investigation included a description of the geologic and geomorphic setting, characterization of the subsurface stratigraphy of Kelly Bar, installation of six shallow groundwater wells, and recommendations regarding stable side slopes, suitability of materials for re-use, water management, sediment control and site stabilization.

The geologic report indicates the project area is in an alluvial valley located in the Klamath Mountain physiographic province. The valley walls consist of poorly consolidated and sheared metamorphic rocks as well as deeply weathered granitic rocks that are particularly susceptible to erosion and mass wasting events during periods of heavy rainfall.

The subsurface investigation indicated that the materials comprising Kelly Bar are fairly consistent and made up of stratified, unconsolidated, cohesionless coarse-grained alluvial materials ranging in size from sands to boulders. The report characterized the materials as having a high intrinsic permeability, allowing for a rapid response in groundwater conditions with river fluctuations. PWA recommended that the maximum side-slopes for excavated areas not exceed 3H:1V.

2.3 Hydrology

The project area includes the NF Salmon River at Kelly Bar and Kelly Gulch. The drainage area to the river at Kelly Bar is 145.8 square miles. The drainage area to Kelly Gulch is 1.6 square miles. Both drainage areas are characterized by steeply sloping, primarily forested terrain. Annual precipitation for the project area ranges between 40 and 50 inches per year (Prism, 2010) and falls as both rain and snow. The lower elevations along the river corridor and most of the Kelly Gulch watershed receive most of their precipitation in the form of rainfall. The higher elevations within the North Fork Salmon River watershed receive precipitation primarily in the form snowfall. However, warmer precipitation events during the wet season can result in rainfall throughout nearly the entire river basin, often leading to the highest flow events during the year. In the late spring and early summer snowmelt generally creates sustained elevated flows in the river.

2.3.1 Peak Flows

Flows at the project site are not gaged, however, there are two USGS stream gaging stations on the Salmon River. The South Fork of the Salmon River near Forks gage (USGS Station No. 11522300) was active between 1953 and 1977 and has a drainage area of 252 square miles. The Salmon River at Somes Bar gage (USGS Station No. 11522500), has been active since 1911, and has a drainage area of 751 square miles. Log Pearson Type III (LPIII) probabilistic analyses (USGS, 1982) were prepared using annual peak flow data from both stream gages to predict peak flow magnitude and frequencies. Peak flows were then normalized to flow per square mile (cfs/mi^2) for both gages. Normalized peak flows from the two gages were averaged and scaled to the drainage area of the river at Kelly Gulch and for Kelly Gulch to estimate peak flow magnitudes and frequencies at these locations, as summarized in Table 2-1.

LPIII analyses of the Somes Bar gage identified four flood events with return periods greater than 20-years occurred between 1955 and present. These include the 1964 flood which had an approximately 90-year return period, the 1955 flood which had a 44-year return period, and 30-year and 22-year return periods in 1997 and 2005 respectively.
Appendix C provides the peak flow hydrologic analyses.

Table 2-1. Estimated return period of peak flows for the North Fork Salmon River at Kelly Bar and Kelly Gulch.

North Fork Salmon River at Kelly Bar							
Drainage Area	Return Period of Peak Flow						
	1.2-Year	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
145.8 miles^2	2,036 cfs	3,983 cfs	7,056 cfs	9,514 cfs	13,086 cfs	16,079 cfs	19,353 cfs
Kelly Gulch							
Drainage Area	Return Period of Peak Flow						
	1.2-Year	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
1.6 miles^2	22 cfs	44 cfs	77 cfs	104 cfs	144 cfs	176 cfs	212 cfs

2.3.2 Flow Duration, Daily, and Monthly Flow Analyses

Daily flow duration analyses were prepared using daily average flow records from the two USGS Salmon River gaging stations for the period that they were concurrently operational; water years 1958 through 1965. Daily flows for both gages were normalized to the drainage area of the NF Salmon River at Kelly Bar. Annual exceedance flows for the project were based on averaging the normalized results from both gages, as shown in Figure 2-1.

The relative magnitude of flows in the Salmon River during the project monitoring period was compared with historical by comparing average monthly flow for the Somes Bar USGS gage with the monthly average flow during water year (WY) 2014/2015 (Table 2-2). The provisional 15-minute data was used to compute the average monthly flow for April through August, 2015. As evident in the table, average monthly flows in the Salmon River in fall of 2014 were similar or higher than the long term average. During the winter of 2015, flows in the Salmon River were less than 50% of average, except in February, which experienced two large runoff events. Spring and summer of 2015 experienced extremely low flows. This is largely due to a lack of snowpack that typically provides a sustained high flow during snowmelt.

Appendix C provides the flow duration analyses and monthly flow data.

2.3.3 Estimating Real-Time NF Salmon River Discharge at Kelly Bar

NF Salmon River flows during the project monitoring period were estimated relying on the USGS Salmon River at Somes Bar 15-minute real-time flow data. This data was scaled to the drainage area of the river at the project site. Subsequent analysis suggests this approach provided relatively accurate estimates during periods when flows were relatively constant throughout the day.

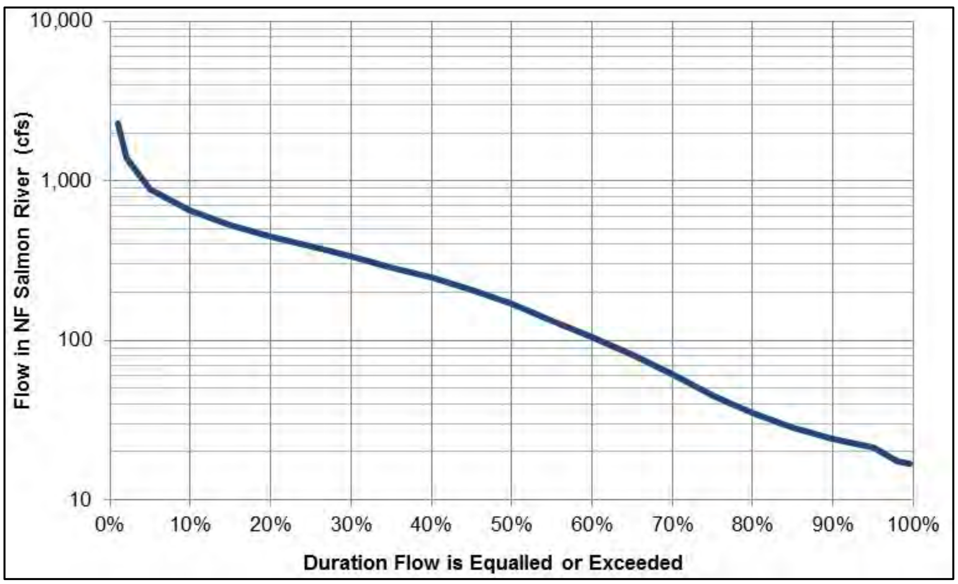


Figure 2-1. Constructed flow duration curve for NF Salmon River at Kelly Bar estimated using USGS gage data scaled by drainage area.

Table 2-2. Historical mean monthly flows on the Salmon River at Somes Bar (USGS Station No. 11522500) for a 104-year period of record, compared to monthly mean flows during water year (WY) 2015.

Data Record	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Historical Mean Monthly Flow (cfs)	341	1,040	2,230	2,920	2,900	2,920	3,010	3,100	1,900	621	261
2015 WY Monthly Mean cfs)	551	1,005	3,177	1,638	4,529	1,329	1,060*	696*	443*	244*	154*
2015 WY Percent of Historical Mean	161%	97%	142%	56%	156%	46%	35%	22%	23%	39%	59%

** computed using 15-minute provisional data*

2.4 *Water Level and Water Quality Monitoring*

Water surface elevations (WSE) in the river along the project area were monitored by SRRC to identify seasonal water surface elevations in the river, for correlating them to groundwater levels along Kelly Bar, and for use in calibrating the hydraulic models developed for the project. Water temperature and dissolved oxygen (DO) were also monitored in the river and in the groundwater wells to establish if the water quality of the groundwater would be suitable for groundwater-fed off-channel features. The monitoring period extended from October 9, 2014 through July 27, 2015, and additional spot readings of water temperature and DO were measured in the river, Kelly Gulch and Kelly Pond on September 22, 2015.

2.4.1 Water Level Monitoring Methods

Six shallow groundwater monitoring wells were installed on Kelly Bar in September 2014 in the locations shown on Figure 1-2. Elevations of the well rim and adjacent ground were surveyed. Water levels in the wells were measured by SRRC during baseflow and high flow events between October 9, 2014 through July 29, 2015. A total of 11 sets of measurements were made. Standing water levels in the Willow Pond and Kelly Pond were also recorded. Water levels in Kelly Pond were collected only during May, June, and July 2015.

In September 2014, five T-posts were installed and surveyed along a 1,000-foot length of the river adjacent to Kelly Bar, as shown on Figure 1-1. The locations and elevations of the T-posts were surveyed and then used as fixed elevations for measurement of river WSE. Discrete river WSE adjacent to the T-posts were concurrently with measurements at monitoring wells. A total of 11 sets of measurements were made, with river flows ranging from 25 cfs to approximately 4,300 cfs. Photographs of river conditions and a written description of field-observations were also logged during each monitoring event.

2.4.2 Water Level Monitoring Results and Discussion

Figure 2-2 presents the results of the ground and surface-water monitoring for three of the 11 monitoring events, reflecting the conditions during lower monitored river flows of 46 cfs (75% daily exceedance flow), conditions when flows in the river were near the 25% daily exceedance flow (471 cfs), and conditions during an approximately 1.01-year flow event (2,083 cfs). Similar plots of the other monitoring events are presented in Appendix D.

Standing water levels in the Kelly Pond ranged from 0.5 to 1.0 feet deep from May through June (Appendix D). During the July 29th field measurements, approximately 25 0+ juvenile chinook and steelhead salmonids were observed in the pond. On September 22nd Kelly Pond was still wetted and salmonids were observed residing in the pond.

As evident in Figure 2-2 and Appendix D, measured water levels in the wells generally tracked water levels in the river, indicating that the subsurface materials in the bar, characterized by the project geologist as having a high intrinsic permeability (Section 2.2), allowed rapid response of groundwater levels to changes in river water levels. The remainder of this report will refer to groundwater elevations associated with daily exceedance flows in the river.

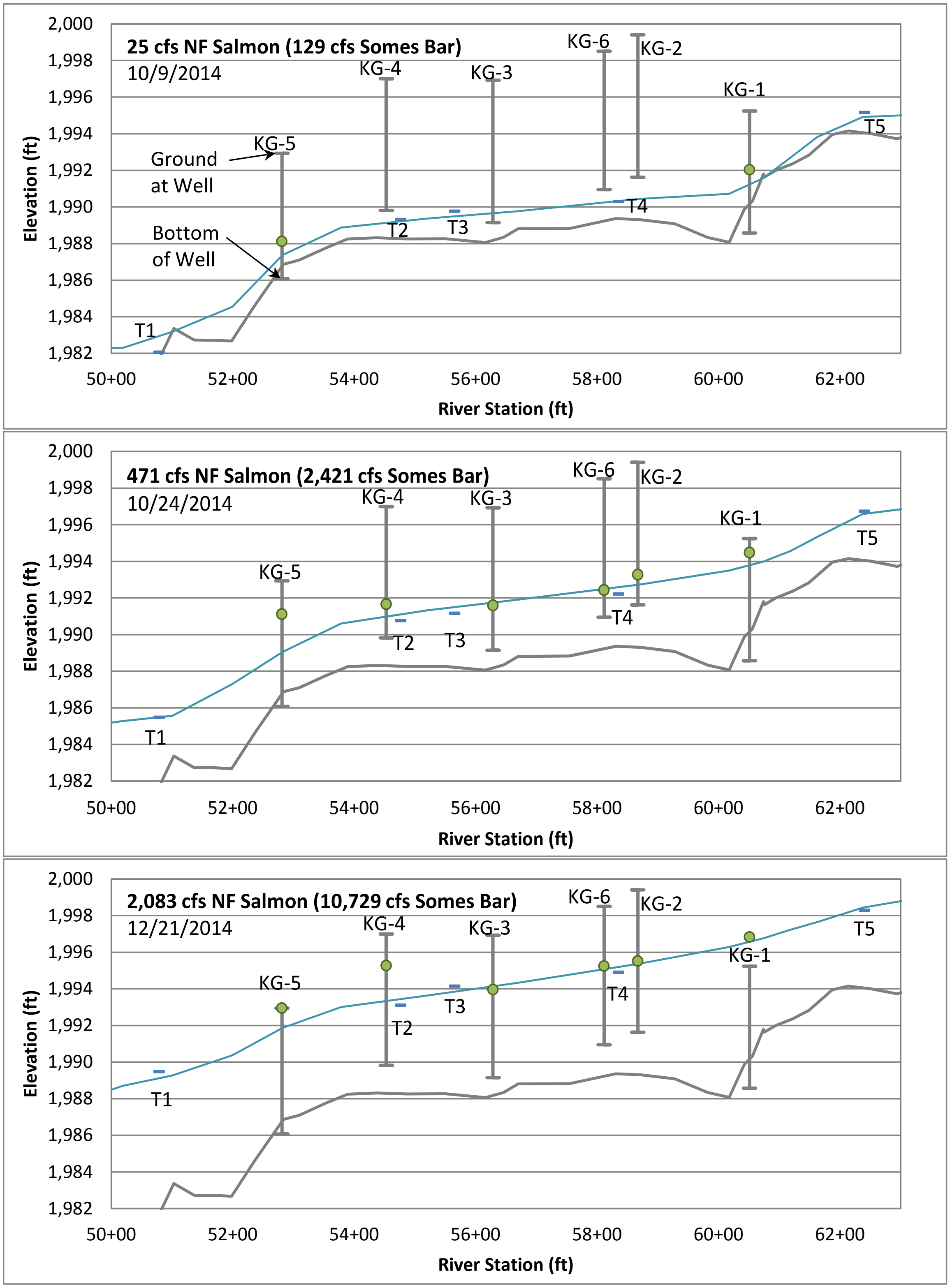


Figure 2-2. Measured ground and surface water elevations at Kelly Bar, and calibrated HEC-RAS water surface profiles for three flow events. Missing well water surface elevation (WSE) readings indicate that the well was dry.

Groundwater levels at KG-1, located in the Willow Pond, are generally higher than the adjacent river levels, but appear to coincide with water levels on the riffle in the river a short distance upstream of the well. This suggests a hydraulic gradient from the riffle to the groundwater level at KG-1 that drives hyporheic flow and results in shallow groundwater that supports the willow growth at this location on the bar.

Standing surface water levels measured in the Kelly Pond indicated that the pond remains inundated by both surface flow and subsurface flow from Kelly Gulch well into the dry season. The groundwater gradient from Kelly Gulch and Kelly Pond appears to be relatively localized, as adjacent wells, KG-4 and KG-5, were substantially lower than Kelly Pond water level, as shown for July 29th monitoring event on Figure 2-2.

2.4.3 Water Quality Monitoring Methods

To establish the suitability of the ground and surface water at the project area for warm season thermal refugia, water temperature was monitored by SRRC in four of the six monitoring wells and in a riffle in the river. Monitoring was conducted using Hobo Temp data loggers at the locations shown on Figure 1-2. Water temperatures were logged every 5 minutes from October 2014 through July 1, 2015. Continuous temperatures were not collected in well KG-6 and the data logger from well KG-4 failed to work, therefore, no continuous temperature data was available for these wells.

Discrete water temperature and dissolved oxygen (DO) were also collected by SRRC between November 9, 2014 and July 29, 2015. A total of eleven sets of measurements were made. DO was collected occasionally during the monitoring period. Water temperature and DO levels were also collected in Kelly Pond during the last three monitoring events in May, June, and July 2015.

2.4.4 Water Quality Monitoring Results and Discussion

Figure 2-3 presents the results of the water quality monitoring in the river, Kelly Pond, and groundwater wells for the monitoring period. All data by monitoring event is in Appendix E. Flows in the in the river are shown for reference. Though all wells except KG-1 and KG-5 went dry during the drier months of the sampling period, the ambient temperature in the wells maintained consistent temperatures so the data was retained.

Water Temperature

Optimum water temperatures for growth of coho range from 14 to 18 ^{o} C (Sullivan, et al., 2000). Based on findings from a multi-year study to assess key aspects of the seasonal life-history patterns of juvenile coho salmon within the Klamath River, coho begin to seek thermal refugia when water levels reach 19^{o} C (Hillemeier, et al., 2009). When water temperatures reach 22 to 24 ^{o} C, coho become stressed (Hillemeier, et al., 2009 and Eaton et al., 1995). The findings also indicate that steelhead are able to tolerate slightly warmer temperatures than coho. For this study, it was assumed that salmonids would begin seeking off-channel refugia from warm water when river temperatures exceed 19 ^{o} C.

During the monitoring period, peak river water temperatures exceeded 19 ^{o} C beginning in late May (Figure 2-3a), and rose above 22 ^{o} C by mid-June, indicating that salmonids will likely be seeking thermal refugia from the river after May and through late summer. September river temperatures fell below 19 ^{o} C, indicating that the river becomes suitable for rearing in the fall with the decrease in solar insolation.

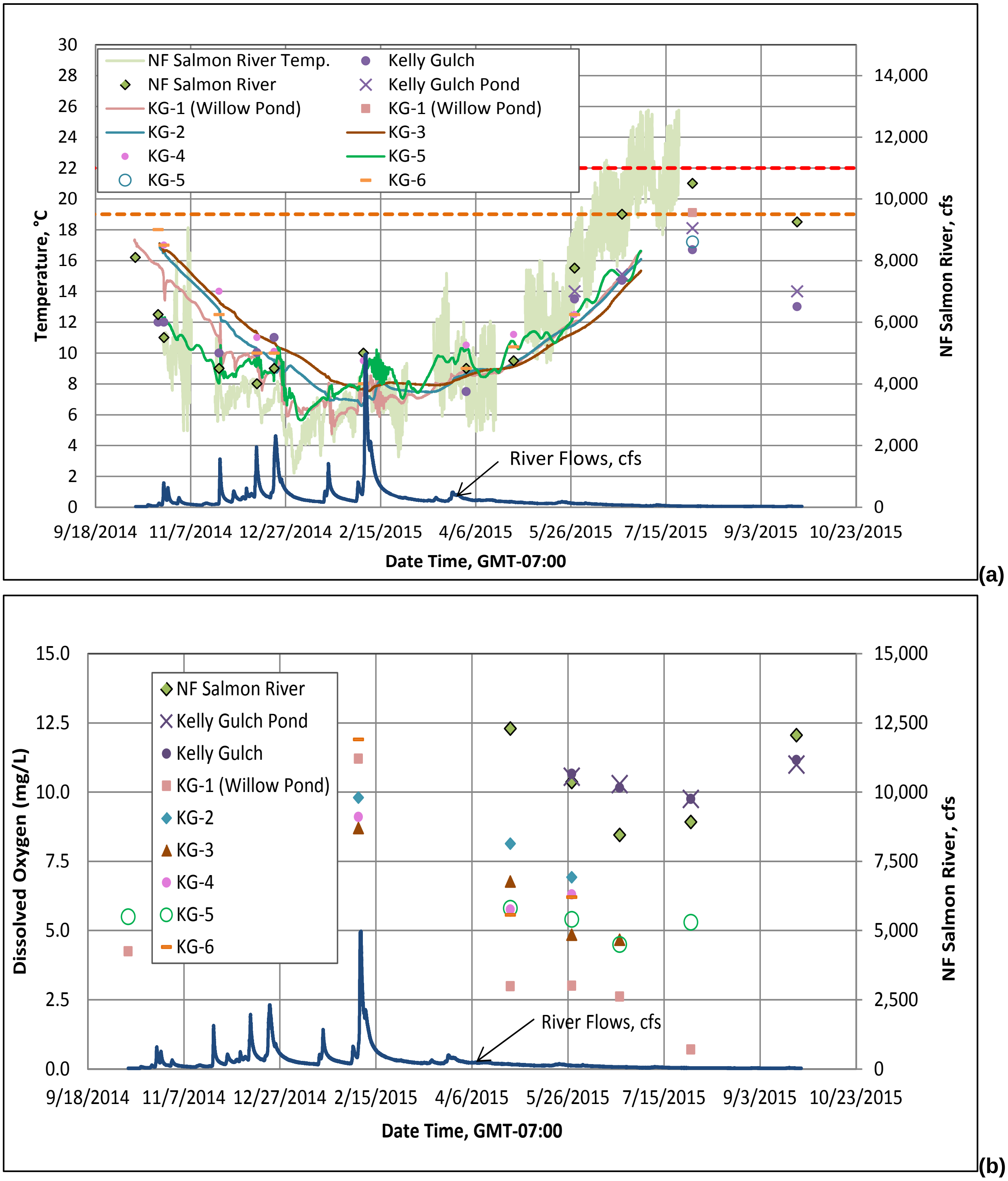


Figure 2-3. Results of water temperature (a) and dissolved oxygen (b) in the river and groundwater monitoring wells at the Kelly Bar project area. Continuous lines represent continuous measurements and symbols represent discrete measurements. The dashed lines indicate 19° C (orange) threshold for when coho salmon may seek thermal refugia, and 22° C (red) threshold for when they become stressed.

Generally, groundwater temperatures along Kelly Bar remained lower than river temperatures in the summer months, but remained warmer than the river as it cooled in the fall (Figure 2-3a), which has been found to be the optimum pattern for off-channel coho rearing (Lestelle, 2007). It does not appear that the summer groundwater temperatures are being substantially cooled by hyporheic flows; however, groundwater temperatures remain similar to minimum daily river water temperatures because they are not exposed to daily solar insolation.

Surface water temperatures in Kelly Gulch and Kelly Pond followed a similar pattern to the groundwater temperatures, remaining lower than river temperatures in the summer months, but then remained warmer than the river during the winter months (Figure 2-3a). Water temperatures in Kelly Gulch and Kelly Pond did not exceed 19° C during the monitoring period, and appear to be suitable year-round for juvenile rearing. A surface water temperature of 18.1° C was recorded in the Kelly Pond during the July 29, 2015 monitoring event. At that time, approximately 25 0+ juvenile chinook salmon and steelhead were observed using the pond. Similarly, during the September 22nd monitoring event, water temperatures in Kelly Pond had dropped to 14° C and fish were still utilizing the pond.

Groundwater temperatures of 19.1° C recorded in the Willow Pond (KG-1) during the July 29th monitoring event indicated that groundwater temperatures are closer to but still cooler than the river water temperature of 21° C. Groundwater temperatures in Willow Pond may be suitable to provide for off-channel rearing habitat throughout the year. Given that river flows were unusually low during the latter part of the monitoring period, both river and groundwater summer temperatures would likely be lower during more typical water years.

Dissolved Oxygen

Juvenile salmonids are frequently found thriving in waters with dissolved oxygen (DO) concentrations as low as 5 to 6 mg/l (Michael Wallace, CDFW, Personal Communication). Habitat with even lower DO concentrations can still be of value. For example, coho have recently been found consistently utilizing off-channel habitat with DO as low as 1 mg/l in the lower Klamath River basin, but water temperatures were generally 15° C or less (Beesley and Fiori, 2014).

DO in the groundwater readings were lower than DO in the river and Kelly Gulch, as shown in Figure 2-3b. Except in the Willow Pond well (KG-1), groundwater DO levels remained near 5 mg/l or higher at all monitoring locations. A DO concentrations of 0.7 mg/l was recorded in KG-1, during the July 29th monitoring event, suggesting DO could be highly unsuitable for rearing salmonids in the latter summer months if a perennial pond was constructed at this location. The extreme low flows in the river could be contributing to the low summer DO concentrations in the pond, and more normal flow conditions could result in better late-summer rearing conditions in the Willow Pond.

2.5 Existing Hydraulic Conditions

Two different hydraulic models were used for the project. HEC-RAS (ACOE, 2010a,b), a 1-dimensional hydraulic model, was used to create a calibrated model of existing conditions of the river. Because it is a 1-D model, HEC-RAS only yields information on a cross sectional basis, and does not provide details regarding complex channel and overbank flow interaction present at Kelly Bar.

The SRH-2D model (Bureau of Reclamation, 2008) is a 2-dimensional hydraulic model that was prepared using the results of the calibrated HEC-RAS model to evaluate in detail existing and proposed-condition flow inundation frequency, depths, velocities, and shear stress in the main channel and along the side channels within the project area.

2.5.1 HEC-RAS Modeling

A calibrated HEC-RAS model was prepared to determine appropriate hydraulic loss coefficients and establish boundary conditions for use in SRH-2D. A HEC-RAS model was prepared for 2,715 feet of river channel, encompassing 1,600 feet of the project area along Kelly Bar and the West Bar. Cross sections were derived from the merged LIDAR/surveyed digital terrain model. Cross sections were spaced on average approximate every 100 feet, with closer spacing to define stream features such as riffles and pools. The model was prepared as a single thread channel, and did not seperate the existing high-flow side channels on Kelly Bar or the West Bar.

The HEC-RAS model was calibrated using eleven flow events captured as part of the project monitoring. Water surface elevations measured at the T-posts (Section 2.4) and a flow event captured by the LIDAR were used. Flows at the project area were scaled from the real-time reported flows at the USGS gage at Somes Bar for the sampling period (Section 2.3).

For all calibration runs, the steady-state HEC-RAS model was executed in mixed flow, using a critical depth boundary at the upstream end of the model and at the downstream end a normal depth water surface slope of 0.006 based on the LIDAR water surface slope. Expansion and contraction coefficients were set at 0.5 and 0.7 respectively, to reflect moderately abrupt flow transitions between cross sections due to the highly variable nature of the river channel (ACOE, 2010b).

To calibrate the HEC-RAS model, the water level measured at each T-post for each flow event was entered into HEC-RAS using the "observed water surface" function. Channel roughness values were adjusted so that the model-predicted water surface elevations (WSE) matched the observed water surfaces within a few tenths of feet, where possible. Overbank roughness values were set at 0.1. Model-predicted WSE compared to the river WSE at the T-posts for flow events are shown on Figure 2-2 and results for the other flow events are presented in Appendix D and F.

The model calibration yielded a Manning's roughness coefficient ranging from 0.055 to 0.09. The roughness values of 0.055 were used in relatively straight reaches of channel in the lower sloped riffles and pools. A roughness value of 0.075 was used for the two straight and steep riffles upstream of Kelly Bar and upstream of the sharp bend at Sawyers Bar Road. A roughness value of 0.09 was used within the sharp bend to account for energy losses resulting from abrupt flow separation and turbulence that occurs at the bend. These roughness values are typical of major channels with irregular and rough cross sections (Chow 1959).

The 2/6/2015 flow scaled from the USGS gage at Somes Bar did not calibrate well with the measured water surface elevations at Kelly Gulch. A higher modeled flow was necessary to obtain the calibration using the same roughness values as the other flows. The measurement event occurred on the rising limb of a 2-year event, and it is likely that there was a flow timing difference between the two sites due to the rapid rise of the hydrograph.

2.5.2 SRH-2D

A steady-state 2-dimensional model was used to evaluate in detail existing and proposed-condition water surface elevations, inundation depths, water velocity, and sediment transport competence for a range of flows within the project area. The Sedimentation and River Hydraulics- Two Dimensional (SRH-2D) model was selected for the hydraulic analysis due to its suitability for the hydraulic conditions being assessed and its overall stability.

SRH-2D is a grid-based model that solves the standard St. Venants equations for gradually varying flow using finite-volume methods. The grid elements are a combination of rectangular elements within channels and triangular elements on floodplains and adjacent valley walls. A 2-dimensional (2-D) model was prepared for the 2,715 feet of surveyed channel that encompasses the project area. The model extended on both sides of the river channel and up the valley walls. The main river channel, Overflow channel and Mid-Bar Channel were modeled with 4-side elements ranging from 3 to 8 feet in width and approximately 15 feet in in length, oriented with the long axis parallel to the flow direction. The floodplains and valley walls were modeled using triangular elements with 15-foot sides. The elevations of the grid were derived from the project's digital terrain model (DTM) derived by merging the LIDAR and topographic survey DTMs.

The model was prepared in steady flow for each simulated flow event. Flow events evaluated ranged from 25 cfs (99% exceedance flow) to the 10-year peak flow (9,514 cfs). A stage-discharge curve derived from HEC-RAS was used as the downstream boundary condition for all model simulations. The upstream boundary condition consisted of inflows at the upstream end of the model domain in the river and at Kelly Gulch. The model was started with the elements dry and executed with 3-second time steps until flows stabilized.

It was assumed that Kelly Gulch flows peak earlier than the river. Therefore, the peak flow in Kelly Gulch was not used during the model simulation. Instead, flows ranging from 1 cfs to 20 cfs were modeled, with higher flows modeled during larger river flow events. Based on field observations by SRRC, during flow events less than 2-year, the Back-Channel paralleling Sawyers Bar Road did not convey flow. Therefore, no flows were modeled in the Back-Channel for flows less than a 2.2-year event. Flows ranging from 10 to 20 cfs were modeled in the Back-Channel for the 2.2-year event and larger. Flows in Kelly Gulch and the Back-Channel are not calibrated flows, and were used primarily to evaluate flow patterns and during events. Observations by SRRC of overbank flow patterns assisted in calibration of the model.

The value for the Manning's roughness coefficient was assigned to each grid element. SRH-2D does not use contraction and expansion coefficients as part of the computations. Therefore, contraction and expansion losses need to be incorporated into roughness values. Channel roughness values were obtained from the calibrated HEC-RAS model, and further calibrated using the measured water surface elevations at the T-posts for monitored flows. A total of five roughness values were used, as shown in Table 2-3.

Figure 2-4 and Figure 2-5 present the results of the existing-condition model-predicted water depths and velocities for the 2.2-year peak flow. Additional modeling results for other flow events are presented in **Appendix G**. The 2-D results indicate that flows remain within the main channel of the river until approximately a 1.1-year flow event. Both field observations and model results indicate that the Mid-Bar Channel on the West Bar begins to convey flow during approximately a

1.1-year event. The Overflow Channel on Kelly Bar becomes active during an approximately 2.2-year event. Based on field observations by SRRC, the Willow Pond receives inflow from the Back-Channel adjacent to Sawyers Bar Road during 2-year and larger events. The Back-Bar Channel on the West Bar begins to receive a small amount of flow during a 2.2-year event, and is fully activated during an approximately a 5-year event. The model results indicate neither Kelly Bar nor the West Bar become fully inundated, with water spreading from valley wall to wall, until larger than a 10-year event.

Table 2-4 summarizes model-predicted total flows in the river mainstem and flows in the side channels during a range of flow events. The Overflow Channel on Kelly Bar carries no flow during a 1.2-year event, which increases to nearly 7% of flow during a 10-year event. During 1.1- and 2.2-year flow events, the Mid-Bar and Back Bar channels carry 0.2% to 5.7% of total channel flows, which increases to a total of 21.7% during a 10-year flow event.

Table 2-3. Manning's roughness coefficient used for 2D modeling of the Kelly Bar project area.

Feature	Manning's Roughness Coefficient
Straight River Channel Unvegetated Side Channel	0.055
Floodplain (Young or Sparse Vegetation)	0.065
Riffle (Steep), Forested Side Channel	0.075
Pool at tight Bend	0.110
Floodplain (Mature or Dense Vegetation)	0.150

Table 2-4. Existing condition model-predicted total flow in the river and amount of flows through side channels. Percentages indicate the amount of flow in the side channel relative to the total river flow.

Location	Return Period of Flow Event			
	1.2 Year	2.2 Year	5 Year	10 Year
Total Flow	2,083 cfs	4,300 cfs	7,056 cfs	9,514 cfs
Overflow Channel on Kelly Bar	0 cfs (0%)	4 cfs (0.09%)	270 cfs (3.8%)	660 cfs (6.9%)
Mid-Bar Channel on West Bar	4.5 cfs (0.2%)	243 cfs (5.7%)	897 cfs (12.7%)	1546 cfs (16.3%)
Back Bar Channel on West Bar	0 cfs (0%)	0.3 cfs (0.01%)	123 cfs (1.7%)	513 cfs (5.4%)

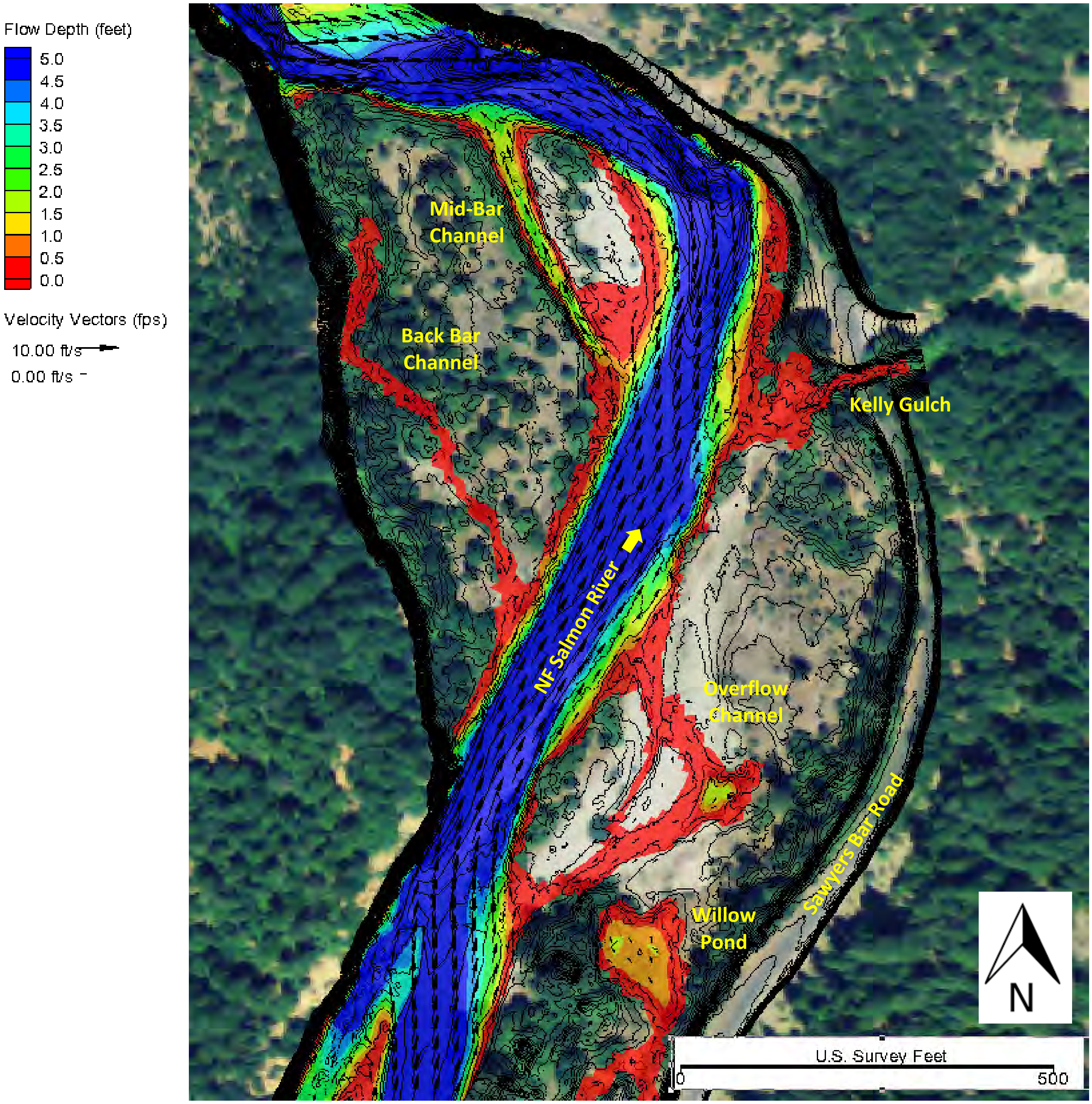


Figure 2-4. SRH-2D predicted flow depths (in feet) and inundation extents during a 2.2-year flow event in the NF Salmon River at Kelly Bar (4,300 cfs). The arrows represent water velocities, with the larger arrows indicating higher velocities. Flow depths greater than 5 feet are show as blue.

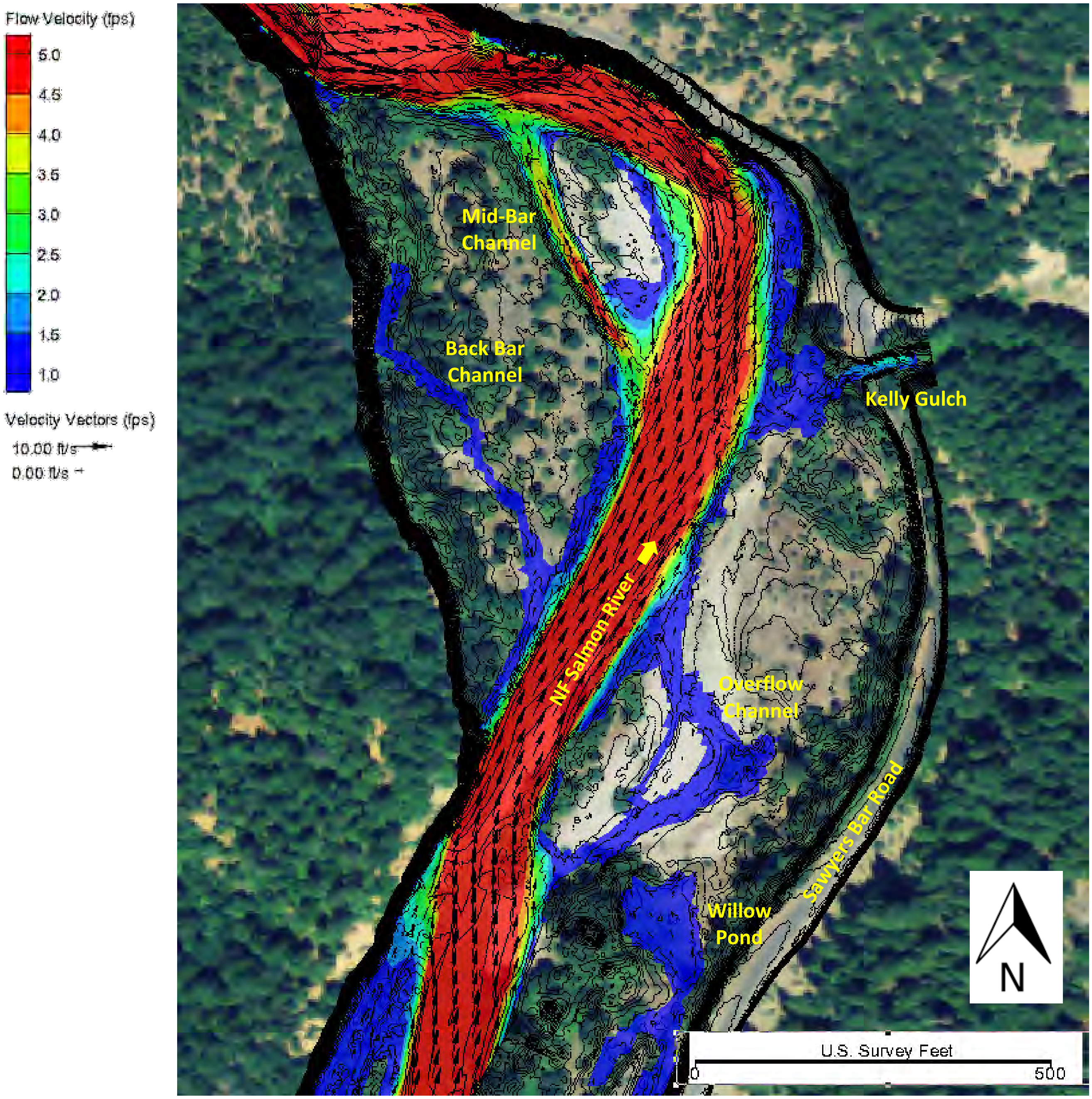


Figure 2-5. SRH-2D predicted flow velocities and inundation extents during a 2.2-year flow event in the NF Salmon River at Kelly Bar (4,300 cfs). The arrows represent water velocities, with the larger arrows indicating higher velocities. Flow depths greater than 5 feet are show as blue.

2.6 Geomorphic Assessment

To characterize the existing geomorphology of the project area and to understand the extents that the river alignment can be expected to change over short and longer time periods, a geomorphic assessment was conducted for the project area. The assessment included interpretation of historical aerial photos and a field-based geomorphic assessment.

2.6.1 Historical Aerial Photograph Interpretation

Historical aerial photographs of the project area were available from 1944 through 2012 (1944-1995 Salmon River Restoration Council, unknown source, 2012 NAIP) and are shown in Appendix H. Only the 2012 aerial photo was ortho-rectified. To overlay photographs, each aerial was digitally 'rubber sheeted' to match landmarks visible on both the subject aerial photo and the 2012 image. Figure 2-6 presents tracings of the main river channel and visual extents of active scour for 1955 and 1965 overlain on a 2012 aerial photograph (Section 2.3).

The river did not appear to undergo significant changes between 1944 and 1955. As evident in Figure 2-6 , the main river channel along Kelly Bar shifted nearly 400 feet to the west between 1955 and 1965, likely due to the 1964 flood. The 1964 flood had an approximately 90-return period at the Somes Bar USGS gage (Section 2.3). The existing Back-Channel that runs along the base of Sawyer Bar Road appears to be a remnant of the abandoned 1955 channel. A stereo-pair inspection of the 1955 aerial photographs shows a landslide scar on the western hillslope adjacent to the channel, which is still visible today. It appears that the landslide deposits had forced the river towards the east, as seen in the 1955 photograph. The 1964 flood eroded this deposit and shifted the channel alignment to the west, placing it at the toe of river valley. As seen in Figure 2-6, a remnant band of mature riparian trees persists to date on river right that was historically on river left.

The change in channel alignment upstream and adjacent to Kelly Bar appears to have caused a shift in the channel alignment downstream, resulting in the channel moving eastwards towards the center of the river valley adjacent to the West Bar. Inspection of the aerial photographs indicates that the Back-Bar Channel on the West Bar is likely a remnant of the 1955 river alignment (Figure 2-6).

Between 1965 and 2012, the alignment of the main river channel underwent only minor changes, despite a 30-year flow event in 1997 and a 22-year flow event in 2005. In the 2012 photograph, the river channel upstream and adjacent to Kelly Bar has shifted back to the center of the river valley, leaving a side channel in the location of the abandoned 1965 channel. Throughout this time period, the river mainstem also shifted slightly back and forth on the West Bar, and the Mid-Channel Bar is likely a remnant of a thread of the 1975 river alignment (Appendix H).

The currently active Overflow Channel appears to be a remnant of overbank scour that occurred between 1965 and 1975 and has persisted until present. A bedrock bank forming just north of Kelly Gulch creates a nearly 90 degree turn in the river and prevents river migrating northward. Vegetation scoured from the alluvial deposits as seen in the 1965 aerial, has begun to recolonizing the overbank alluvial surfaces.

The aerial photograph interpretation revealed that the project area lies within a dynamic reach of the NF Salmon River, having historically undergone substantial channel changes in response to landslides and the large 1964 flood event. Since 1964, only minor changes to the river alignment and bar systems have occurred.

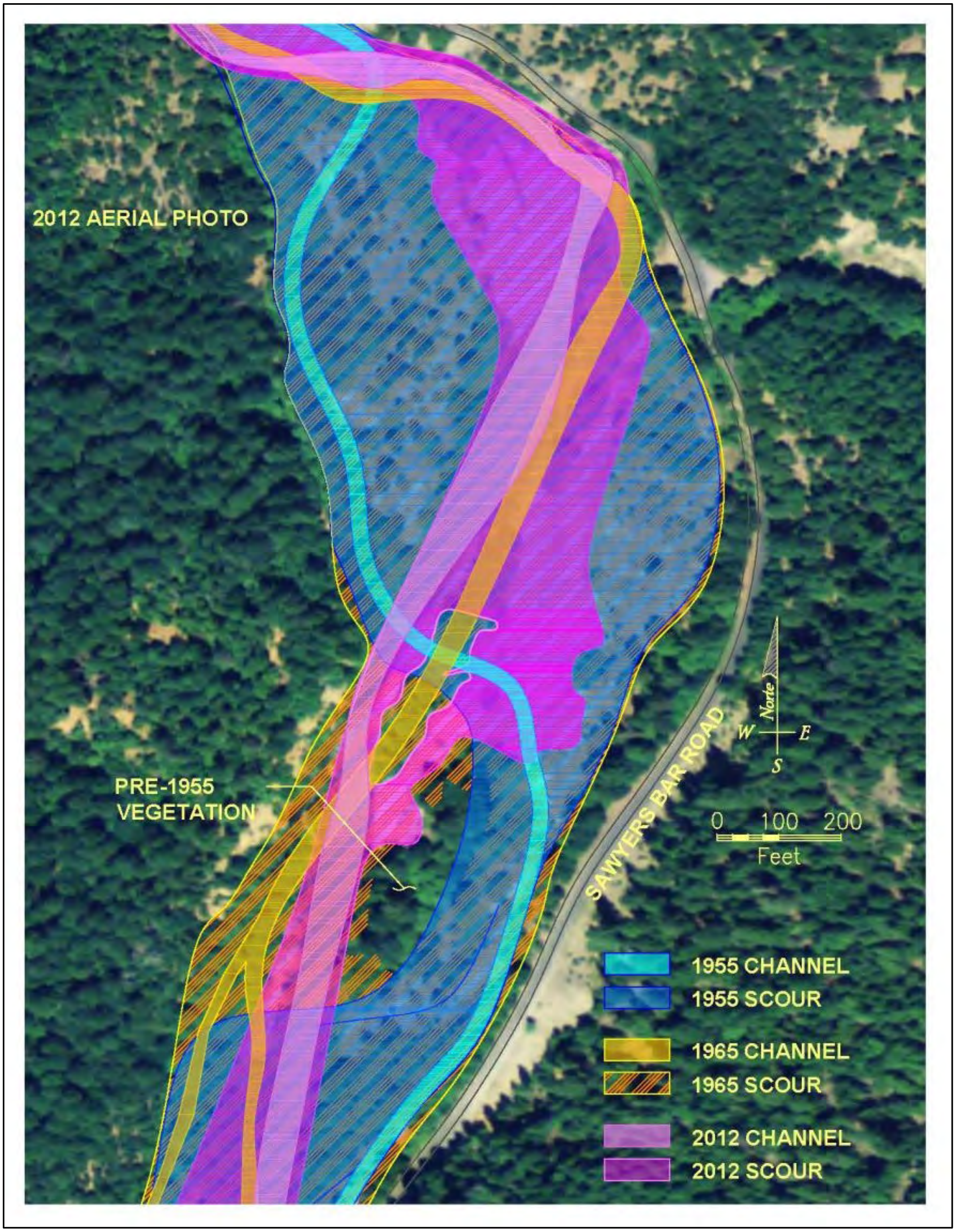


Figure 2-6. Tracings of historical aerial photographs from 1955 and 1965 overlain on a 2012 aerial photograph. Flow is from bottom to top. The "channel" lines indicate the alignment and extends of the wetted channel at the time of the photography, and "scour" delineates visible extents of the flow scour lines at the time of the photo.

2.6.2 Field Geomorphic Assessment

The geomorphic assessment of the project area consisted of pebble counts, sketches of existing flow patterns, and interpretation of the overall geomorphic function of the river and adjacent floodplains, with consideration of geomorphic controls upstream and downstream of the project area. Figure 2-7 presents a geomorphic sketch map of the project area, Figure 2-8 presents the annotated thalweg profile of the river, and pebble count results are provided in Appendix I.

The river is a semi-alluvial river with an active channel width of about 80 to 120 feet. The valley width varies from about 100 to 500 feet and consists of both intact and decomposed bedrock. Generally, the planform of the valley controls the planform of the river. The main river channel within the project area generally flows northward, but makes an abrupt 90-degree bend to the west just north of the confluence of Kelly Gulch. A bedrock outcrop on the valley wall at this location prevents northward channel migration, and bedrock is exposed in the deep scour pools at this bend. Bedrock exposures on the left bank at Station 60+00 and 43+00 also control the planform of the river (Figure 2-7). As identified in the aerial photograph interpretation (Section 2.6.1), the active channel of the river and bar systems have the potential to shift substantially during extreme flow events, but appears to undergo only smaller shifts in channel planform as it responds to moderate flow events.

The river in the project area has an overall slope of 0.85%, with steeper slopes at riffles as shown in Figure 2-8. The channel thalweg consists of alternating riffles and pools predominantly forced by bedrock and boulders. The steep riffle near the Kelly Gulch confluence is likely a result of a high-flow backwater occurring at the tight bend in the channel. Within the project reach, pools downstream of riffles were deeply scoured. Pebble counts in two of the riffles indicate that the median grain size in riffles ranges from 83-112 mm cobbles, with the largest particle sizes in the riffles consisting of 500-550 mm boulders.

Kelly Bar and West Bar Floodplain Complexes

The Kelly Bar and the West Bar floodplain complexes are both alluvial bar complexes forming floodplains within the project area. The bars are characterized by multiple high-flow side channels and scoured features forming depressions. The results of the geologic investigations (PWA, 2015, shown in Appendix B) and two pebble counts of subsurface materials at Kelly Bar indicate that the material comprising the bar consists of stratified alluvially deposited materials. These materials range in size from sands to boulders, with a median grain size of 12-25 mm gravels, and the largest particle sizes consisting of 250 mm boulders. Surface materials are sands, with cobbles and gravels in overflow channels. Visual observations of the West Bar indicate it has similar grain size as Kelly Bar.

Kelly Bar has been historically mined, and is currently lies within two mining claims. At the upstream end of the project area are two historical tailing piles in the stand of mature riparian trees that persisted through the 1964 flood event. Except for the stand of riparian trees among the two tailing piles, and a band of trees along the roadway embankment, the bar was fully scoured during the 1964 flood event (Section 2.6.1). The bar is slowly becoming revegetated with willow and alder in lower elevation portions of the bar. The higher-elevation back of the bar is visibly drier and has been planted with conifers. The Willow Pond is a low area with shallow groundwater, and appears to be in line with the abandoned 1955 channel.

The results of the existing-condition hydraulic modeling and field observations indicate the Overflow Channel on Kelly Bar become active during flows larger than a 2-year event and the Back-Channel (abandoned 1955 channel) along Sawyers Bar Road also receives flows (primarily groundwater per SRRC observations) during 2-year and larger events (Appendix G). Flows from the Back-Channel provide ground and surface-water inflow to the Willow Pond, which then drains into the Overflow Channel. Most portions of Kelly Bar are inundated during a 10-year event, except for the higher back-bar area and a higher area between the river and the abandoned 1955 channel.

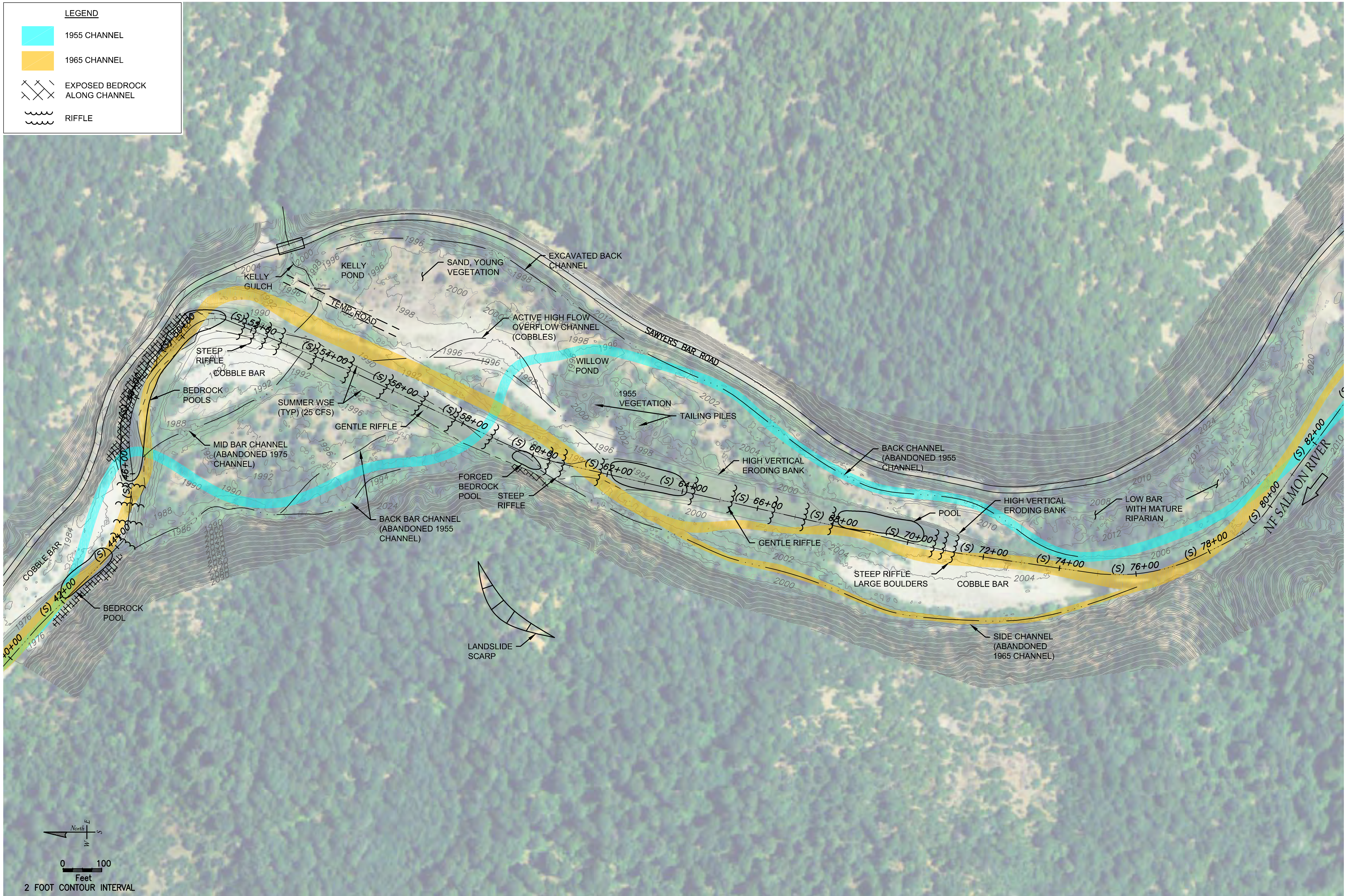
The West Bar has a mining claim but is not currently being mined. No evidence of historical mining activities on the West Bar were observed. The bar was completely scoured of vegetation to the base of the hillslope during the 1964 flood event (Section 2.6.1). A large portion of the bar has become revegetated with dense stands of willow and alder. The results of the hydraulic modeling and field observations indicate that the Mid-Bar Channel (abandoned 1975 channel) becomes inundate during an approximately 1.01-year and larger flow events, while the Back Bar (abandoned 1955 channel) channel does not become active until approximately a 2-year event (Appendix G). Flows remain separated in the two side channels through a 10-year flow event. The Back Bar Channel, located at the toe of the adjacent hillslope may receive seasonal spring-fed flows.

The Kelly Bar and West Bar floodplains can be classified as a confined vertical accretion floodplains, based on a 2-year stream power of approximately 500 watts/m^2 (Nanson & Croke, 1992). These types of floodplains are typically found in confined valleys with laterally stable channels and floodplains. The floodplains are shaped by extreme events and experience fine-grained vertical accretion and revegetation between extreme flow events. Floodplain surfaces are characterized by back-channels and scour holes. Only extreme flow events have the power to reshape them, allowing the bars to persist over long periods of time between extreme flow events. Vegetation also has a substantial role in stabilizing the floodplains and preventing knickpoint erosion from cutoff channels (Burge, 2006).

Kelly Gulch and Kelly Pond

Kelly Gulch flows onto Kelly Bar as a steeply sloping single-thread channel and delivers a sediment load of sands and small gravels. Downstream of the Sawyers Bar Road bridge, sediment deposition causes the channel to split into multiple, less defined threads. During the summer, flows often become subsurface, eliminating a direct connection between Kelly Gulch and the river, though flows were observed to emerge adjacent to the river bank. Along an approximate 100-foot length of river, shallow margin flows in the river are substantially cooler due to inflow from Kelly Gulch and were observed to be heavily used by juvenile chinook during the March 2015 field meeting.

One of the multiple channels forming Kelly Gulch creates a perennial surface flow source to Kelly Pond, a depression in the floodplain that was excavated historically for a hunting pond, colloquially knows as the "Duck Pond." A ditch connection between the Back-Channel channel adjacent to Sawyers Bar Road (remnant 1955 channel) and the pond was also excavated to provide additional drainage to the pond. Standing water has persisted in Kelly Pond throughout the monitoring period, and during the 7/29/15 field measurements, approximately 25 0+ juvenile chinook and steelhead salmonids were observed to be using the pond. The groundwater monitoring indicates that the Kelly Pond is fed primarily by surface water (Section 2.4.2).



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DRAFT

VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

Salmon River Restoration Council
KELLY BAR OFF-CHANNEL
FISHERIES AND RIPARIAN HABITAT DESIGN

GEOMORPHIC SKETCH MAP

DATE
OCT. 2015
SUBMITTAL
30% DESIGN
DESIGN
RS ML
DRAWN
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FIGURE
2-7

Q:\Kelly Bar\DWG\FIGURES\GEOMORPHIC MAP.dwg

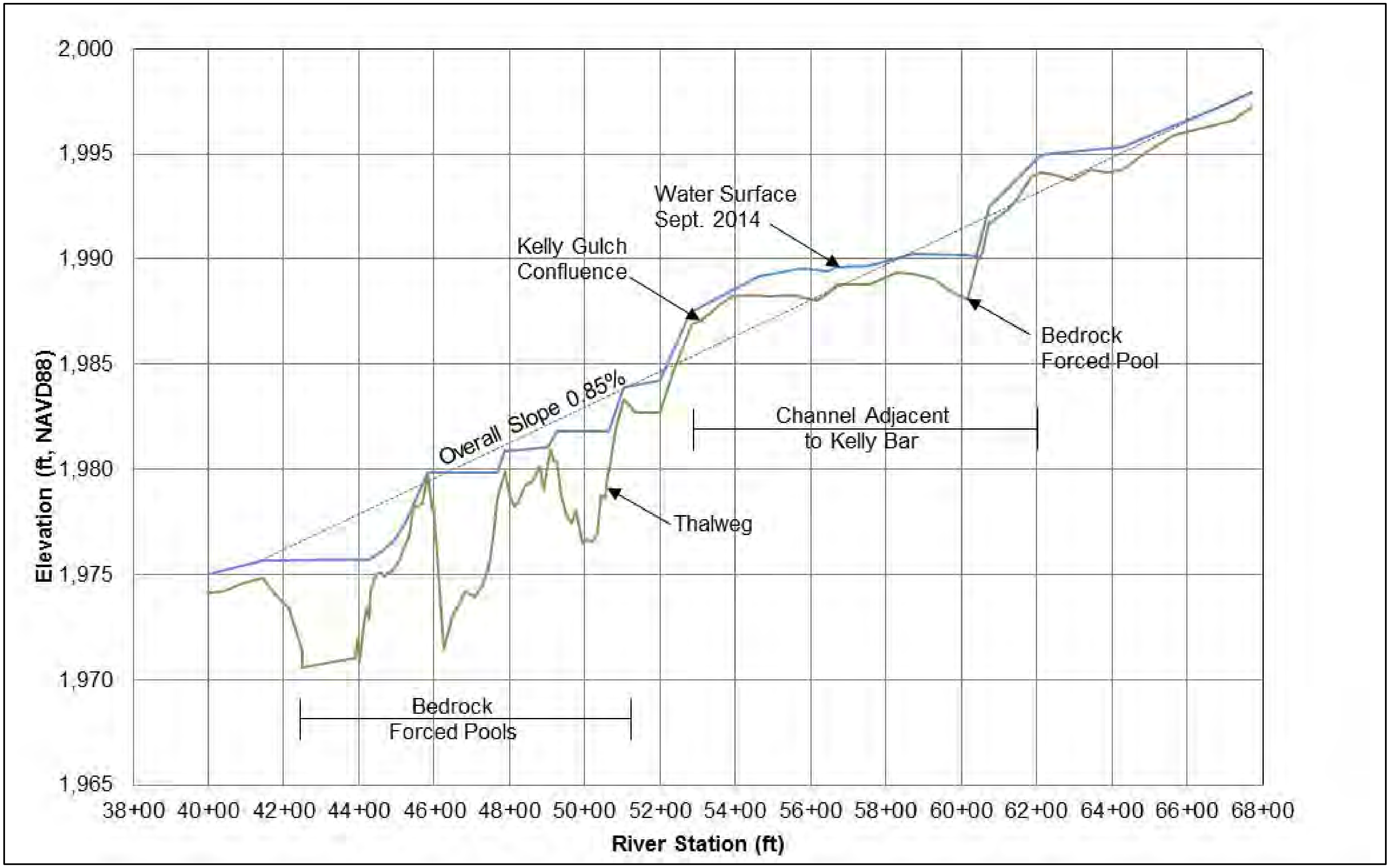


Figure 2-8. Existing thalweg profile of the NF Salmon River at the Kelly Bar project area.

3 DESIGN APPROACH AND CONSIDERED ALTERNATIVES

3.1 Concept Design Approach

Based on the results of the monitoring and project area geomorphology, the project focused on creating several types of salmonid rearing habitat. These included enhancing the existing high-flow side channels, creation of self-maintaining alcoves at the downstream ends of the side channels, and enhancing two seasonal open-water ponds. The side channels, alcoves, and seasonal ponds are expected to provide off-channel high flow refugia for rearing juveniles during the winter months. Groundwater-cooled alcoves and seasonal ponds are expected to provide off-channel warm season thermal refugia for rearing juvenile salmonids.

Associated with each of these habitat types would be the installation of large wood features to facilitate geomorphic processes and create diverse in-stream habitat, and placement of willow baffles to direct flows and initiate sediment deposition for riparian recruitment.

3.1.1 Side Channel and Alcove Design Approach

The geomorphic analysis indicated that the river is a dynamic river system that has historically undergone substantial alignment changes during extreme flow events with 50 to 100-year return periods. Side channels formed by the shifting of the river channel and abandonment of historical channel alignments during extreme events have persisted in a moderately stable geometry between extreme flow events. The abandoned channels form the side channels present at the Kelly Bar project site today. Because they were created during extreme flow events, only extreme flow events can reshape them, allowing them to persist over long periods of time between extreme flow events. Therefore, making small adjustments to the river and its floodplain to improve fisheries habitat that would persist for long periods of time appears to be geomorphically feasible.

Side-channels considered for enhancement included the Overflow Channel on Kelly Bar, and the Mid Bar Channel and Back Bar side Channel on the West Bar. The design approach for the side-channels included conceptually evaluating the feasibly and benefits of increasing inflows at the upstream end of the side channels, reshaping the side channel, and excavation of an alcove at the downstream of the side channels.

Alcoves at the downstream ends of the side channels were designed to provide a minimum of 1-foot of water depth during 99% exceedance flows in the river, be inundated by backwatering from the river, and to be sufficiently deep to tap into the groundwater inflow from the bar upstream throughout the year. The alcoves would also extend approximately 100 feet behind the channel bank to provide high-flow refugia.

Stable high-flow side channels typically become active at or above bankfull flows, and carry approximately 10-20% of total flow, which preserves sediment transport continuity in the mainstem (Miori, et al., 2006). Stable, self-maintaining side channels receive flows frequently enough to scour out fine sediments to maintain an open channel, and are stabilized with the presence of vegetation and/or low bed mobility during overtopping flow events (Burge, 2006). To enhance flows into the side channel, approximately 10-20% of total river flow was targeted for conveyance in a side channel. Where two side channels are present on the West Bar, a total combined flows of 20% of total river flow was targeted.

Stable upstream bifurcation angles of side channels from the mainstem range from 40-60°, with the more stable channels having a lower bifurcation angle (Burge, 2006). For this project, bifurcation angles of about 40 ° were targeted, which is similar to the existing condition bifurcation angles.

The downstream confluence angle of the side channels with the mainstem drives the length and depth of the scour pool that forms and maintains alcoves, with a deeper longer scour hole forming at higher confluence angles and/or higher side channel flow conveyance (Best, 1988). A minimum confluence angle of approximately 20° and sufficient flow to scour the alcove is necessary to form a scour hole at the downstream confluence of a side channel with the mainstem channel (Best, 1988). As the confluence angle rises from 20°, a scour hole deepens and lengths, but increasingly larger flow separation zones result in increased flow stagnation zones at the apex of the confluence and in the main channel downstream of the confluence. These areas of flow stagnation result in sediment deposition could result in partial closure of the side channel outlet (Best, 1988). Therefore, a confluence angle of 20-40° was selected for this project to create a self-maintaining scour pool at each alcove.

To minimize vegetation removal and excavation volumes, the alignment of each side channel generally followed the alignment of the existing high-flow channel.

3.1.2 Groundwater-Fed Feature Design Approach

Groundwater-fed features considered for the project included consideration of enhancements to Kelly Pond and the Willow Pond, and in the alcoves at the downstream ends of the side channels. Though not monitored, it was assumed that groundwater levels along the West Bar will be similar to the river water levels because of the similarity of bar materials.

The results of the water quality monitoring indicate that high water temperatures in the river will likely cause juvenile salmonids to seek cooler water temperatures in off-channel habitat during the summer and early fall. Groundwater temperatures and DO levels along Kelly Bar and Kelly Pond appear to be suitable to provide groundwater-fed off-channel rearing habitat. Therefore, creating off-channel features in the Kelly Pond and alcoves that rely on groundwater appears to be a feasible approach to creating warm-season thermal refugia for rearing salmonids.

Late summer DO levels in the Willow Pond were not as suitable, and deep excavation of the pond to provide late-summer habitat may not be cost effective given the marginal habitat benefit. For conceptual design purposes, poor water quality conditions in the Willow Pond were assumed to be a product of extreme low-flow conditions, and may provide more suitable habitat during more normal years. Therefore, both the Willow Pond and Kelly pond were considered as potential features that could provide seasonal groundwater-fed rearing habitat.

Enhancements to the Kelly Gulch and Willow Ponds included evaluating the feasibility of excavating the ponds to create open-water rearing area with both bathymetric and shoreline complexity. Studies by Whitmore (2014) have found that juvenile coho salmonids remain longer in ponds with depths on the order of 5 feet. Observations by Toz Soto (personal communication), a biologist for the Karuk Tribe, observed that a minimum pond depth of 3-4 feet is necessary for thermal stratification pond to occur, which would retain cooler waters at the bottom of the pond. To develop thermal stratification, the pond depths were targeted at a minimum of 3 to 4 feet deep.

In the event that pond water quality declines, ingress and egress channels would be necessary for each pond. The elevations and slopes of these channels were designed to maintain a water depth of 3 to 4 feet deep in the ponds, maintain groundwater flows in the channel, and provide a direct connection to the river.

As indicated in the previous section, the Alcoves at the downstream ends of the side channels were designed to provide a minimum of 1-foot of water depth during 99% exceedance flows in the river. The Alcoves will also be inundated by backwatering from the river, and to be sufficiently deep to tap into the groundwater inflow from the bar upstream throughout the year. The alcoves would also extend approximately 100 feet behind the channel bank to provide high-flow refugia.
Large wood habitat features would be incorporated into the ponds to provide cover and edge complexity.

3.1.3 Design Constraints

There are two mining claims within the Kelly Bar/West Bar project area. The boundary between the two mining claims is an east-west line located near station 60+00 on Figure 1-2. The Spoil material from each claim must be kept within the boundary of the claim. The presence of riparian areas on both bars limits the locations where spoil materials can be placed. Therefore, it will be necessary to balance the amount of material excavated from a project feature with available space for spoil placement. Therefore, the identified spoil placement areas and amount of excavation associated with each feature of the project may need to be adjusted depending on actual claim lines and extents of vegetation. Recorded documents for the two mining claims are shown in Appendix J.

The USFS, has planted the eastern portion of Kelly Bar with conifers, which are beginning to become established. This area was avoided as part of the design. Additionally, impacts to established native vegetation were also avoided as feasible.

Sawyers Bar Road runs along the north and east side of the river. Most of the roadway is located on a steep earthen roadway embankment, except at a large bedrock outcrop where the river turns abruptly to the west. To minimize the potential for erosion of the roadway embankment, no grading or flow routing was considered in the Back-Channel near the roadway to maintain the embankment integrity.

Based on the recommendations from the geologist, all graded slopes would be no steeper than 3H:1V.

4 CONSIDERED ALTERNATIVES

Conceptual designs were prepared for six different alternatives, as summarized in the following sections. Each alternative included preliminary planimetric and profile layout. In many cases, alternatives can be combined with others to form the overall project. The alternatives were presented at the two stakeholder meetings, with the merits of each alternative compared qualitatively using several metrics, as summarized in Table 4-1.

The selected alternatives, which are indicated in Table 4-1, were further analyzed and developed, as presented in Chapter 4.

4.1 Alternative 1: Kelly Bar Overflow Channels and Alcoves

Alternative 1 involves further development of PWA's recommendations to create self-maintaining side channels with alcoves on Kelly Bar. A schematic plan view of Alternative 1 is presented in Figure 4-1 and profile Figure 4-2. Perennial side channels, as recommended by PWA, were not considered due to the channel depth necessary to reach the perennial groundwater elevation, and the possibility of river avulsion associated with such a deep side channel.

Alternative 1 would enhance both branches of the existing Overflow Channel on Kelly Bar and use them to produce scour as these overbank flows return to the river. The scouring forces would sustain two new alcoves adjacent to the river. Under existing conditions, the Overflow Channel becomes active during an approximately 2-year flow event. The upstream inlet to the Overflow Channel would be lowered to increase flow frequency through the channels to about a 1.01-year event to create more frequent and sufficient scouring forces to maintain an open channel and scour sediment deposition from the alcoves. An inlet weir constructed with large wood at the upstream end of the two channels and tied into an existing tailings pile would form a hardened feature that resists scour, maintains the inlet elevation, and limits the amount of flow entering the side channels to reduce the possibility of river avulsion. Minor excavation of the existing channels would better define flow paths and delivery of flows to the alcoves located at the end of the channels.

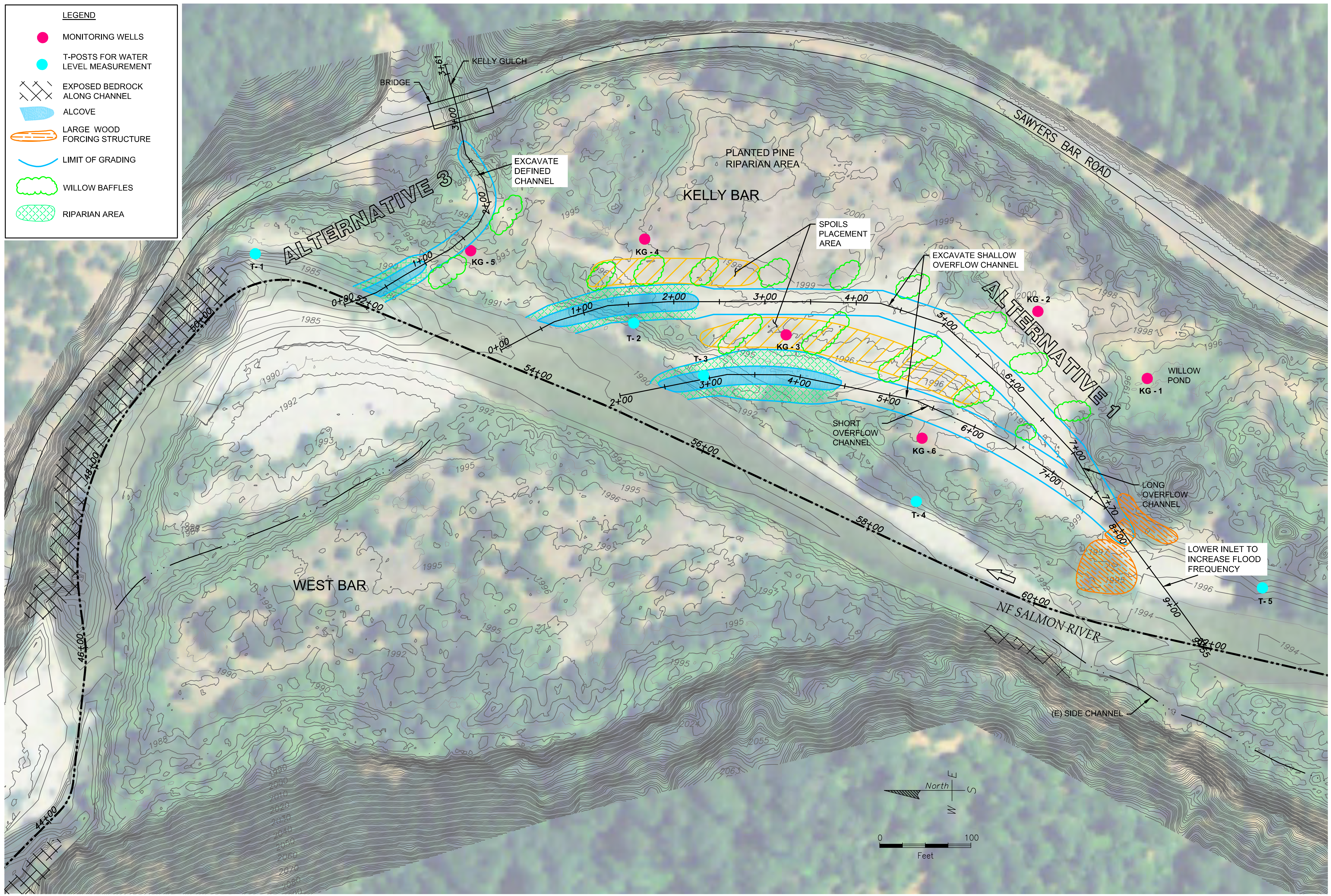
The two alcoves would be located at the downstream ends of each of the overflow channels and would provide approximately 1-foot of standing water during a 99% exceedance flow in the river (lowest flows occurring during drought years). Each alcove would be approximately 150 feet long (Figure 4-2). The alcove for the Short Overflow Channel would connect to a gentle riffle on the river and the alcove for the Long Overflow channel would connect to the river near the head of a steep riffle, as shown in Figure 4-3.

The graded streambanks around the alcoves would be at sufficient depth to use groundwater to support riparian vegetation during the latter part of the dry season. The riparian shading around the alcoves may assist with some cooling of waters and reduction in daily temperature fluctuations.

Table 4-1. Qualitative comparison of alternatives for improving off-channel juvenile salmonid habitat at Kelly Bar on the NF Salmon River. Selected Alternatives are denoted with an asterisk.

Metric	Alt. 1 Kelly Bar Overflow Channels & Alcoves	Alt. 2* Kelly Bar Perennial Pond & Alcove	Alt. 3 Kelly Gulch Realignment	Alt. 4* Pond next to Kelly Gulch	Alt. 5*,[1] Back-Bar Overflow Channel/Alcove	Alt. 6* Mid-Bar Overflow Channel/ Alcove
Fish Access from River	U/S Alcove: Good D/S Alcove: Poor	Good	Poor	Moderate	Poor	Good
Winter Rearing	Good	Better	Moderate	Better	Moderate	Good
Summer Rearing	Moderate	*Alcove*: Good *Pond*: Moderate to Poor	Good	Better	Poor	Good
Created Habitat Size	Moderate	Large	Small	Large	Moderate	Moderate
New Riparian Area	Low	Higher	Low	Higher	Low	Moderate
Persistence/Durability -Avulsion Risk -Sedimentation Risk	 Low to Moderate Moderate in Alcoves	 Low to Moderate Low to Moderate	 N/A Moderate to High	 Low Low	 Low Moderate	 Low Low to Moderate
Impact to Existing Riparian	Low	Moderate	Higher	Higher	Low	Low
Construction Access	Good	Good	Good	Good	Difficult	Moderate
Cost	Moderate	Higher	Lower	Higher	Lower	Higher

[1] *assuming that alcove is not constructed*



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VERIFY SCALE
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Salmon River Restoration Council
KELLY BAR OFF-CHANNEL
FISHERIES AND RIPARIAN HABITAT DESIGN

ALTERNATIVES 1 & 3

DATE	OCT. 2015
SUBMITTAL	30% DESIGN
DESIGN	RS ML
DRAWN	NN
FIGURE	4-1

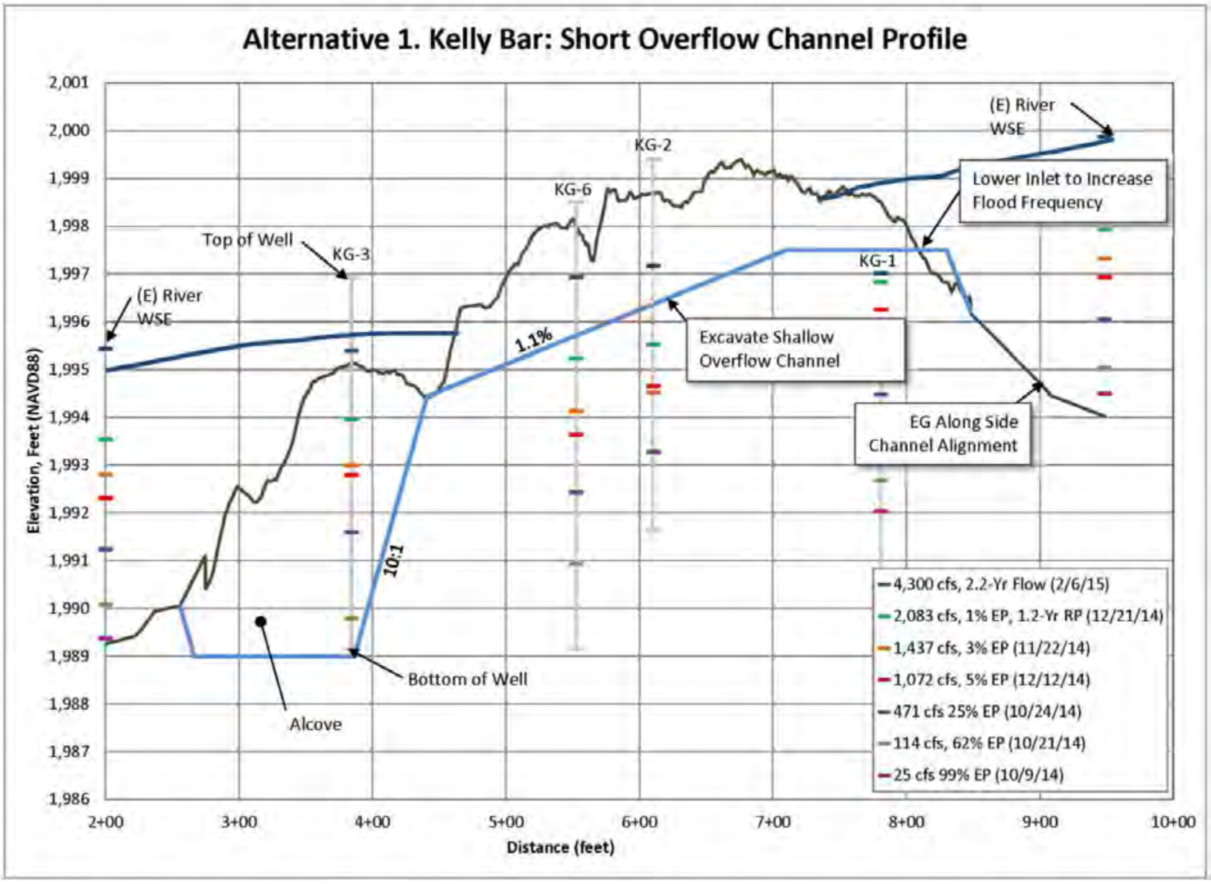


Figure 4-2. Schematic profile view of the Short Overflow Channel for Alternative 1.

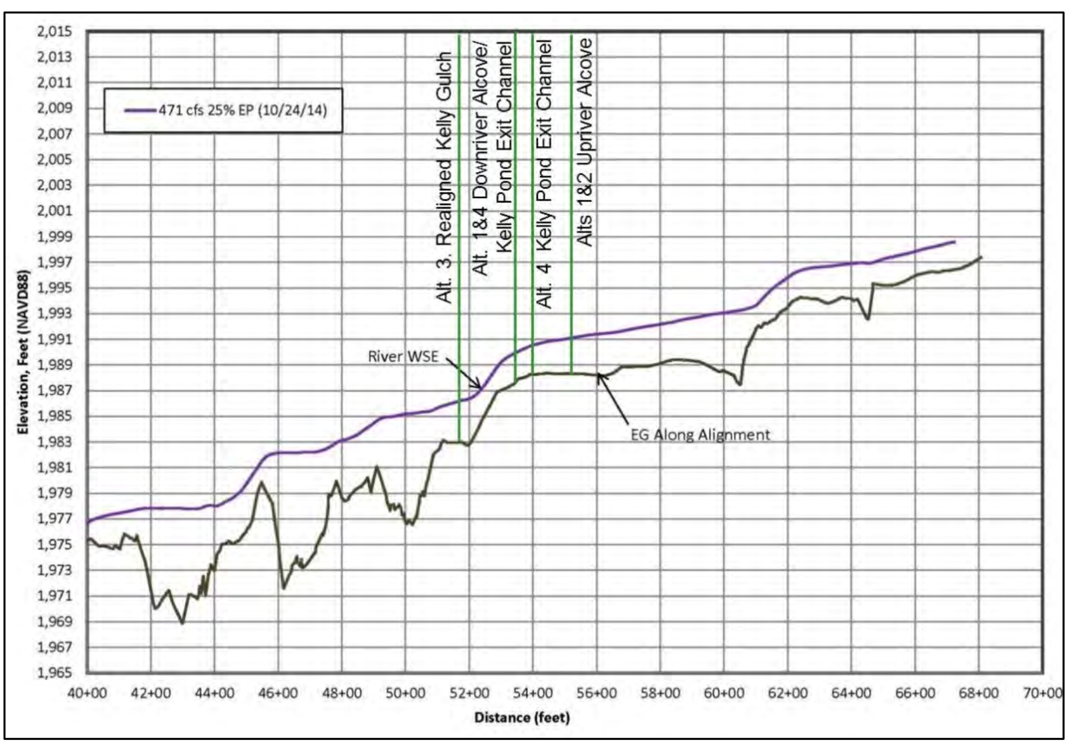


Figure 4-3. Proposed alcove locations along the NF Salmon River for Alternatives 1 - 4.

To reduce the potential of the Short Overflow Channel to avulse into the Long Overflow Channel, and to dispose of spoils excavated from the channels and alcoves, a berm could be constructed between the two side channels. Similarly, spoils could be placed to the northeast of the downstream alcove, limiting overland flow toward Kelly Gulch and concentrating it in the alcove to facilitate bed scour. Willow baffles on the spoil areas between the channels and on the east side of the Long Side Channel would shade the side channels, provide root strength to define the channel banks, and facilitate sediment deposition for riparian recolonization of the bar.

Though this alternative would provide two alcoves that could be used for both summer and winter rearing habitat, the downstream alcove is located on a steep riffle. Fish access to the downstream alcove during higher may be more difficult due to the high flow velocities in the riffle. Other than willow baffles, this alternative would not create deeper channels or ponds where riparian vegetation could persist during low groundwater conditions. For these reasons, this alternative was not selected for further consideration.

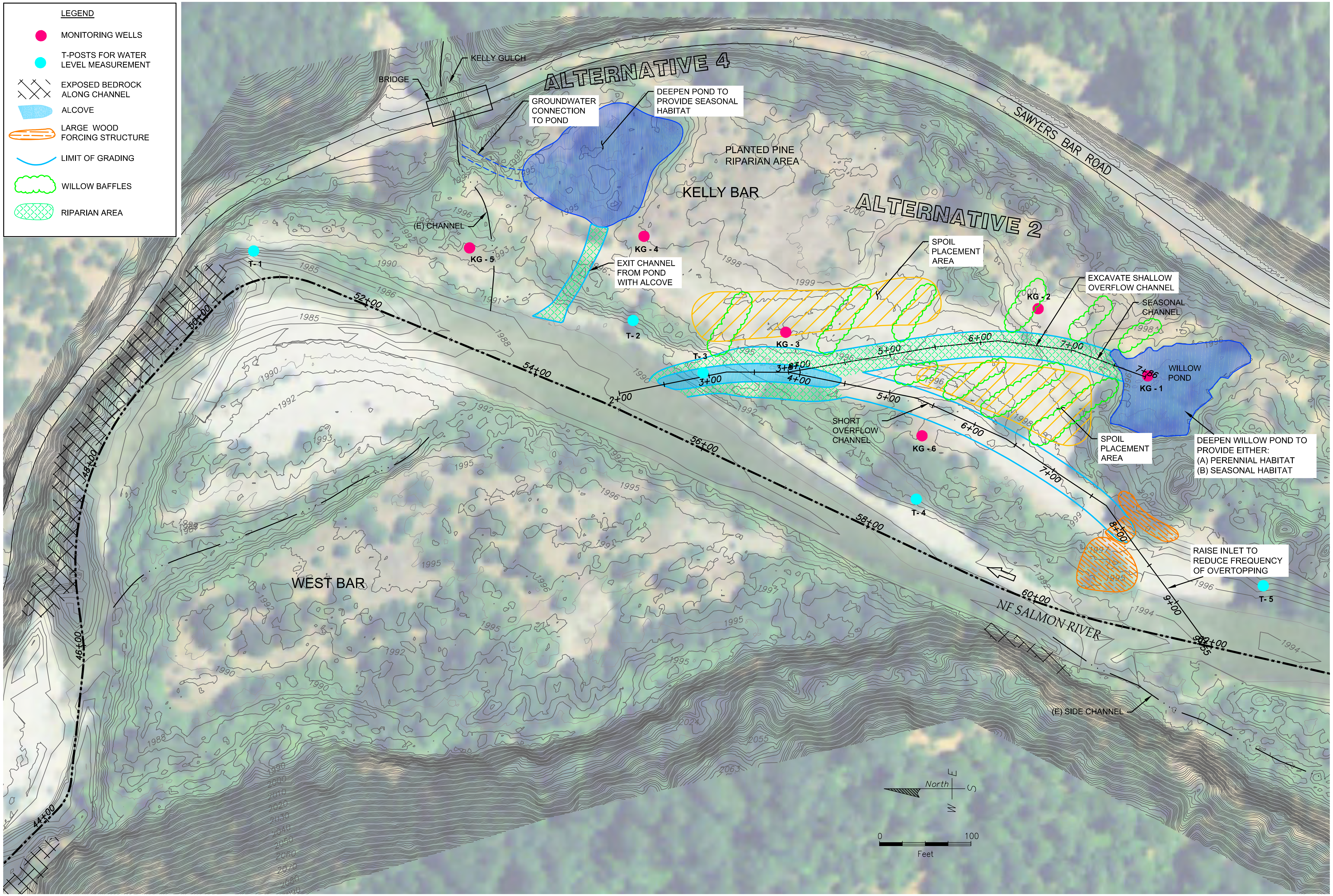
4.2 Alternative 2: Kelly Bar Overflow Channel with Alcove and Perennial 'Willow Pond' (Selected Alternative)

Alternative 2 would include the Short Overflow Channel and alcove from Alternative 1, but would exploit the shallow groundwater identified in the "Willow Pond" area to create a perennial pond with a seasonally groundwater fed-channel connecting the Willow Pond to the alcove. A schematic plan view and profile of Alternative 2 is presented in Figure 4-4 and Figure 4-5, respectively.

Similar to Alternative 1, minor grading of the existing Overflow Channel would shape it to concentrate flows and direct them into the alcove. The inlet to the channel would remain similar to existing conditions and a large wood structure would serve as an inlet weir at the upstream end of the two channels. This would protect the inlet from scour, limit the amount of flow entering the side channel, and reduce the possibility of river avulsion.

An approximately 150-foot long alcove at the downstream end of the Overflow Channel would be located within a gently sloping riffle on the river (Figure 4-3), and would provide approximately 1 foot of standing water during a 99% exceedance flow on the river (Figure 4-5). Like alternative 1, the alcove would likely receive negligible hyporheic flow during low-flow periods based on groundwater monitoring. The graded streambanks around the alcove would be at sufficient depth to use groundwater to support riparian vegetation, which would provide some cooling of the water in the alcove.

To develop thermal stratification, the perineal Willow Pond would be excavated to a depth of 3.5 feet below the groundwater elevation associated with 50% exceedance flows on the river, as shown in Figure 4-5. A Seasonal Channel excavated to below groundwater levels associated 50% exceedance river flows would create a groundwater-fed seasonal channel that would provide seasonal fish ingress and egress to the pond. Though the Seasonal Channel would stop flowing during dry months, disconnecting the pond from the river, the Seasonal Channel would give fish substantial time to exit the pond before water quality becomes unsuitable. Both the pond shoreline and seasonal channel would be excavated to a depth where riparian vegetation could be supported by groundwater during the latter part of the dry season.



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ALTERNATIVES 2 & 4

DATE	OCT. 2015
SUBMITTAL	30% DESIGN
DESIGN	RS ML
DRAWN	NN
FIGURE	4-4

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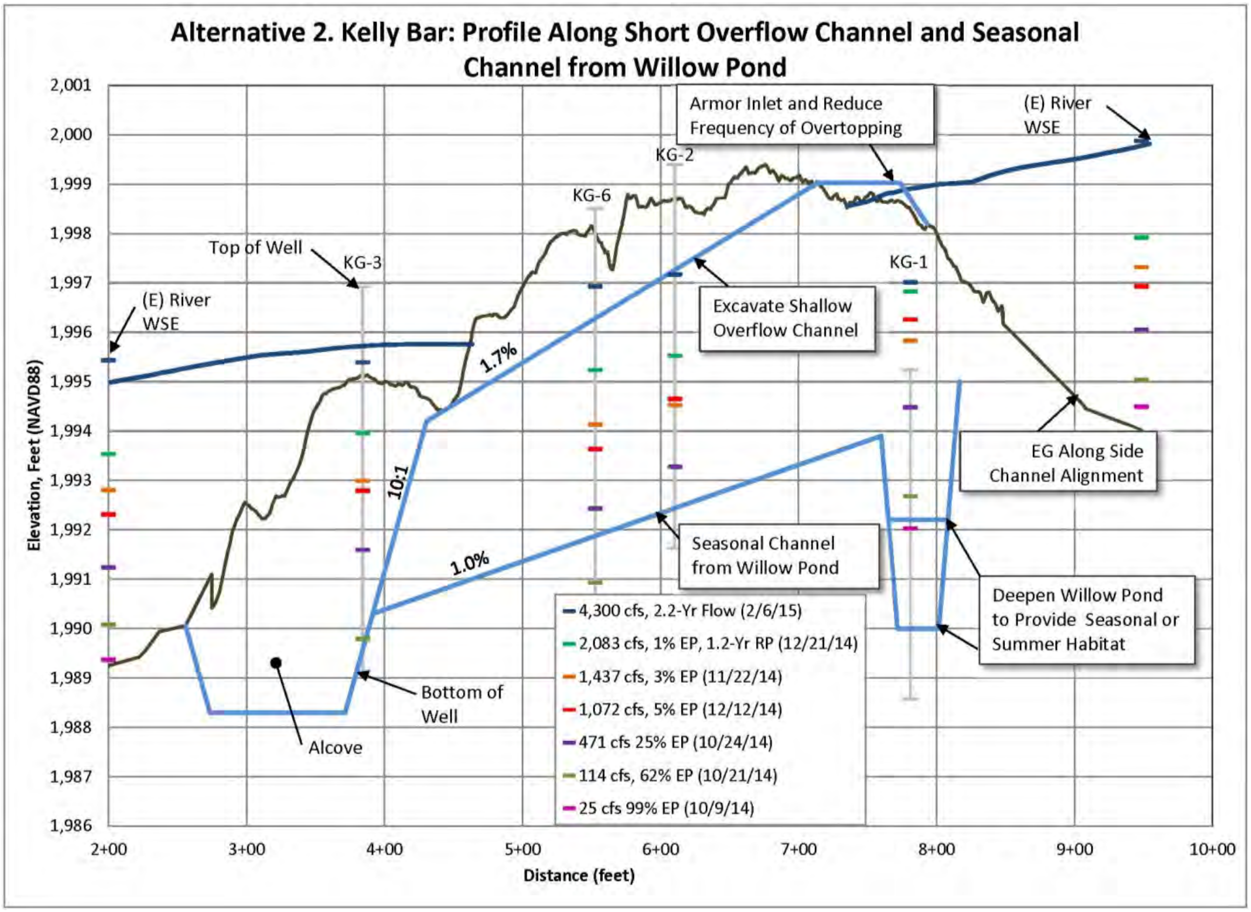


Figure 4-5. Schematic profile view of the Overflow Chanel and Seasonal Channel and Willow Pond for Alternative 2.

To reduce the potential of the Overflow Channel to avulse into the Seasonal Channel, and to dispose of spoils excavated from the channels, alcove and pond, a berm would be constructed between the two channels. Spoils would also be placed to the northeast of the Alcove, limiting overland flow toward Kelly Gulch and concentrating it into the alcove. Willow baffles on the spoil areas and on the east side of the alcove and seasonal channel would shade the two channels, provide root strength to define the channel banks, direct flow off the berm and into the Overflow Channel, and facilitate sediment deposition for riparian recolonization of the bar.

This alternative provides an alcove on a gentle riffle that would be easily accessible by fish during higher flows, and would also provide both winter and summer rearing opportunities. Summer low dissolved oxygen concentrations measured in 2015 in the well at the Willow Pond may limit the pond's suitability for summer rearing, though it may remain more suitable during normal flow years. The pond margins and Seasonal Channel would be at a sufficient depth to use groundwater to support riparian vegetation to increase shading. There is a chance that non-native bullfrogs could move into the area if the pond remains perennial. If the pond is found to lead to stranding of fish in poor water quality conditions, or lead to usage by bullfrogs, then the pond could be partially filled so it becomes dry during the summer months. This alternative was selected for further development.

4.3 Alternative 3: Kelly Gulch Channel Realignment

Alternative 3 develops PWA's recommendations to realign Kelly Gulch into a single threaded channel with an alcove at the confluence at the river. A schematic plan view of Alternative 3 is presented in Figure 4-1 and Figure 4-6. To facilitate a self-maintaining alcove with a downriver skewed confluence with the river, the Kelly Gulch channel could be realigned to the north, downstream of its present location. This alignment would create a channel profile similar in slope to Kelly Gulch upstream of Sawyers Bar Road; an approximately 6.2% slope. Creation of a longer channel extending further to the north with a lower slope was evaluated but the proximity of bedrock and the roadway embankment with the river in this location precluded this option.

The alcove would be located in a short reach of lower sloped riffle within the steep riffle on the NSFR. Though not desirable, the proximately of shallow bedrock and the roadway embankment precluded locating the alcove in the pool downstream of the riffle. The alcove would provide approximately 1-foot of standing water during a 99% exceedance flow, allowing the fish to hold in the Alcove or use it as a resting area before migrating upstream to Kelly Gulch. Kelly Gulch experiences perennial flow, therefore, the realigned channel and alcove banks could be expected to support riparian vegetation.

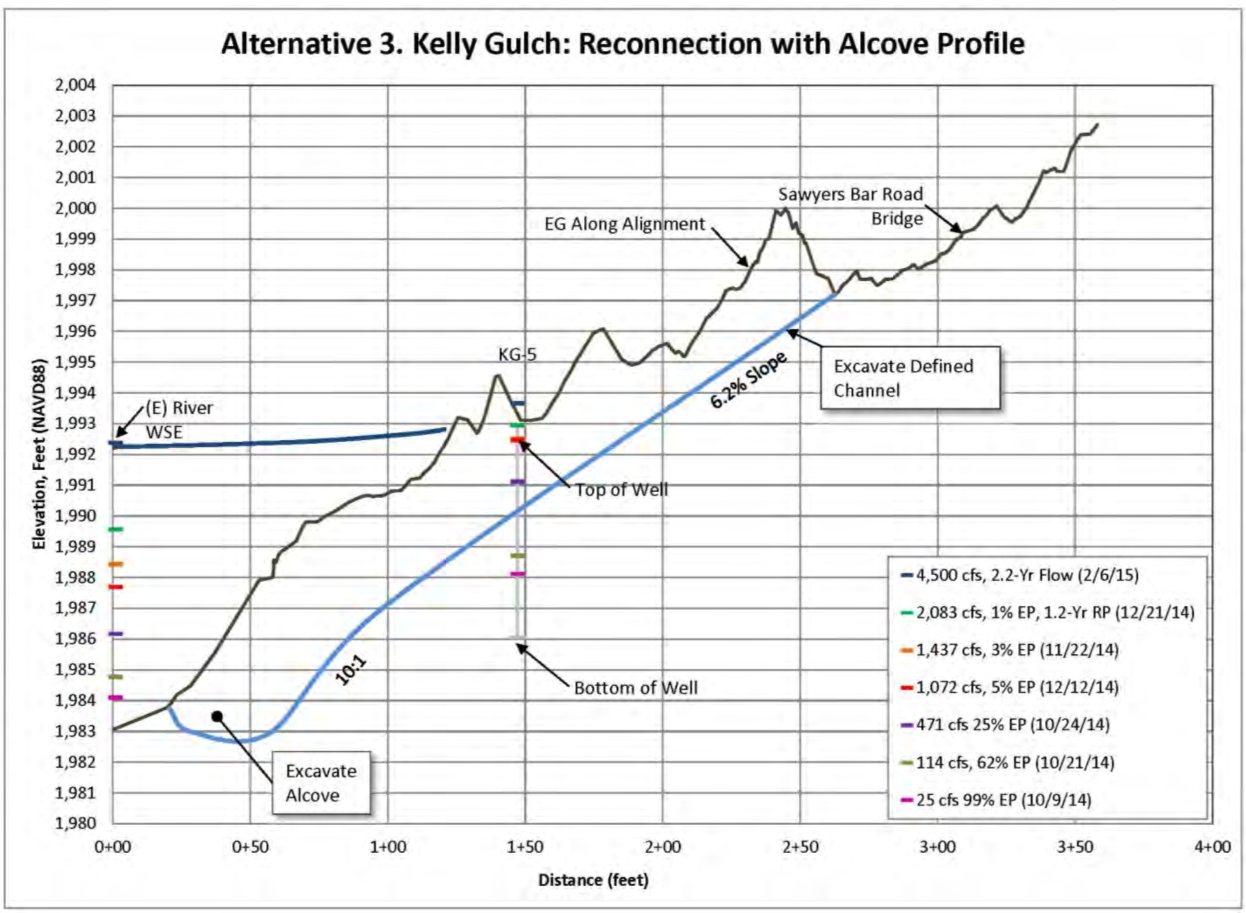


Figure 4-6. Schematic profile view of the realigned Kelly Gulch Channel for Alternative 3.

Willow baffles constructed to the south of the realigned channel can be used to create riparian area, improve channel bank strength, and to divert high flows from Kelly Bar into the river rather than into Kelly Gulch.

The alcove for this alternative is located on a steep riffle where the fish access may be difficult due to higher water velocities. A moderate amount of riparian area would need to be cleared to constructed the realigned channel and alcove. During the March stakeholder meeting, the area where Kelly Gulch flows into the river was assessed. Numerous juvenile chinook salmonids were observed in an approximately 100-foot long channel margin using the cool water inflows from Kelly Gulch. It was agreed that as it is, the flows from Kelly Gulch provides an important cold water resource to the margins of the river, and channelizing Kelly Gulch would be detrimental to this habit and was not desirable. Additionally, the long-term stability of the realigned channel and alcove is doubtful. Therefore, this alternative was not selected for further development.

4.4 Alternative 4: Enhancement of Kelly Pond (Selected Alternative)

Alternative 4 would leave Kelly Gulch in its existing alignment, but would utilize the seasonal rearing habitat already observed in the pond adjacent to Kelly Gulch, referred to her as "Kelly Pond". A schematic plan view of Alternative 4 is presented in Figure 4-4. This alternative was identified after the April 2015 TAC meeting, therefore, specific pond depths, exit channel alignments and elevation, and spoil placement areas were was not explored in detail during the schematic phase of the project.

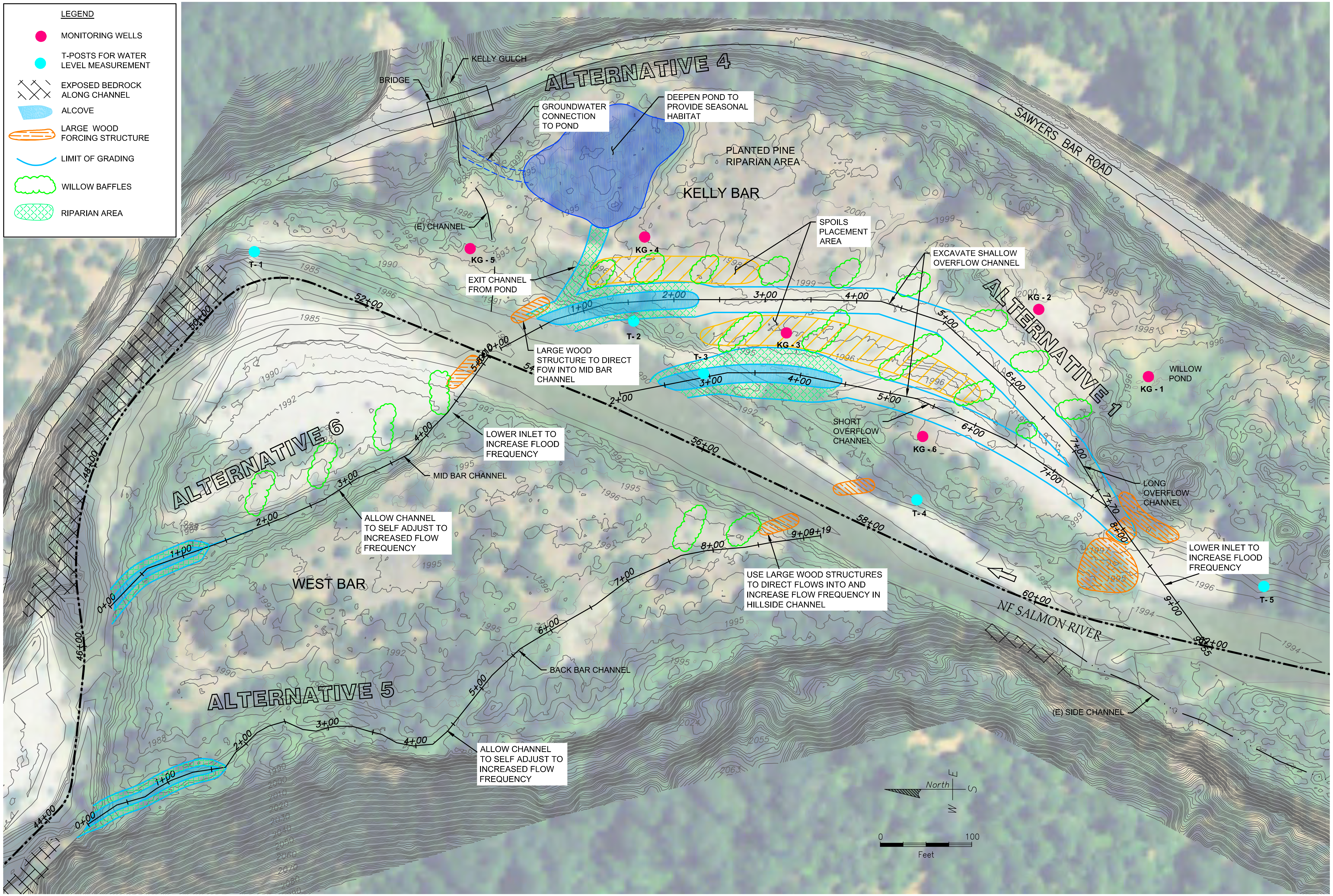
Surface flows from Kelly Gulch currently spills into an adjacent pond where numerous salmonids were observed rearing during the hottest/driest portion of the monitoring period (Section 2.4). This pond would be deepened and enlarged to provide 3 to 4 feet of standing water in the pond during the dry season. Inflows to the pond could be enhanced with a groundwater connection in addition to the existing surface connection.

An exit channel from the pond would give fish the opportunity to enter and leave the pond. The exit channel would be connected to the river. Kelly Gulch maintains perennial flow during the duration of monitoring, thus can be expected to provide a perennial source of cool water to the pond and exit channel.

This alternative would enhance the summer and winter rearing habitat already provided in the Kelly Pond, and would also provide direction connection to the river. The pond margins and seasonal exit channel would maintain a groundwater-fed baseflow during a large portion of the year, and would support a groundwater-fed riparian area. This alternative was selected for further development.

4.5 Alternative 5: Back-Bar Channel Enhancements and Alcove on the West Bar

Alternative 5 would create an alcove at the downstream end of the existing Back Bar Channel on the West Bar. The alcove would provide approximately 1 foot of standing water during a 99% exceedance flow on the river, would likely receive hyporheic flows as water from the river flows through the West Bar, and be backwatered by river flows. The Alcove would be located in a pool in the river (Figure 4-10). A schematic plan view of Alternative 5 is presented in Figure 4-7 and profile in Figure 4-8.



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ALTERNATIVES 1, 4, 5 & 6

DATE
OCT. 2015
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FIGURE
4-7

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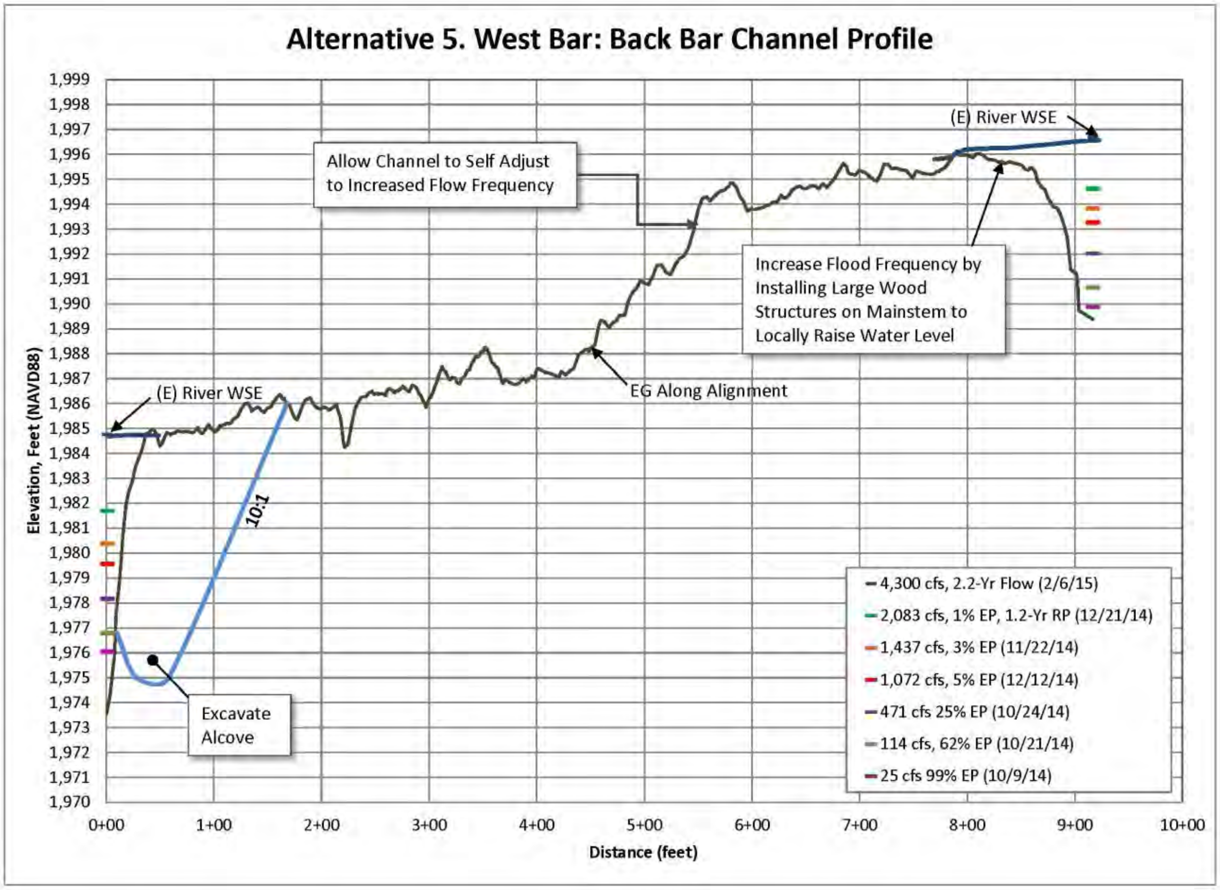


Figure 4-8. Schematic profile view of the Back Bar Channel enhancements on the West Bar for Alternative 5.

Under existing conditions, the Back-Bar Channel becomes active during an approximately 2-year flow event. These flows are not likely sufficient to create scouring forces to maintain the alcove. Due to dense vegetation, the entire extent of this channel was not walked, and it is not known how continuous it is. The riparian area surrounding the channel is mature, and it was considered undesirable to impact the riparian are to excavate a more defined channel. Additionally, the inlet location(s) to this channel is unclear, and is covered in dense vegetation, therefore, excavation of an actual inlet was not considered.

Rather than excavating an inlet, a large wood structure installed along the river bank downstream of the inlet could be used to locally raise river levels, increasing the frequency that this back-channel would be inundated. The channel would then be expected to self-adjust in response to the increase flow regime, and scour a more defined channel and maintain the Alcove.

During the March stakeholder meeting, it was observed that there is bedrock present where the alcove would be located, which would not be cost-effective to excavate. Additionally, a riffle has formed in the alcove location that could cause sedimentation in the outlet. Even with increased flow frequencies through the Back Bar Channel, there is also some uncertainty if flows would be sufficient to maintain an open alcove. Additionally, this site is also the most difficult to access and would result in some impacts to exiting riparian area for access.

Components of this alternative was selected for further development. It was agreed that a more low-impact approach would be used with this side channel to improve it for winter rearing habitat. Only the large wood structure would be installed at the upstream end of the channel to increase the flow frequency into the side channel. No alcove would be constructed.

4.6 Alternative 6: Mid-Bar Channel Enhancements and Alcove on the West Bar (Selected Alternative)

Alternative 6 would enhance the existing side channel on the West Bar, referred to as the Mid-Bar Channel. It would include constructing an alcove at the confluence of the side channel with the river. A schematic plan view of Alternative 6 is presented in Figure 4-7 and profile in Figure 4-9.

Under existing conditions, the Mid-Bar Channel becomes active during an approximately 1.01-year flow event. Similar to the Back Bar Channel, the Mid-Bar Channel is bounded by mature vegetation that would be impacted if the channel was excavated. Instead, the upstream inlet to the Mid-Bar Channel would be lowered to increase frequency that the channel becomes activated by overflow, which would cause the channel itself to self-adjust.

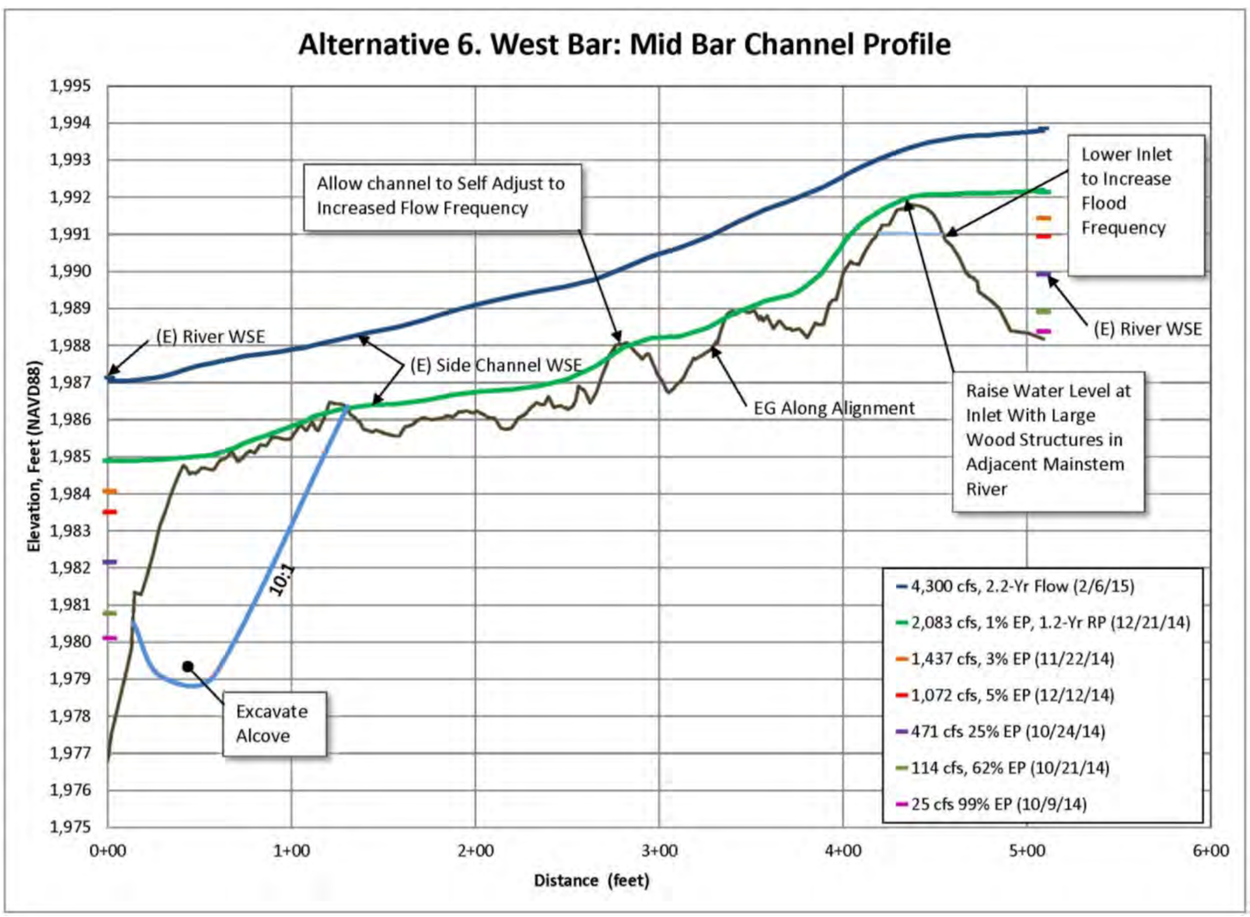


Figure 4-9. Schematic profile view of the Mid-Bar Channel enhancements on the West Bar for Alternative 6.

An alcove at the downstream end of the Mid-Bar Channel would provide approximately 1-foot of standing water during a 99% river exceedance flow, and is expected to receive hyporheic flows. The alcove would be located adjacent to a pool in the river, as shown in Figure 4-10, providing for good low and high flow fish access. The graded streambanks around the alcove would be at sufficient depth to use groundwater to support riparian vegetation during the latter part of the dry season.

Spoils excavated from the alcove would be placed along the Mid-Bar Channel where there are currently no trees. The placed spoils would increase the capacity of the Mid-Bar Channel, thus increasing its scour potential at the alcove.

This alternative provides an Alcove located in a pool that would be easily accessible by fish during higher flows, and would also provide both winter and summer rearing through most if not all of the year. Construction would require that equipment cross the river; however, during the summer flows are sufficiently low on the riffle adjacent to the bar that access should not be difficult. This alternative was selected for further development.

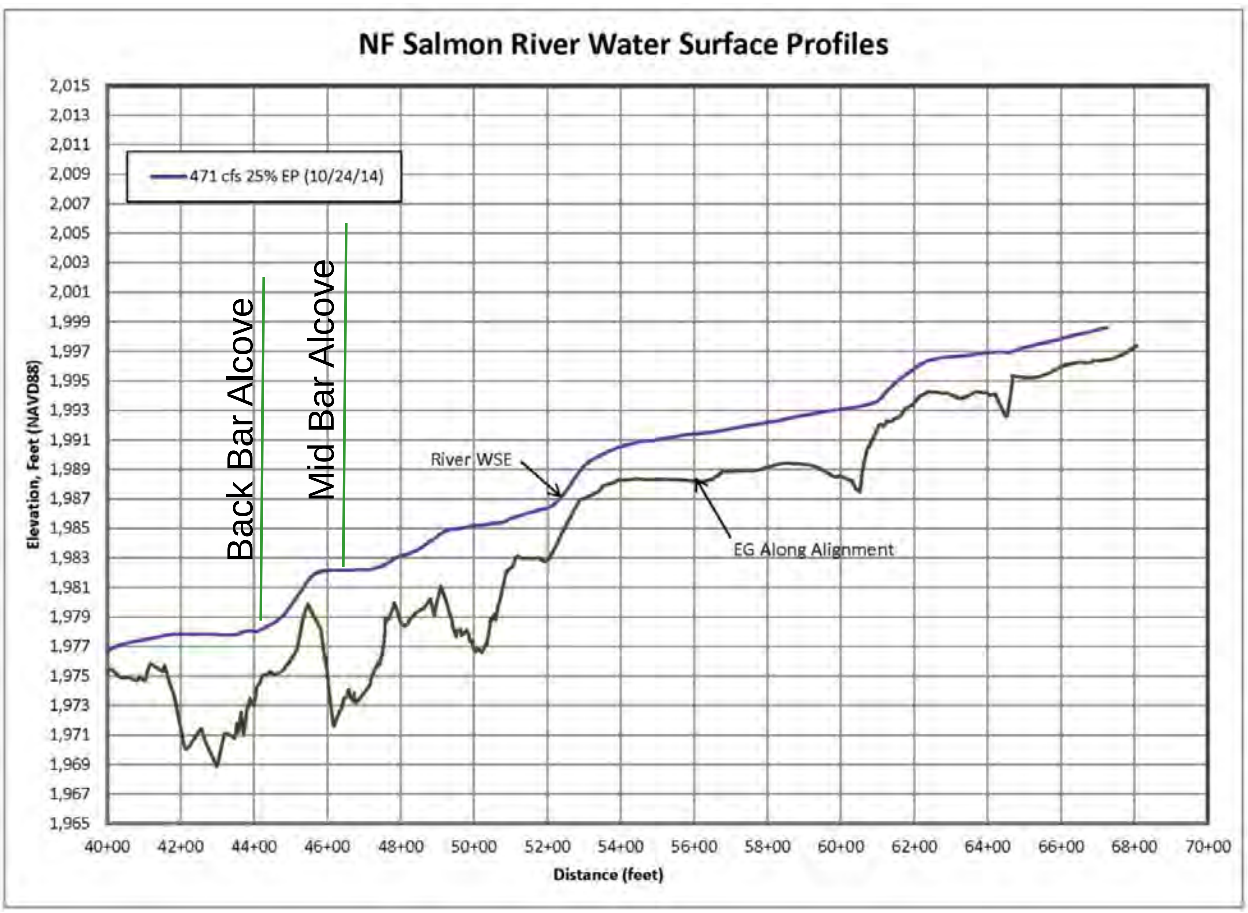


Figure 4-10. Proposed alcove locations for Alternatives 5 and 6 on the NF Salmon River.

4.7 Alternative Considered But Not Developed

Consideration was given to increasing flows to the Back-Channel (abandoned 1955 channel) that follows the toe of the Sawyers Bar Road embankment. Observations of flows in this area during the monitoring period indicated that this channel begins to receive small amounts of inflow during an approximately 2-year flow event. Increasing flows to this channel could create an additional area of off-channel high-flow velocity refugia for salmonids.

There is a concern that higher and more frequent flows within this area could compromise the integrity of the roadway embankment and also potentially cause a channel avulsion. Additional evaluation of this alternative would be necessary.

5 DESIGN DEVELOPMENT

The design development for the project involved developing preliminary (30%) planform, profile and cross sections for each of the side channels and determining the extents of grading and pond bottom elevations for the Kelly Gulch and Willow Ponds. This information was used to develop preliminary grading plan and earthwork quantities for the project. Proposed grading for the project was developed with 3H:1V slopes in both cut and fill.

Preliminary (30%) design plans for the project are shown in Appendix A.

5.1 Design of Habitat Enhancement Features

5.1.1 <u>Kelly Bar Overflow, Seasonal Channel and Willow Pond (Alternatives 2 and 4)</u>

Overflow Channel and Alcove

The proposed alignment of the approximately 500-foot long Overflow Channel and Alcove will generally follow the alignment of the existing Overflow Channel, diverging from the river at the upstream end at an angle of 36 degrees. The proposed inlet elevation of the Overflow Channel was set at an elevation of 1998.0 to allow inflow into the Overflow Channel during events larger than approximately the 1.2-year event. The channel will have an approximately 0.8% slope. The transitional slope to the Alcove will be a 10% slope, which will be backwatered by the river during an approximately 2.2-year flow event. At flows between 1.2-year and 2.2-year the steeper water-surface drop into the Alcove is intended scour fine deposition from the head of the Alcove. During flows smaller than a 1.2-year event, the Overflow Channel will be dry. The Overflow Channel will be formed by shallowly grading the existing Overflow Channel to create a defined channel with a 20-foot bottom width.

At the inlet of the Overflow Channel, a large wood Apex Bar Jam will protrude into the flow area of the river channel, locally elevating the river water levels to increase flows into the Overflow Channel. The Apex Bar Jam will be connected to a large wood Inlet Weir. The purpose of the Inlet Weir is to maintain the inlet elevation and control flows entering the Overflow Channel such that the river cannot avulse into the Overflow Channel. It is also expected to create pool habitat along its upstream face resulting from vertical scour. A large wood Abutment Jam will be connected to the inside edge of the Inlet Weir, and will connect to an existing high-elevation mine tailings pile. The Abutment Jam will armor the right bank of the Overflow Channel inlet to prevent it from widening. The top elevation of the Apex Bar Jam was set at 2001 feet, so that it becomes overtopped during 2.2-year and larger events. The top elevation of the Abutment Jam was set at an elevation of 2005.0 feet to prevent it from being overtopped until approximately a 10-year event.

An Alcove will be located at the downstream ends of the Overflow Channel. The Alcove will have a bottom width of 20 feet, and was designed with a bottom elevation of 1989.0 to provide a minimum of 1.6 feet of water depth during a 99% exceedance flow in the river. This will allow the Alcove to be inundated fairly frequently during the winter months and also to be sufficiently deep to receive inflows from groundwater nearly year-round. The Alcove will have a confluence angle with the river of approximately 30 degrees to reduce sedimentation potential.

Spoils from the channel and alcove excavation will be placed in a berm between the Overflow Channel and Seasonal Channel and in a spoil placement area to the northeast of the Seasonal Channel. The berm will separate the Overflow Channel from the Seasonal Channel during flow events larger than a 10-year flow event, reducing the chance of the Overflow Channel avulsing into the Seasonal Channel. Brush baffles will be placed along the berm on the east side of the Overflow Channel and west side of the Seasonal Channel. These baffles are intended to concentrate flows in the Overflow Channel and redirect flows into the Overflow Channel when flow elevations overtop the berm. The brush baffles will also trap sediment and encourage development of riparian areas adjust to the channels.

The spoils placed in the spoil area northeast of the channel will slow overbank flow and sediment transport into Kelly Pond. Brush baffles placed in this area will also help slow flow and trap sediment so that it does not enter Kelly Pond. The placement of the fill and brush baffles in this location will be done so that equipment access is maintained to the southern mining claim.

Willow Pond and Seasonal Channel

The bottom of the 0.2 acre Willow Pond will be excavated to an elevation ranging from 1989.0 to 1990.0, which will provide minimum of 4 feet of pool depth during the median flow in the river and maintain a groundwater fed "Seasonal Channel". As the dry season proceeds and groundwater levels drop, it is expected that water level in the Willow Pond will drop, disconnecting it with the Seasonal Channel and leaving 2 feet or more of standing water in the pond at the lowest anticipated river flows.

The outlet of the Willow Pond, forming the head of the approximately 450-foot long Seasonal Chanel, was set at an elevation of 1993.2, which is approximately the median flow in the river, allowing fish frequent ingress and egress to the pond. The seasonal channel will extend from the Willow Pond at a 0.6% slope to the Alcove. The slope of the Seasonal Channel tracks approximately 0.5 feet below the groundwater elevation associated with 25% exceedance flows in the river, ensuring that the channel will seasonally contain flows. The Seasonal Channel transitions into the Alcove at a 10% slope. This break in slope will be backwatered by the river at 50% exceedance flows and larger, allowing fish to swim into the Seasonal Channel when it is flowing. The Seasonal Channel will be formed by excavating a trapezoidal channel that is approximately 6 feet deep, with a 5 foot bottom width.

Spoils from the excavation of the Seasonal Channel will be placed on the berm between the Overflow Channel and Seasonal Channel, as well as in a low area to the northeast side of the Seasonal Channel.

Kelly Pond and Outfall Channel

The existing Kelly Pond will be enlarged to approximately 0.16 acres and deepened to an elevation of 1990 to 1991 feet to provide a minimum of 4 feet of standing water below the pond water surface elevation measured in June 2015. Enlargement and shaping of the pond will be field-determined based on working around existing trees near the pond.

This pond is currently fed by a combination of surface-water and groundwater connection that has been reliable for numerous years, according to the SRRC. , Much of the inflow into the pond during the summer months appears to be surface water from adjacent Kelly Gulch percolating into the cobble bar and re-emerging into the pond through a groundwater connection. Given the sediment load in Kelly Gulch, it was agreed that routing Kelly Gulch into the pond would cause excessive sedimentation, and constructing an engineered surface-water flow split was not necessary. Rather, the water supply source to the pond will remain the existing surface and groundwater connections. SRRC has indicated that, if necessary, hand-maintenance of vegetation and hand-shifting of sediment deposition can be performed under an existing maintenance permit to maintain the surface water connection from the channel to the pond. Based on previous observations, it is expected that any maintenance would be rare and inexpensive.

Several alignments were considered for the Outfall Channel from the pond, including tying into the Kelly Gulch channel closer to the pond. This option was not considered further because it was determined that a more defined surface water connection from the pond to the river would be more desirable to provide more reliable ingress and egress for fish to the Kelly Pond.

Kelly Gulch is a perennial stream. It is expected that the Willow Pond will remain wetted all year to a minimum water surface elevation of approximately 1994, which was measured in the pond on 7/29/2015, when flows in the river were near an 80% exceedance flow. The Outfall Channel will connect the Kelly Pond directly with the river along an approximate 90-foot long channel. The upstream elevation of the channel was set at 1994 feet to preserve the existing standing water elevation in the pond. The Kelly Pond Outfall Channel will tie into the margin of the river at an elevation of 1990.5, which is located in an actively scoured area of the river. Excavation of a deeper channel that would extend further into the active channel of the river is not advisable to because it would likely fill in with sediment. The channel will be trapezoidal in shape with a 5-foot bottom width, one to three feet deep, and with a 4.4% slope stabilized with log steps.

The new Outfall Channel will be a lower elevation than the existing Kelly Gulch channel. To avoid affecting the geomorphology and hydrology of the existing Kelly Gulch stream channel, the Outfall Channel will be separated from the Kelly Gulch Chanel by approximately 25 feet and flow in a westward direction to meet the river at a nearly 90 degree angle upstream of where Kelly Gulch enters the river.

An approximately 100-foot long Connecting Channel will connect the Kelly Pond to the Back Channel and excavated swale adjacent to Sawyers Bar Road. The channel will be a trapezoidal in shape, with a 5-feet bottom width, approximately 2 feet deep, and will have a slope of 1.1%.

Spoils from the excavation of Kelly Pond, the Outfall Chanel and Connecting Channel can be placed to the northeast and southeast of Kelly Gulch.

5.1.2 West Bar: Mid-Bar Channel (Alternative 6)

Enhancements to the Mid-Bar Channel include modifying the inlet of the channel to receive more flows and construction of an alcove at the downstream end of the channel. The proposed alignment of the inlet follows the current flow path of the side channel, which diverges from the river at an approximately 40 degree angle. The Mid-Bar Channel will be allowed to self-adjust to the changed flow regime.

The inlet of the Mid- Bar Channel will be excavated 1 to 2 feet to an elevation of 1990.0, forming a trapezoidal channel with a bottom width ranging from 6 to 35 feet wide. The enhancements to the inlet would allow inflows into the Mid-Bar Channel during flows of approximately 500 cfs (25% Exceedance) and larger. A large wood Apex Bar Jam placed on the downstream side of the side channel inlet will protrude slightly into the flow area of the river channel, locally elevating the river water levels to increase flows into the side channel. The top elevation of the Apex Bar Jam was set at 1994, overtopping during 2.2-year and larger events.

The proposed alcove at the end of the Mid-Bar Channel will have a bottom width of 6 feet and was designed with a bottom elevation of 1979.0 to provide a minimum of 2.2-feet of water during a 99% exceedance flow in the river. This will allow the Alcove to be inundated fairly frequently by the river during the winter months and also be sufficiently deep to receive inflows from groundwater nearly year-round. The transitional slope to the alcove from the existing thalweg elevation of the Mid-Bar Channel will be at 10%, which will be backwatered by the river during an approximately 2.2-year flow event. The steep slope is intended to create a chute, similar to those found on naturally-formed cut-off side channels, that helps scour and maintain the alcove. It is expected that the Mid-Bar Channel, including the transition slope to the alcove will self-adjust over time to the increased flow regime from the inlet modifications. The alcove will have a confluence angle with the river of approximately 45 degrees.

Spoils from the Mid-Bar Channel inlet and alcove excavation can be located along the northeast side of the Mid-Bar Channel where there are currently few trees. Brush baffles will be placed along the spoil placement area to concentrate flow in the Mid-Bar Channel, trap fine sediment, and encourage development of riparian areas adjacent to the channel.

5.1.3 West Bar: Back Bar Channel (Alternative 5)

Enhancements to the Back Bar channel include installation of an Apex Log Jam immediately downstream of the inlet to the channel. The Apex Bar Jam will project slightly into the river flow, locally elevating the water level in the river and increasing flows into the Back Bar Channel at 2.2-year and higher flow events. It is expected that the Back Bar Channel will self-adjust to the increased flows. The top of the Apex Bar Jam was set at elevation 1996.0, so that it becomes overtopped during events larger than a 2.2-year flow. The Apex Bar Jam will also create local scour, forming a pool around its outer edge suitable for rearing salmonids.

5.2 Design-Condition Hydraulic Modeling

The proposed habitat enhancements to the Kelly Bar project area were evaluated using 2-dimensional hydraulic modeling to verify that the intended design objectives were met. Specific design objectives evaluated in each enhanced habitat feature as part of the modeling included:

1. Inundation magnitude and frequency
2. Flow velocities
3. Sediment transport

The quality of rearing areas during dry season (summer and early fall) low-flows are dependent on groundwater elevations and water quality, which can be predicted based on existing condition monitoring. Hydraulic modeling of dry-season conditions was not evaluated using the hydraulic model.

5.2.1 2-D Model Setup

The two-dimensional (2-D) SRH-2D hydraulic model was used to evaluate proposed conditions by adapting the existing condition model to reflect the grading and changes in channel roughness associated with the proposed habitat features, large wood structures, and brush baffles. The 2-D modeling grid developed for existing conditions was used, with refinements to the grid in the areas of the proposed habitat enhancements. Grid elevations were based on a digital terrain model of design-condition elevations derived in AutoCAD Civil3D.

Manning's roughness coefficients were assigned to the grid elements using polygons representing variations in channel and floodplain roughness. In addition to the roughness coefficients assigned to existing conditions (Section 2.5.2), roughness coefficients were assigned to the proposed open-water pond areas (0.02) and large wood structures (0.20). The Overflow Side Chanel, Seasonal Channel, alcoves, and the Mid-Bar Channel inlet were modeled using Side Channel roughness value of 0.055. Brush baffles and floodplain area between each baffle were modeled as forested floodplain, with roughness values of 0.15

The model was prepared in steady flow for each flow event simulated. Flow events evaluated included the 50% exceedance flow in the river, the 1.2-, 1.5-, 2.2-, 5-, and 10-year flow events. The same inflow boundary-condition were used as for existing conditions.

Note that the 2-D hydraulic model used for this project does not model groundwater inflows. Therefore, features inundated by seasonal groundwater elevations, such as the Willow Pond, Seasonal Channel, Kelly Pond and the Kelly Pond Outfall Channel are not shown in the modeling results when they do not receive surface water.

5.2.2 Design Condition Hydraulic Modeling Results

Flow Inundation Magnitude and Frequency

The proposed modifications to the Overflow Channel, Mid-Bar Channel and Back Bar Channel were intended to increase the magnitude and frequency of flows into these side channels. As indicated in Section 3.1.1, stable high-flow side channels typically become active at or above bankfull flows and carry approximately 10-20% of total flow (Miori, et al., 2006). Figure 5-1 and Figure 5-2 present model-predicted design-condition water depths and velocity patterns for the 2.2 and for 5-year flow event. Similar results for other flow events are presented in Appendix K. Table 5-1 summarizes design-condition flows in the river mainstem and the side channels during a range of flow events.

Under design conditions, the Overflow Channel becomes active at a 1.2-year flow event, and carries 9% of total river flows during a 10-year flow event. During final design, increasing this flow amount may be considered. This could be accomplished by slightly lowering the inlet or moving the Apex Bar Jam further into the river channel to deflect more flow.

Flow magnitudes and frequencies are increased substantially in the Mid-Bar Channel, with it carrying nearly 7% of flow during a 1.2-year event and over 18% during a 10-year flow event. Flows into the Back Bar Chanel are only increased slightly under design conditions. The total of flows carried by the combination of the Mid-Bar and Back Bar channels exceeds the 20% threshold observed by Miori et al. (2006) in stable side channels. During final design, additional refinements to flows in both the Mid-Bar and Back Bar channels will be considered to potentially reduce the amount that the Mid-Bar Channel carries at higher flows, while increasing both the magnitude and frequency of flows that the Back Bar Channel receives. These adjustment can be accomplished by adjusting the Mid-Bar Channel inlet elevation and the locations of the Apex Bar Jams.

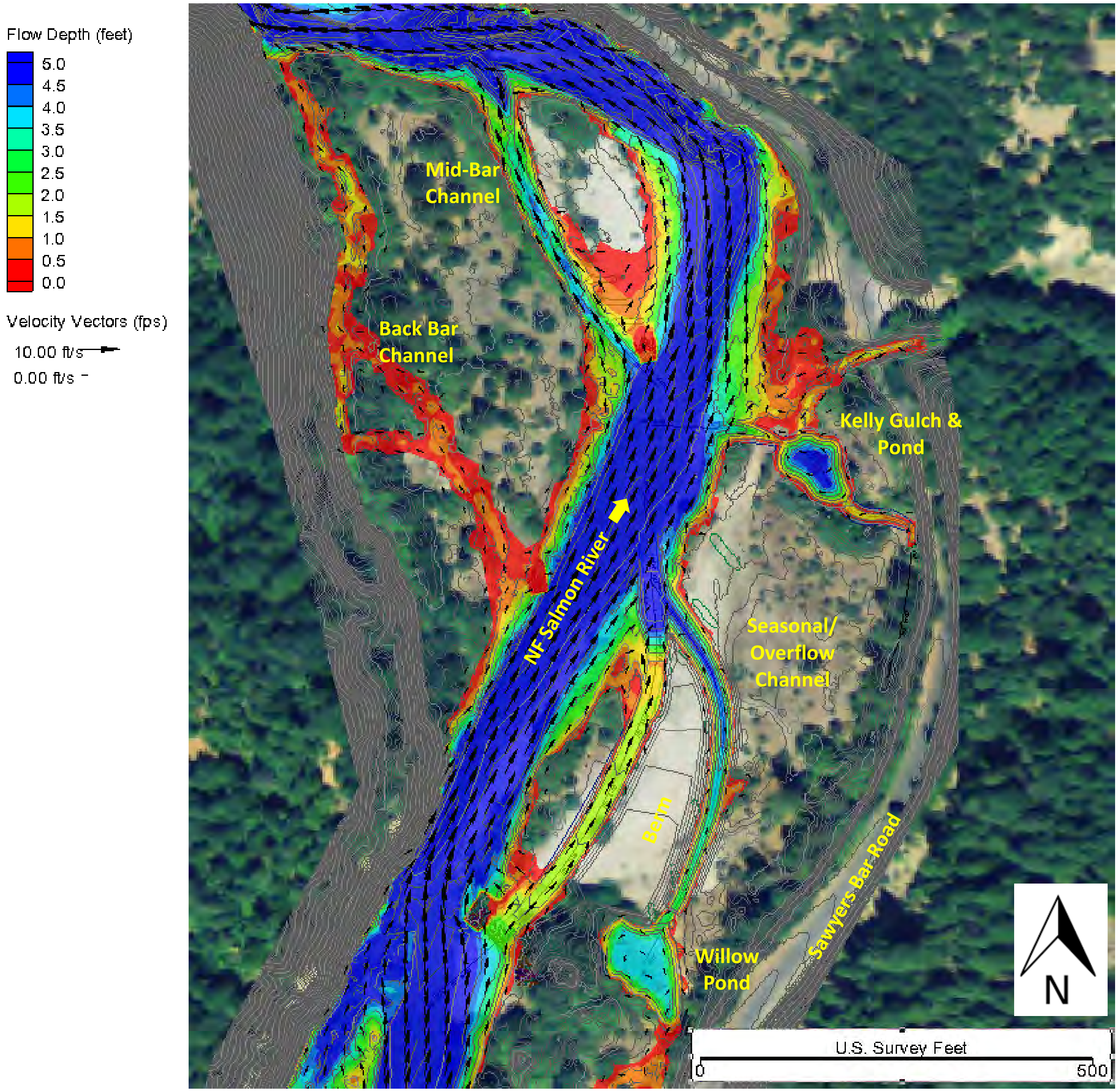


Figure 5-1. SRH-2D-model predicted water depths and inundation extents during a 2.2-year flow on the river at Kelly Bar (2,083 cfs). Contour lines are shown in black. The arrows represent water velocities, with the larger arrows indicating higher velocity. Depths greater than 5 feet are shown in dark blue.

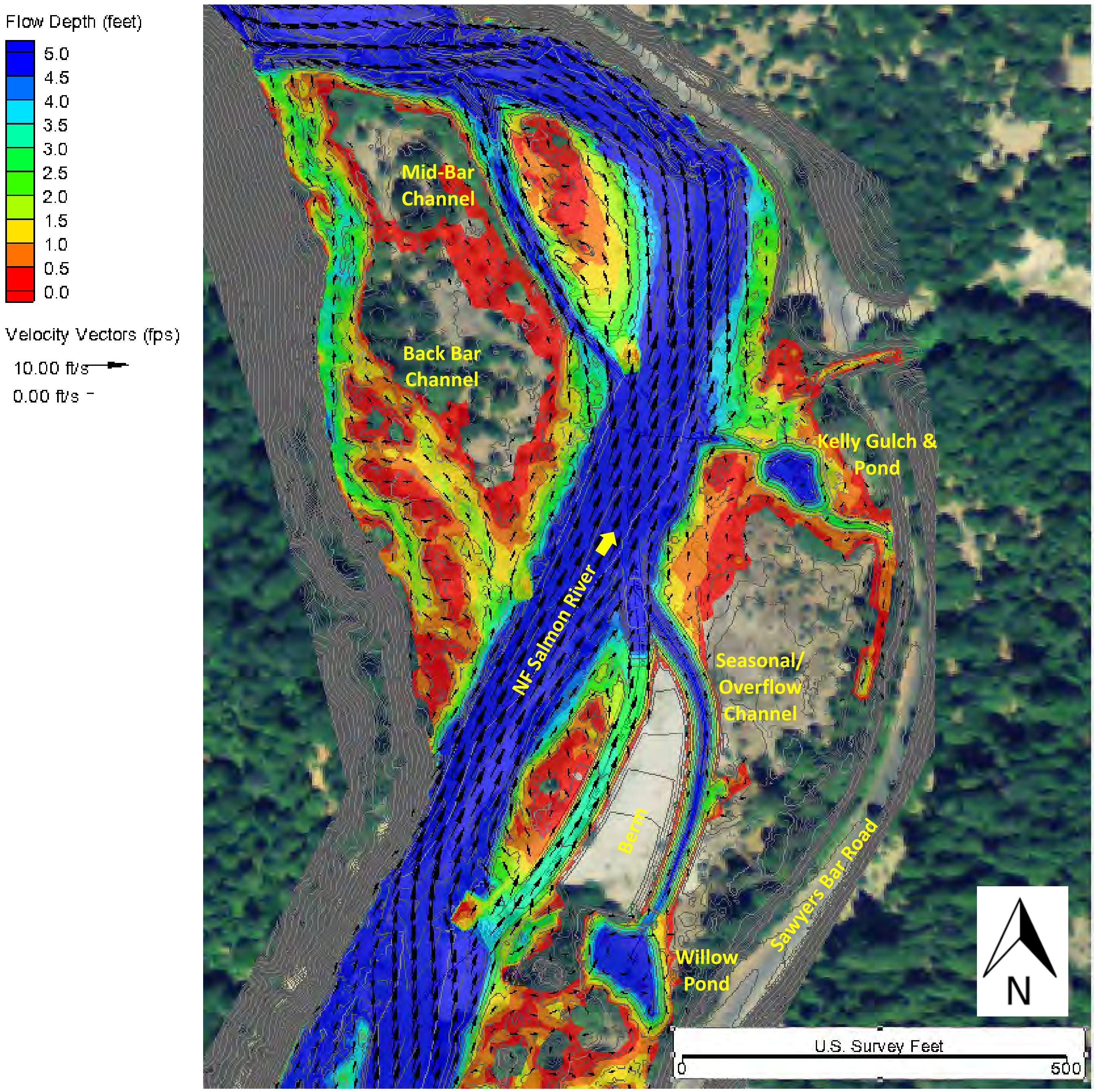


Figure 5-2. SRH-2D-model predicted water depths and inundation extents during a 5-year flow in the river at Kelly Bar (7,056 cfs). Contour lines are shown in black. The arrows represent water velocities, with the larger arrows indicating higher velocity. Depths greater than 5 feet are shown in dark blue.

Table 5-1. Summary of design-condition model-predicted total flow in the river and side channels for a range of flow events through side channels. Percentages indicate the amount of flow in the side channel relative to the total river flow.

Location	Return Period of Flow Event			
	1.2 Year	2.2 Year	5 Year	10 Year
Total Flow	2,083 cfs	4,300 cfs	7,056 cfs	9,514 cfs
Overflow Channel on Kelly Bar	0.5 cfs (0%)	151 cfs (3.5%)	487 cfs (6.9%)	852 cfs (9.0%)
Mid-Bar Channel on West Bar	139 cfs (6.7%)	492 cfs (11.4%)	1074 cfs (15.2%)	1730 cfs (18.2%)
Back Bar Channel on West Bar	0 cfs (0%)	5.5 cfs (0.13%)	177 cfs (2.5%)	678 cfs (7.0%)

Water Velocities for High-Flow Refugia

Over-wintering coho salmon fry have been found to prefer water depths of approximately 1 to 2 feet and water velocities of 0.3 to 1 fps, on average (Lestelle, 2007). Figure 5-3 through Figure 5-5 present predicted water velocities for the 50% exceedance (median) flow, and the 1.1- and 2.2-year flow events. Similar results for other flow events are presented in the previous section and in Appendix K.

During 50% exceedance flow, the Kelly Bar and West Bar alcoves, the Willow Pond, Kelly Gulch Pond and the flow margins of Kelly Gulch are expected to experience water velocities less than 1 fps and provide suitable off-channel rearing habitat during high flows. During this river flow, it is expected that the Kelly Pond will be receiving inflows from Kelly Gulch and draining into the Outfall Channel, providing fish access to the pond. It is also expected that groundwater from Willow Pond will be spilling into the Seasonal Chanel, and that Seasonal Channel will also contain flows fed by groundwater at river flows greater than the 25% exceedance flow.

During a 1.2-year flow event the Seasonal Channel, Willow Pond, Kelly Pond, and the flow margins of Kelly Gulch are predicted to experience water velocities less than 1 fps, which will provide suitable off-channel rearing habitat during high flows. Water velocities in the Overflow Channel are less than 1 fps, but flows may be not sufficiently deep. Water velocities on the river margins downstream of the three proposed apex bar jams are also decreased from existing conditions. The abutment jam located on the east side of the riffle between the inlet and outlet of the Overflow Channel further enhance channel margin rearing areas could be considered as part of final design.

As flows increase above the 1.2-year event, higher velocity flows are necessary scour fine sediments from the side channels and alcoves, making them less suitable for high-flow refugia for salmonids. However, as shown in Figure 5-5 and in Appendix K, suitable flow velocities still persist in the Seasonal Channel, Willow Pond, Kelly Pond and the flow margins of Kelly Gulch for flow events through 5 to 10-year flow events. The Back Bar Channel is also expected to provide suitable off-channel high velocity refugia during 2.2-through 5-year events.

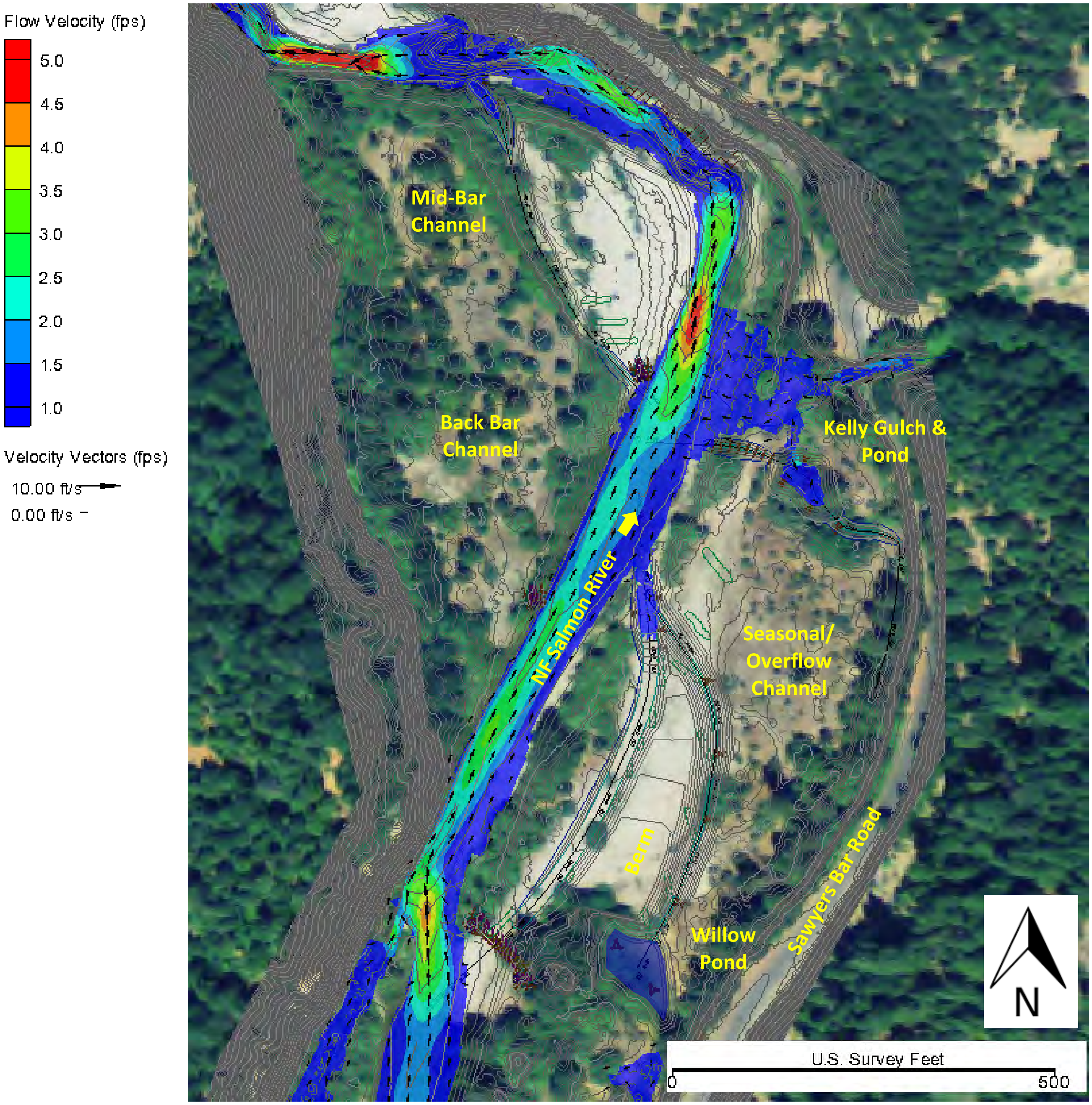


Figure 5-3. SRH-2D-model predicted flow velocities and inundation extents during a 50% exceedance flow on the river at Kelly Bar (197 cfs). Contour lines are shown in black. The arrows represent flow velocities, with the larger arrows indicating higher velocity flow. Flow velocities greater than 5 fps are shown in red.

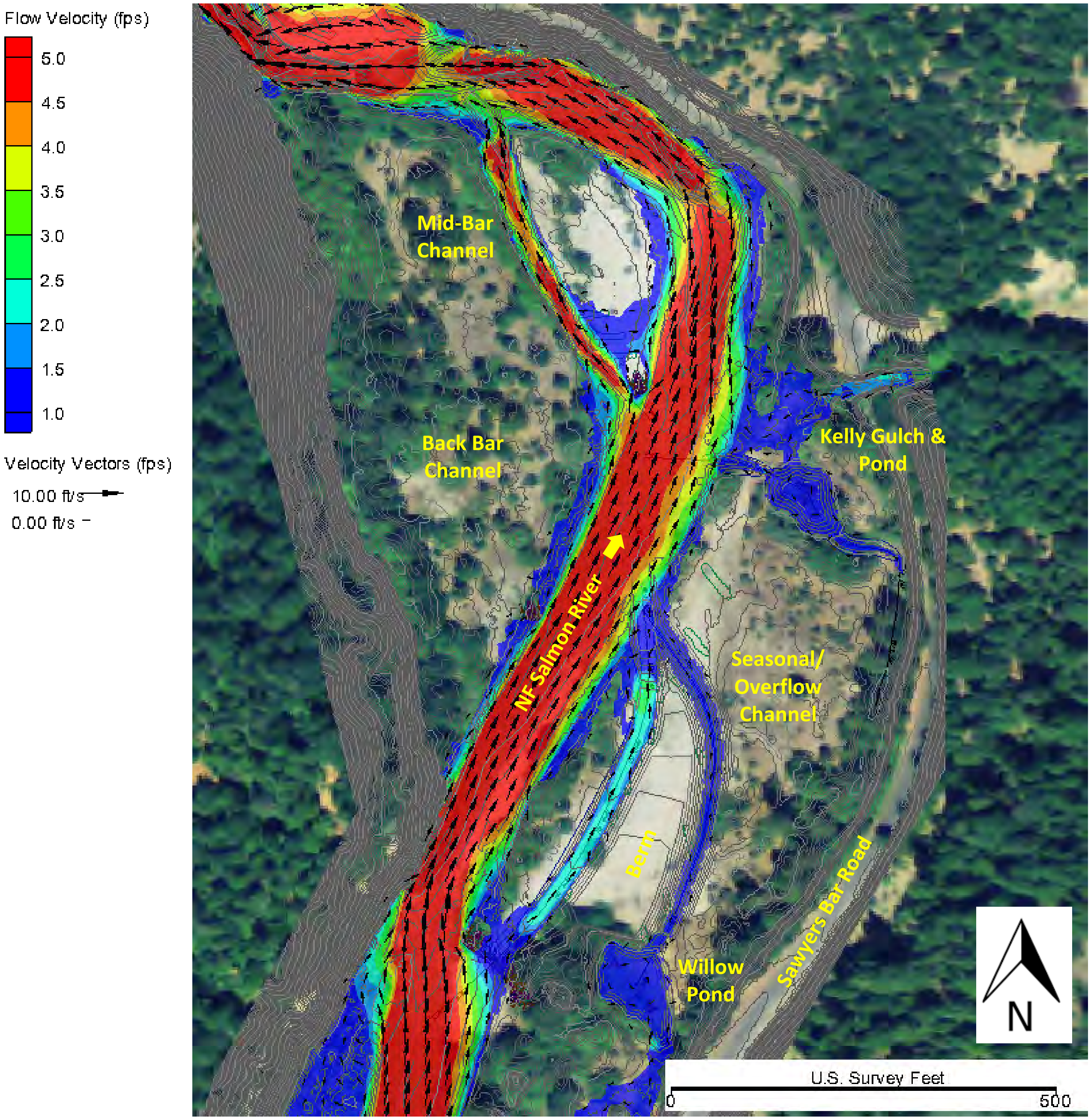


Figure 5-4. SRH-2D-model predicted flow velocities and inundation extents during a 1.2-year flow on the river at Kelly Bar (2,083 cfs). Contour lines are shown in black. The arrows represent flow velocities, with the larger arrows indicating higher velocity flow. Flow velocities greater than 5 fps are shown in red.

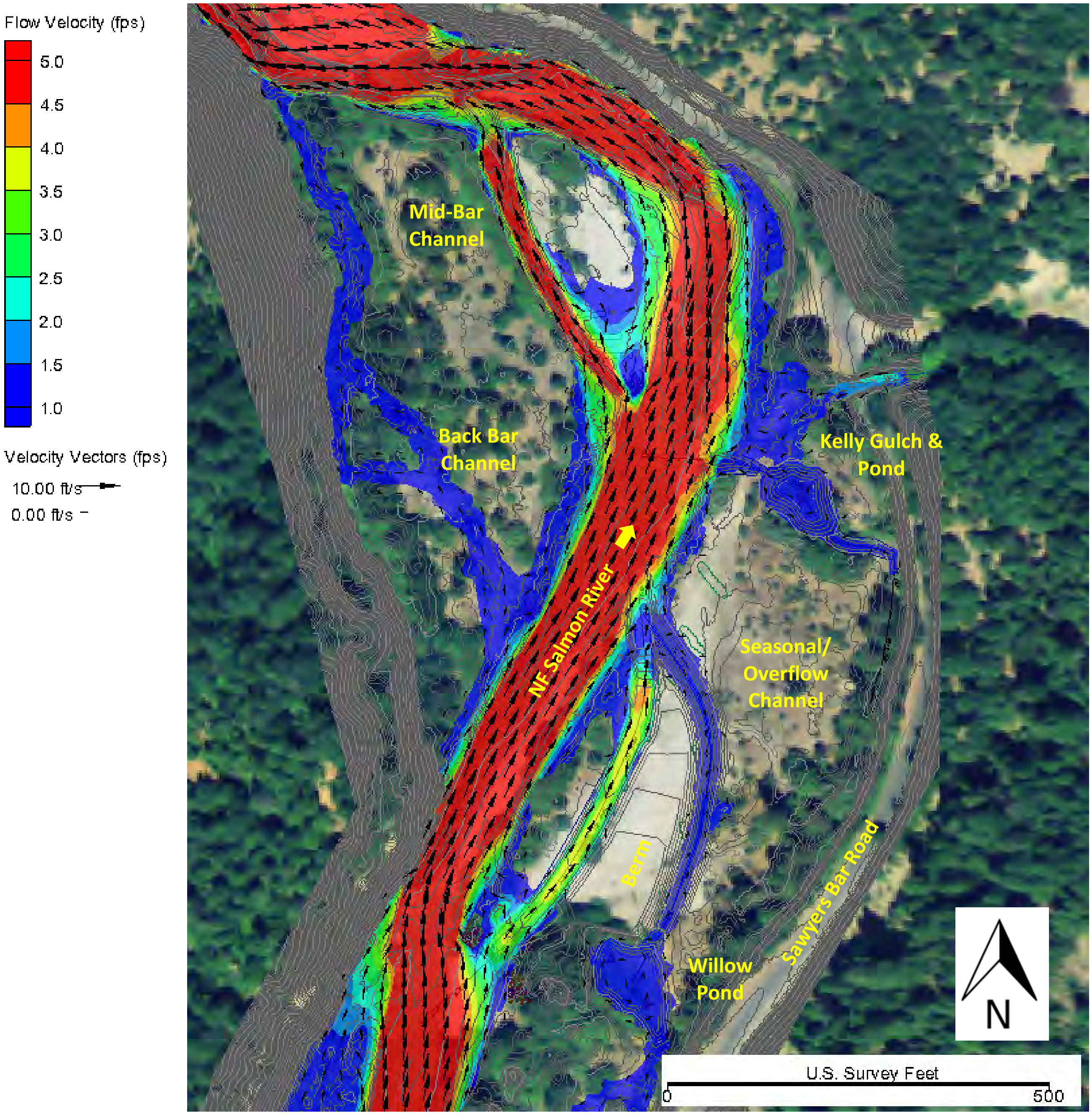


Figure 5-5. SRH-2D-model predicted flow velocities and inundations extents during a 2.2-year flow on the river at Kelly Bar (4,300 cfs). Contour lines are shown in black. The arrows represent flow velocities, with the larger arrows indicating higher velocity. Flow velocities greater than 5 fps are shown in red.

Sediment Transport for Channel Maintenance

Stable, self-maintaining side channels remain persistent by occasionally receiving flows sufficient to scour out deposited sediments and maintain an open channel (Burge, 2006). For this project, flow magnitudes and frequencies between the 1.1- and 2.2-year flow event were selected as the design flows for alcove maintenance. This will ensure that the alcoves are available for rearing habitat during typical wet-season flow conditions.

The ability of the side channels and alcoves to self-maintain was assessed by evaluating their ability to transport sands and smaller gravels that may accumulate within the channels over time. The analysis was performed by evaluating sediment competence in the alcoves. Sediment competence is a measurement of a flow's ability to mobilize or entrain a given size sediment particle, and is typically evaluated using channel shear stress. If the shear stress is greater than the entrainment shear stress of the particle, it is considered mobilized. The entrainment shear stress for a given particle can be estimated using the Shields Equation and an estimate of critical dimensionless shear stress. A critical dimensionless shear stress value of 0.04 was used, which reflects typical gravel bed conditions with sand (Buffington and Montgomery, 1997). The shear stresses predicted from the design-condition 2-D model results were used to compute the grain size of sediment mobilized in the project area for a range of flow events.

Figure 5-6 presents the 2-D model-predicted grain size that is mobilized during a 2.2-year flow event. Results for the 1.2-year event, 5, and 10-year events are shown in Appendix K. During a 2.2-year flow event, shear stresses in the two alcoves have the competence to transport particle sizes between 2 and 80 mm. Therefore, it can be expected that sediment of this size that has accumulated within the alcoves over time, will be flushed approximately every other year.

Note also that the 2-D model results fail to capture the vertical velocity patterns that occur at a channel confluence, which have been observed to maintain a scour pool (Best, 1988).

5.3 Project Area Stabilization and Habitat Enhancements

5.3.1 Revegetation

The revegetation shown in the proposed project design focuses on vegetation installed as bioengineering that will achieve geomorphic stability and function of the stream channel and habitat features. Two different bioengineering methods are proposed for the project: Brush Baffles and Live Stakes.

Brush Baffles

Brush Baffles, also known as siltation baffles, consist of a "wall" of live brush installed to intersect or divert stream flows, slow flow velocities, and cause sediment deposition. The baffles consist of a live brush comprised of species that can develop roots, such as willows and cottonwoods. Often, dead brush is imported into the baffles to increase the stem density. The brush is installed vertically in an excavated trench that intersects the groundwater table to ensure that the live materials have a water supply. Chunks of large wood or wood chips are often installed at the bottom of the trench to act as a "sponge" for water, providing a water supply if groundwater levels drop below the level of the bottom of the trench.

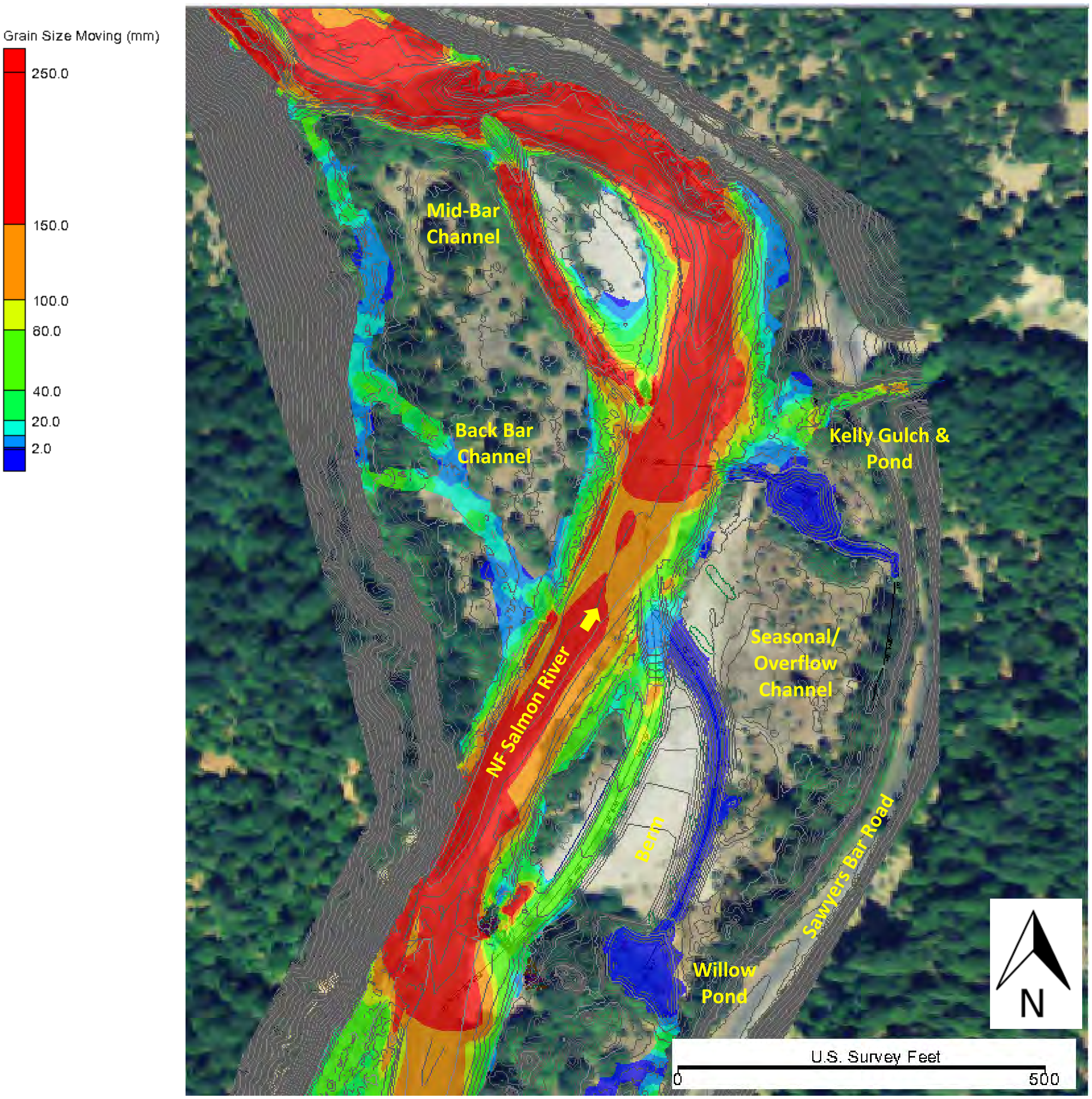


Figure 5-6. SRH-2D-model predicted grain size moving during a 2.2-year flow at Kelly Bar (4,300 cfs). Contour lines are shown in black. Shear stresses necessary to mobilize specific particle sizes are shown in the legend.

It is expected that at the Kelly Gulch project area, the brush baffles would be comprised of willow, cottonwood, and slash. It is unknown if there is sufficient material for harvesting on site. It was assumed that the maximum available length for the live brush cuttings would not exceed 10 feet. Therefore, brush baffles are only proposed in areas where the summer groundwater elevation is within 8-feet of finished grade. In most locations where Brush Baffles are proposed, the groundwater depth is substantially shallower than 8 feet, which would allow for shorter cuttings to be used. The top of the berm separating the Overflow and the Seasonal Channels will be greater than 8 feet above the summer groundwater elevation. Therefore, brush baffles were not proposed for the berm top. Any vegetation installed on the berm top would likely require irrigation until it becomes established.

Live Stakes

Live stakes provide a fairly inexpensive method to increase channel bank stability and begin the development of riparian areas. Live stakes consist of live cuttings of species installed so the bottom of the stake intersects the summer groundwater table, and consist of woody plant materials that can develop roots, such as willow and cottonwood. The Seasonal Channel, channel banks of the Alcoves, Willow Pond, Kelly Pond, and its connecting channels will be lower-elevation features that intersect the seasonally elevated groundwater table and are expected to have shallow groundwater tables during the dry season. Live stakes are proposed for these areas. Similar to the brush baffles, it was assumed that the maximum available length for the live stakes would not exceed 10 feet. Therefore, live stakes are only proposed in areas where the summer groundwater elevation is within 8-feet of finished grade.

5.3.2 Large Wood Structures

Several types of large wood structures are proposed for the project including Apex Bar Jams, Abutment Jams, Inlet Weir, Habitat Structures, and Cover structures. Ballasting and anchoring methods for the large wood structures will be determined during final design, but will include log posts, ballast rock. There is little large wood available for salvage at the Kelly Bar project area, and importation of most of the large wood will be necessary for the large wood structures.

Apex Bar Jams and Abutment Jams

Apex Bar Jams and Abutment Jams are similarly shaped features that provide different geomorphic functions. Both are complex log structures comprised of stacked trees and rootwads with brush and gravel infill. The design intent of Apex Bar Jams is to create a barrier to flows that splits the flow, typically around an island or into a side channel (Abbe, et al., 2005). This also support deposition on the backside of the Apex Bar Jam and promotes scour on the front side. Abutment Jams are used for bank protection where bank erosion is undesirable.

Benefits of both Apex Bar Jams and Abutment Jams are that localized scour holes develop upstream and adjacent to the structures, and a velocity "shadow" occurs downstream. The scour pools are highly desirable for rearing coho as both velocity refugia and as cover between feeding (Lestelle, 2007). The velocity shadows downstream of the structures create localized areas of high-flow refugia for fish in the main river channel during moderate flow events.

Three Apex Bar Jams are proposed for the project: at the heads of the Overflow Channel, Mid-Bar Channel, and Back Bar Channel. In each case, the Apex Bar Jams projects slightly into the active flow area of the river, causing a localized increase in water levels and promoting flow separation and diversion of some river flow into the side channels. Typically, these features are intended to function during small to moderate flow events, and they are allowed to overtop during larger flow events.

One Abutment Jam is proposed for the project, at inlet to the Overflow Channel to control the overall width of the inlet. This Abutment Jam is placed against a tall tailings pile.

Inlet Weir

An inlet weir comprised of stacked trees and root wads will be located between the Apex Bar Jam and Abutment Jam at the inlet to the Overflow Channel. The purpose of the inlet weir is to maintain the inlet dimension and elevation to limit flows entering the Overflow Channel such that the river cannot avulse into the Overflow Channel. The root wads on the structure will face upstream into the flow to dissipate flow energy.

Habitat and Cover Structures

Both Habitat and Cover structures are proposed to enhance fish habitat in the Willow Pond, Kelly Pond, Seasonal Channel and alcoves. Each of these structures is a different configuration of large wood and brush that will cause provide edge complexity and cover. These structures will be further developed during final design.

6 CONSTRUCTION LOGISTICS, COSTS AND NEXT STEPS

6.1 Earthwork

Table 6-1 summarizes the expected excavation quantities for the project which will be derived from excavation of the side channels and alcoves. Because the project area is encompassed within two mining claim, one of the project objectives was to keep all excavated material on site, and within the mining claim from which it was excavated.

The boundary between the two mining claims (Appendix J) is an east-west line located near station 60+00 on Figure 1-2. Therefore, material excavated from the Overflow Chanel inlet, a portion of the upstream end of the Overflow Channel, the Willow Pond and the upstream end of the Seasonal Channel will likely fall within the southern mining clam. The actual boundary between the mining claims and material volumes excavated and placed in each area will be determined during final design.

Plan Sheet 4 in Appendix A indicates potential spoil placement areas and the spoil volumes they will accommodate. These locations were preliminary selected where there is little vegetation and where placement of spoils would be used redirect overbank flows. Except for the Berm, it is anticipated that placed spoils would not exceed 1 to 2 in feet in depth and would not obstruct drainage. The specific spoil area boundaries, fill depths, and capacities will be determined during final design.

Table 6-1. Summary of excavation and backfill volumes for the Kelly Bar project.

Earthwork Item	Excavation	Backfill/Spoil Disposal	
Overflow and Seasonal Channels	3,100 CY	Berm Spoil Areas Wood Jams	3,600 CY 1,380 CY 120 CY
Willow Pond	900 CY		
Kelly Gulch Pond	1,100 CY		
Total Kelly Bar	**5,100 CY**	**5,100 CY**	
West Bar Inlet and Alcove	310 CY	Spoil Area Wood Jams	190 CY 120 CY
Total West Bar	**310 cy**	**310 cy**	
TOTAL EARTHWORK	**5,410 cy**	**5,410 CY**	

6.2 Construction Access

Construction access to the project area will be from a parking area adjacent to Sawyers Bar Road, as shown in Figure 1-2 and along an existing temporary road runs from the road to the southern mining claim. Access is generally only limited on Kelly bar due to existing vegetation. During final design, access routes will be identified that minimize clearance of existing vegetation.

Access to the West Bar will necessitate crossing the river from Kelly Bar. There is a shallow riffle that runs between both bars that can be used as a shallow ford. Allowable access methods and crossing location will be identified as part of final design.

6.3 Water Management

Construction of the project is expected to occur during the dry season when river levels are lowest. Most of the construction can occur out of the channel. However, construction of the connection of the alcoves with the river channel will necessitate isolation of the alcoves from the river channel. Isolation methods will be determined as part of final design. Because there are listed salmonids within the area, fish exclusion screens and fish removal by a qualified biologist will be necessary as part of the project.

Dewatering of nuisance water from the work area and treatment of the sediment-laden water from the dewatering process can be expected. Water from the dewatering operations can be pumped to a flat area away from the work area and allowed to infiltrate into the ground.

6.4 Opinion of Probable Construction Cost

An opinion of probable construction cost (OPCC) is presented in Appendix L. The cost estimate was prepared with a 25% contingency to account for the intermediate nature of the design. The OPCC includes line items with quantities, unit costs, and total costs for each activity anticipated during construction. Costs were based on quantities measured from the 30% design construction drawings (Appendix A) and from material and installation costs derived from bid tabulations of similar and recently completed projects. The OPCC assumes that all wood for the log features will need to be purchased, but that material for the brush baffles can be salvaged from the project area. Excavation unit costs in the OPCC assume that the excess material excavated from the project area can be spoiled on site.

The OPCC covers implementation costs, but excludes preparation of any required environmental documents, permit fees, and construction management and oversight.

The opinion of probable construction cost for the project is $777,750.

6.5 Next Steps

It is expected that SRCC, USFS, CDFW, and other agencies will review and provide comments on the current 30% design plan and basis of design. These comments will be incorporated into 65% design plans.

7 REFERENCES

Abbe. T., D.R. Montgomery, C.A. Adams, R.C. Riley, K.M. Robinson, and E.L. Owens. Bank Protection and Habitat Enhancement using Engineered Log Jams: An Experimental Approach Developed in the Pacific Northwest (DRAFT). Prepared for the NRCS.

ACOE. 2010a. HEC-RAS, river Analysis System User's Manual. Hydraulic Reference Manual: Version 4.1, U.S. Army Corps of Engineers, Hydrologic Engineering Center.

ACOE. 2010b. HEC-RAS, river Analysis System Hydraulic Reference Manual. Hydraulic Reference Manual: Version 4.1, U.S. Army Corps of Engineers, Hydrologic Engineering Center.

Best, J. 1988. Sediment transport and bed morphology at river channel confluences. Sedimentology 35: 481-498.

Blackwell, C.N., C.R. Picard, and M. Foy. 1999. Smolt productivity of off-channel habitat in the Chilliwack river watershed. B.C. Ministry of Environment, Lands and Parks, and B.C. Ministry of Forests. Watershed Restoration Project Report No. 14: 46 pp.

Bureau of Reclamation. 2008. Sedimentation and Rriver Hydraulics-Two Dimensional River Flow Modeling. Version 2.

Burge, L.M. 2006. Stability, morphology and surface grain size patterns of channel bifurcation in gravel-cobble bedded anabranching rivers. Earth Surface Processes and Landforms 1211-1226.

Chow. 1959. V.C. Open-Channel Hydraulics. McGraw-Hill Company, New York. 680 pp.

Eaton, J.G., J.H. McCormick, B.E. Goodno, D.G. O'Brien, H.G. Stefany, M. Hondzo, and R.M. Scheller. 1995. A field information-based system for estimating fish temperature tolerances. Fisheries 20:10–18.

Hillemeier, D., T. Soto, S. Silloway, A. Corum, M. Kleeman, L. Lestelle. 2009. The Role Of The Klamath river Mainstem Corridor In The Life History And Performance Of Juvenile Coho Salmon (Oncorhynchus kisutch) Period Covered: May 2007–May 2008. Submitted to the U.S. Bureau of Reclamation, Mid-Pacific Region, Klamath Area Office.

Lestelle, Lawrence. 2007. Coho Salmon (Oncorhynchus kisutch) Life History Patterns in the Pacific Northwest and California. Prepared for U.S. Bureau of Reclamation Klamath Area Office.

Miori, S., R. Repetto, and M. Turbino. 2006. A one-dimensional model of bifurcations in gravel bed channels with erodible banks. Water Resources Research 42: W11413. 12 pp.

Nanson, G.C. and J.C. Croke. 1992. A genetic classification of floodplains. Geomorphology 4: 459-486.

NMFS. 2014. Final Recover Plan for the Southern Oregon/Northern California Coastal Evolutionarily Significant Unit of Coho Salmon. NOAA Fisheries West Coast Region.

PRISM. 2010. Parameter-elevation Regressions on Independent Slopes Model. Oregon State University.

Pacific Watershed Associates (PWA). 2015. Salmon River Riparian Assessment Pilot Planning Project and Conceptual Design for Fisheries and Riparian Vegetation Enhancement. Prepared for the Salmon River Restoration Council.

Pacific Watershed Associates (PWA). 2012. Geologic Investigation Technical Memorandum for the

Kelly Gulch Off-Channel Fisheries and Riparian Habitat Design Project. Prepared for the Salmon River Restoration Council.

Roni, S., P. Garcia, Detrick, C., D. King, and E. Beamer. 2006. Coho Salmon Smolt Production from Constructed and Natural Floodplain Habitats, Transactions of the American Fisheries Society 135:1398–1408.

Beesly, S. and R. Fiori. 2014. Enhancement of Rearing Habit for Natal and Non-Natal Salmonids in McGarvey Creek-Lower Klamath River. Prepared in partnership wit the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Fish and Wildlife Foundation.

Stanford, J.A., and J.V. Ward. 1992. Management of aquatic resources in large catchments: Recognizing interactions between ecosystem connectivity and environmental disturbance. Pages 91-124 in R.J. Naiman (ed.) Watershed Management – Balancing Sustainability and Environmental Change. Springer-Verlag, New York, NY.

Sullivan, K., D.J. Martin, R.D. Cardwell, J.E. Toll, and S. Duke. 2000. An analysis of the effects of temperature on salmonids of the Pacific Northwest with implications for selecting temperature criteria. Sustainable Ecosystems Institute. Portland, OR.

USGS. 1982. Guidelines for determining flood flow frequency. Bulletin #17B of the Hydrology Subcommittee. Interagency Advisory Committee on Water Data, US Dept. of Interior, Geological Survey, Virginia.

Whitmore. S. 2014. Seasonal Growth, Retention, And Movement Of Juvenile Coho Salmon In Natural And Constructed Habitats Of The Mid-Klamath River. M.S. Thesis, Humboldt State University, Fisheries.

Appendix A

Design Plans

SALMON RIVER RESTORATION COUNCIL

PLANS FOR CONSTRUCTION OF

KELLY BAR OFF-CHANNEL FISHERIES AND RIPARIAN HABITAT DESIGN

OCTOBER, 2015

30% Design Submittal

Prepared For:

- **SALMON RIVER RESTORATION COUNCIL**
- **FISHERIES RESTORATION GRANTS PROGRAM (AGREEMENT No. P1310303)**

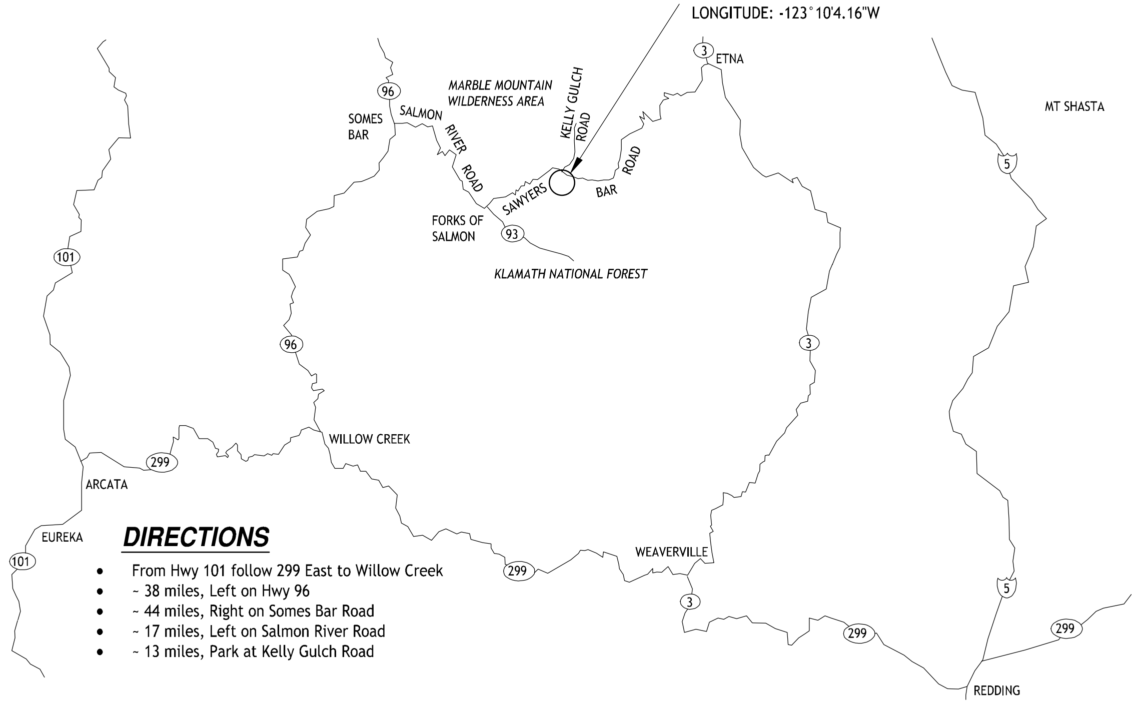
VICINITY MAP

NOT TO SCALE

PROJECT LOCATION

APPROX 125 MILES FROM EUREKA, CA

LATITUDE: 41°18' 57.26"N
LONGITUDE: -123°10'4.16"W



DIRECTIONS

- From Hwy 101 follow 299 East to Willow Creek
- ~ 38 miles, Left on Hwy 96
- ~ 44 miles, Right on Somes Bar Road
- ~ 17 miles, Left on Salmon River Road
- ~ 13 miles, Park at Kelly Gulch Road

LOCATION MAP

NOT TO SCALE

Sheet Number	Sheet Title
1	TITLE
2	ABBREVIATIONS AND LEGEND
3	EXISTING CONDITIONS
4	ACCESS AND SPOILS PLACEMENT
5	MID-BAR SIDE CHANNEL PLAN
6	MID-BAR PROFILE AND SECTIONS
7	KELLY BAR OVERFLOW AND SEASONAL CHANNEL PLAN
8	OVERFLOW PROFILE AND SECTION
9	KELLY GULCH POND AND OUTFLOW CHANNEL PLAN
10	KELLY GULCH POND PROFILE AND SECTION
11	DETAILS

PRELIMINARY

NOT FOR CONSTRUCTION

Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

Salmon River Restoration Council
PO BOX 1089 • 25631 Sawyers Bar RD, Sawyers Bar CA 96027
530-462-4665 Fax 530-462-4664

DRAFT

VERIFY SCALE

THIS BAR IS ONE INCH LONG AT FULL SCALE

Salmon River Restoration Council
KELLY BAR OFF-CHANNEL FISHERIES AND RIPARIAN HABITAT DESIGN

TITLE

DATE: OCT. 2015
SUBMITTAL: 30% DESIGN
DESIGN: RS / ML
DRAWN: NN
SHEET: 1 of 11

LEGEND AND SYMBOLS

EXISTING

	FENCE LINE
95	EXISTING CONTOUR AND ELEVATION
+99.0	SPOT ELEVATION
	CHANNEL THALWEG OR DRAINAGE
1+00	ALIGNMENT STATIONING (FEET)
	CONTROL POINT/TEMPORARY BENCH MARK
	FLOW DIRECTION
	BEDROCK

NEW

	SURVEY CONTROL POINT
16	CONTOUR AND ELEVATION
16	SPOT ELEVATION
1+00	STATIONING ALONG ALIGNMENT (FEET)
	CHANNEL THALWEG OR DRAINAGE
	SLOPE LINE
	LOG/LARGE WOOD STRUCTURE
	WATER SURFACE
	TREE OR STUMP TO BE REMOVED
	SPOIL PLACEMENT AREAS
	BRUSH BAFFLES

ABBREVIATIONS

APPROX, ~	APPROXIMATELY
CA	CALIFORNIA
CL	CENTERLINE
CMP	CORRUGATED METAL PIPE
CP	SURVEY CONTROL POINT
CFS	CUBIC FEET PER SECOND
DIA	DIAMETER
DWG	DRAWING
EG	EXISTING GROUND
EL	ELEVATION
(E)	EXISTING
EP	AVERAGE DAILY EXCEEDANCE PROBABILITY
FG	FINISHED GROUND
'	FOOT OR FEET
HDPE	HIGH DENSITY POLYETHYLENE
LOD	LIMIT OF DISTURBANCE
MAX/MIN	MAXIMUM/MINIMUM
(N)	NEW
NFSR	NORTH FORK SALMON RIVER
NTS	NOT TO SCALE
OZ	OUNCE
O.C.	ON CENTER
RD	ROAD
STA	STATION
SY	SQUARE YARDS
TBM	TEMPORARY BENCHMARK
TYP	TYPICAL
W/	WITH
WSE	WATER SURFACE ELEVATION
YR	YEAR
(1.5:1)	(HORIZONTAL:VERTICAL) SLOPE
%	PERCENT

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DRAFT

VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

Salmon River Restoration Council
KELLY BAR OFF-CHANNEL
FISHERIES AND RIPARIAN HABITAT DESIGN

ABBREVIATIONS AND LEGEND

DATE OCT. 2015
SUBMITTAL 30% DESIGN
DESIGN RS / ML
DRAWN NN
SHEET 2 of 11

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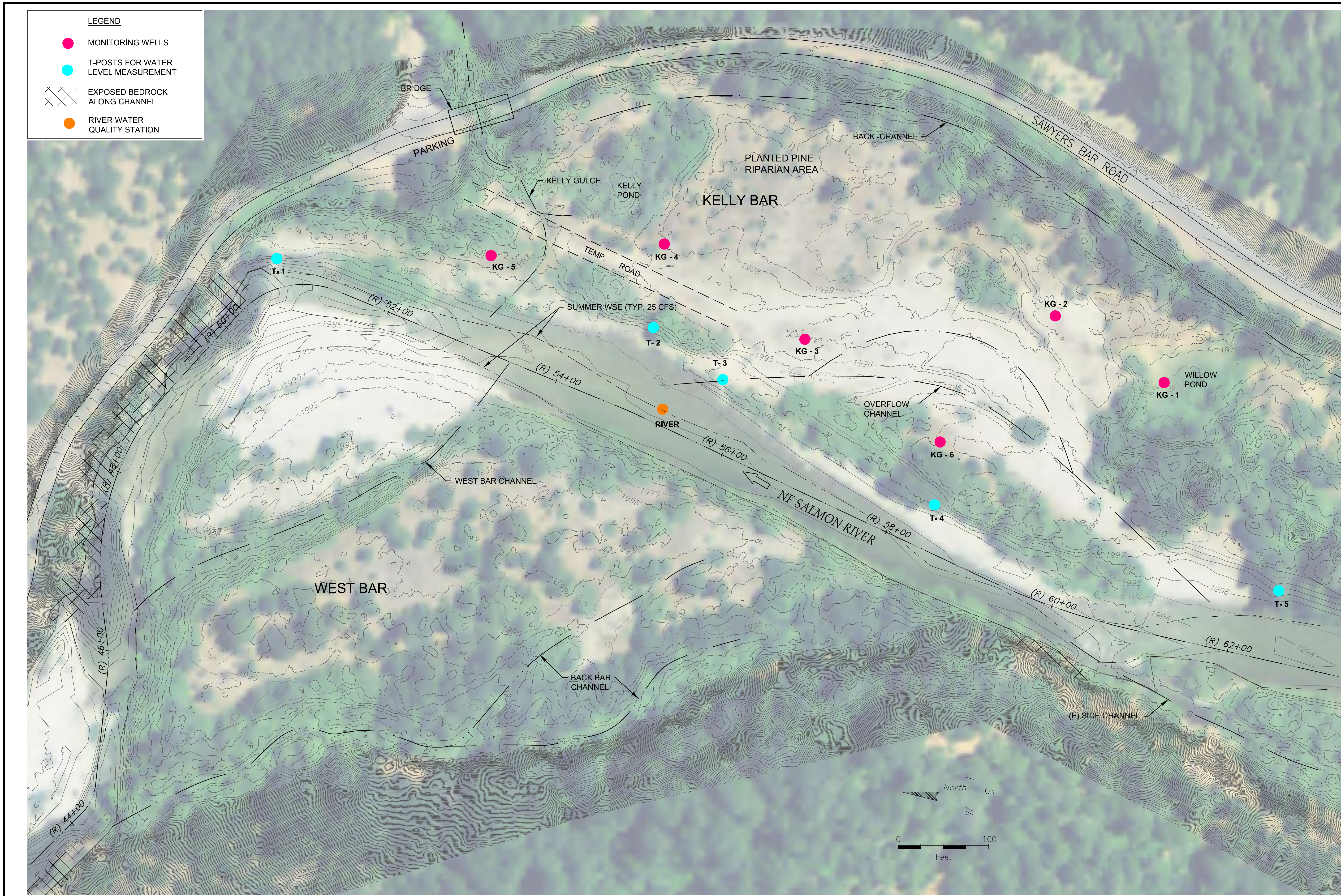

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VERIFY SCALE
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Salmon River Restoration Council
KELLY BAR OFF-CHANNEL
FISHERIES AND RIPARIAN HABITAT DESIGN

EXISTING CONDITIONS

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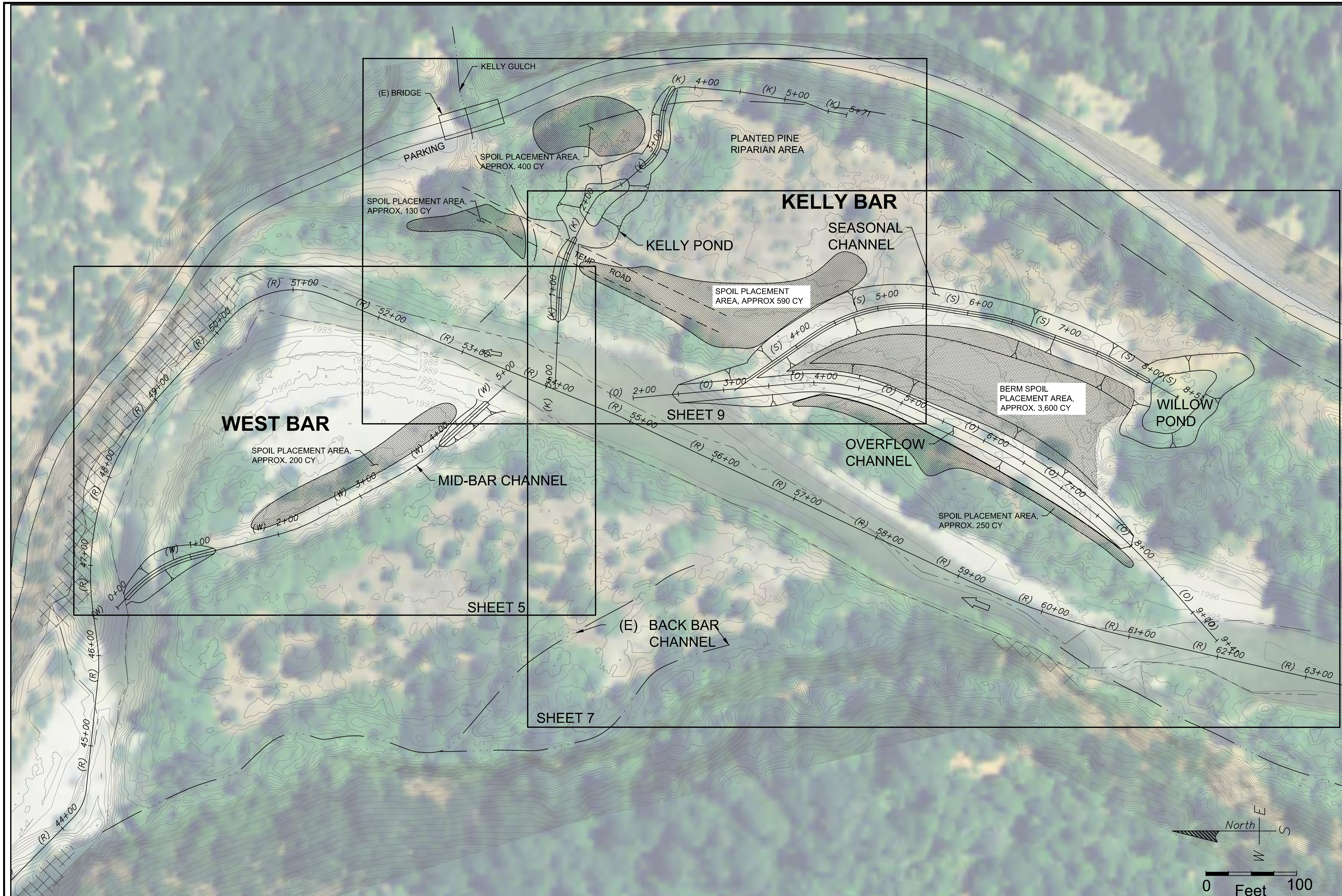

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KELLY BAR OFF-CHANNEL
FISHERIES AND RIPARIAN HABITAT DESIGN

ACCESS AND SPOILS PLACEMENT

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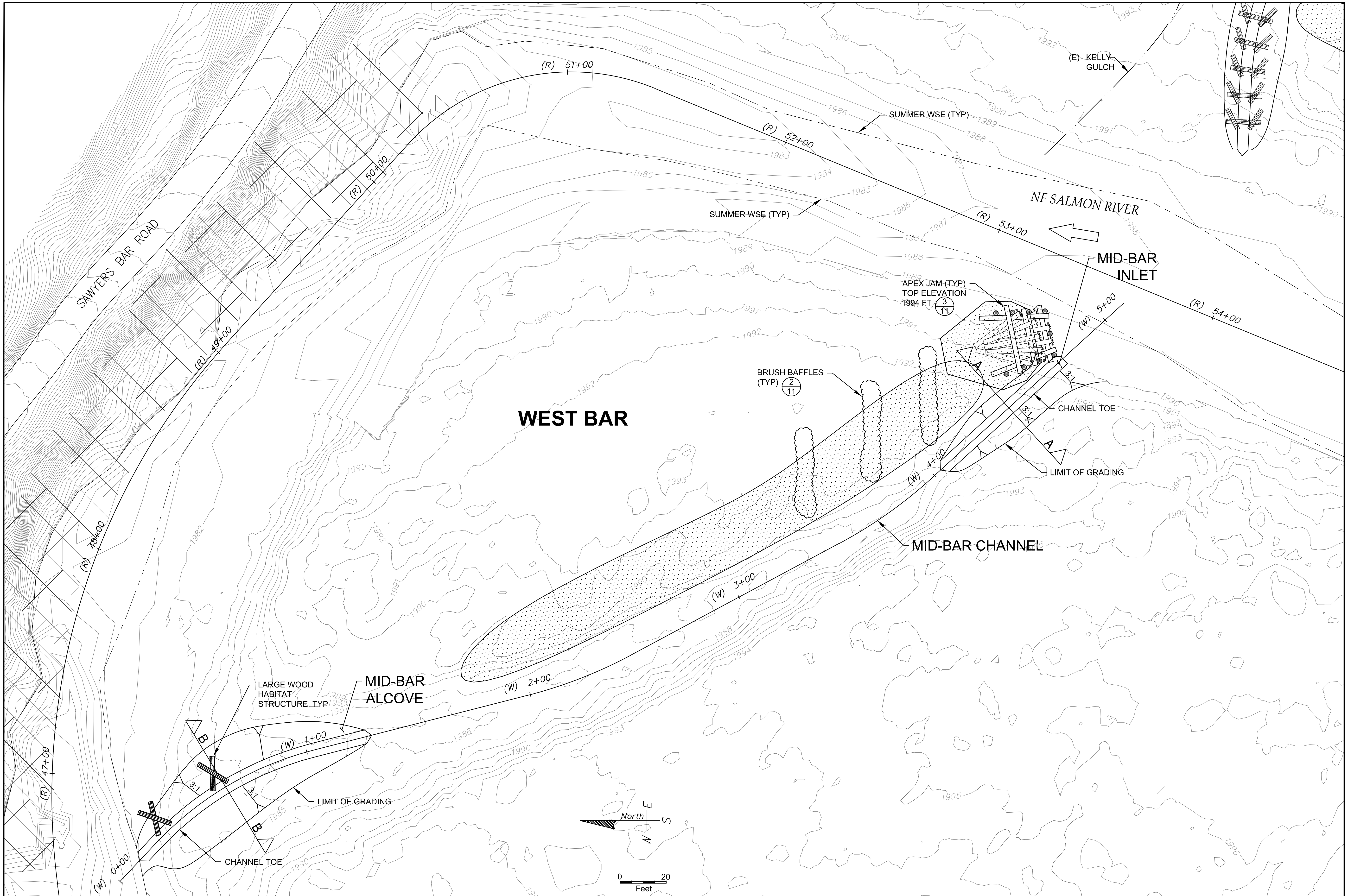

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KELLY BAR OFF-CHANNEL
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MID-BAR SIDE CHANNEL PLAN

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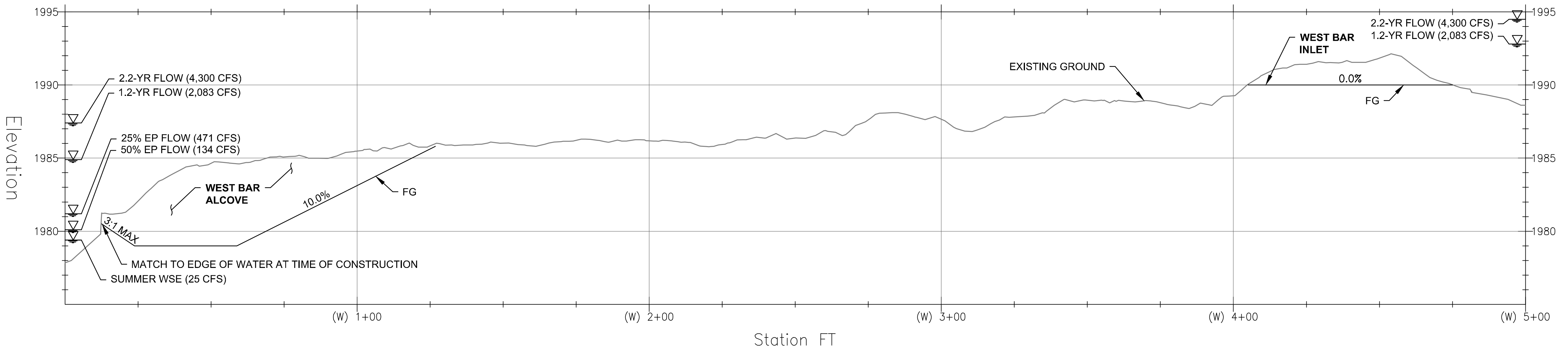

MID-BAR CHANEL INLET AND ALCOVE
PROFILE ALONG (W) ALIGNMENT

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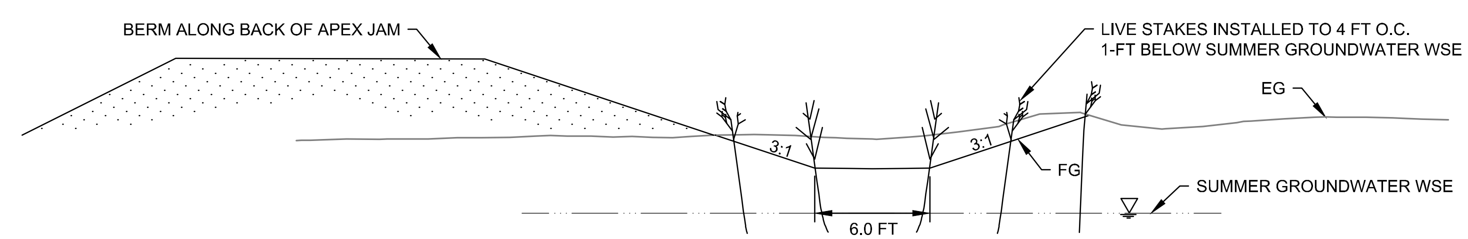
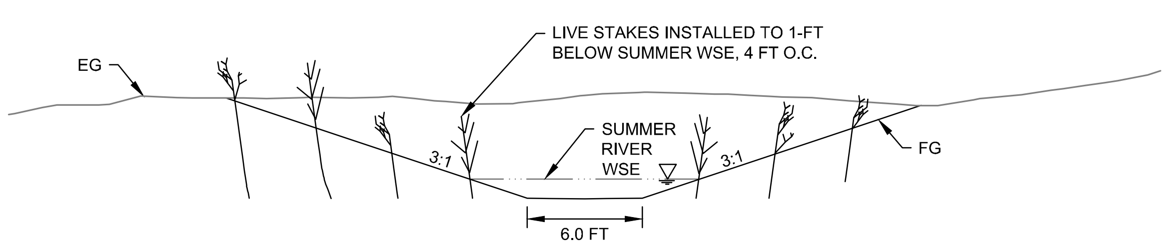
VERTICAL SCALE: 0 2 4 Feet





A MID-BAR CHANNEL ALCOVE SECTION
TYPICAL **NTS**

B MID-BAR CHANNEL INLET SECTION
TYPICAL **NTS**

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FISHERIES AND RIPARIAN HABITAT DESIGN

MID-BAR PROFILE AND SECTIONS

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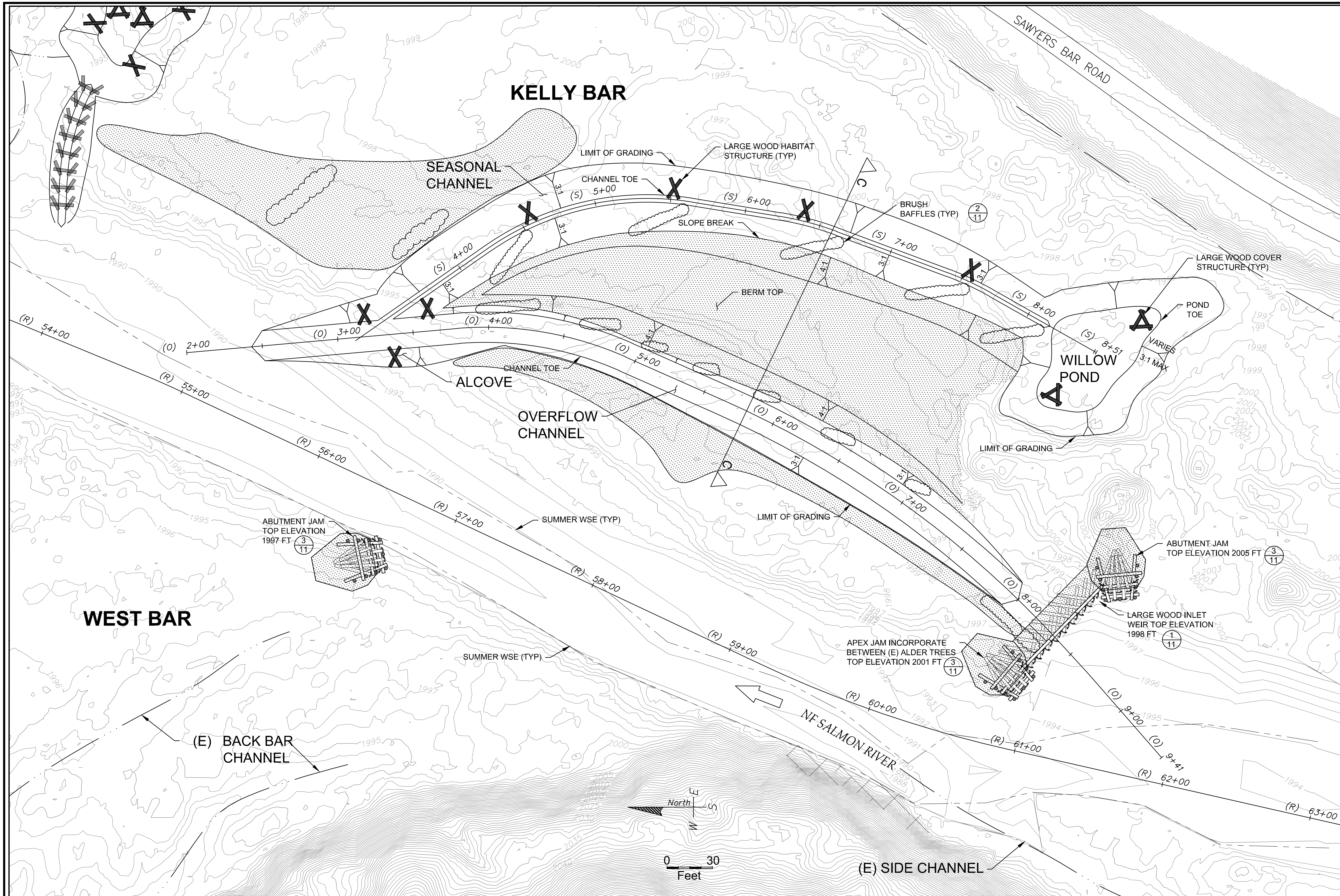

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KELLY BAR OFF-CHANNEL
FISHERIES AND RIPARIAN HABITAT DESIGN

KELLY BAR OVERFLOW AND SEASONAL CHANNEL PLAN

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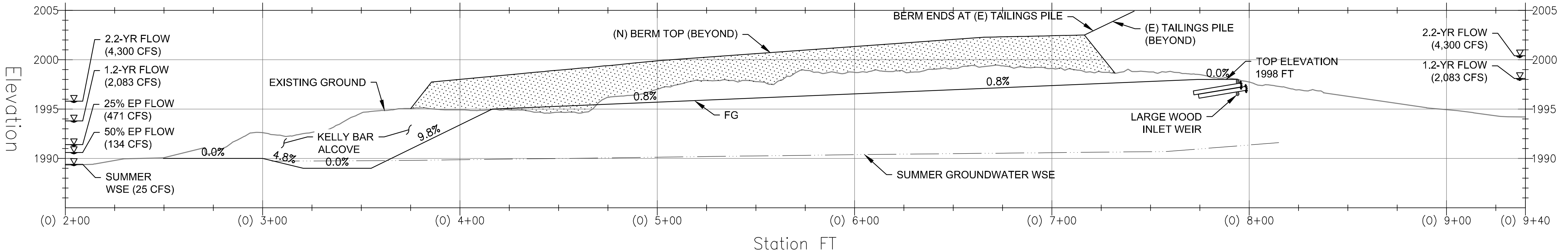

KELLY BAR OVERFLOW CHANNEL THALWEG
PROFILE ALONG (O) ALIGNMENT

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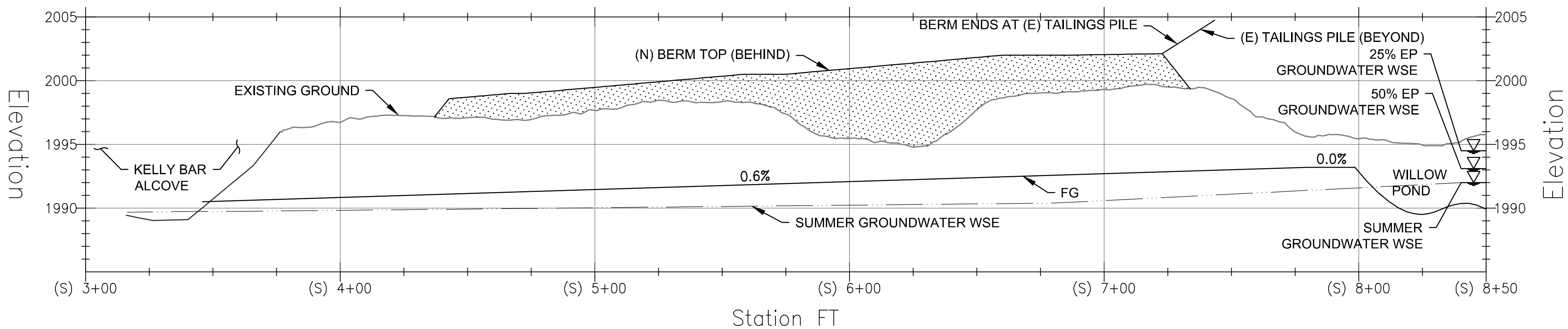
VERTICAL SCALE: 0 3 6 Feet



KELLY BAR SEASONAL CHANNEL THALWEG
PROFILE ALONG (S) ALIGNMENT

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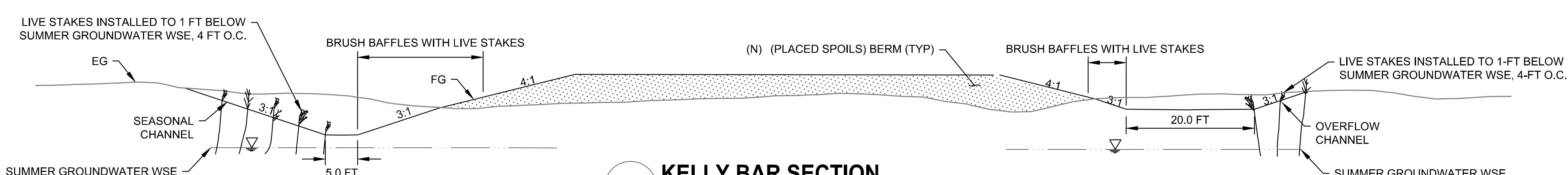
VERTICAL SCALE: 0 3 6 Feet



C KELLY BAR SECTION
TYPICAL **NTS**

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KELLY BAR OFF-CHANNEL
FISHERIES AND RIPARIAN HABITAT DESIGN

OVERFLOW PROFILE AND SECTION

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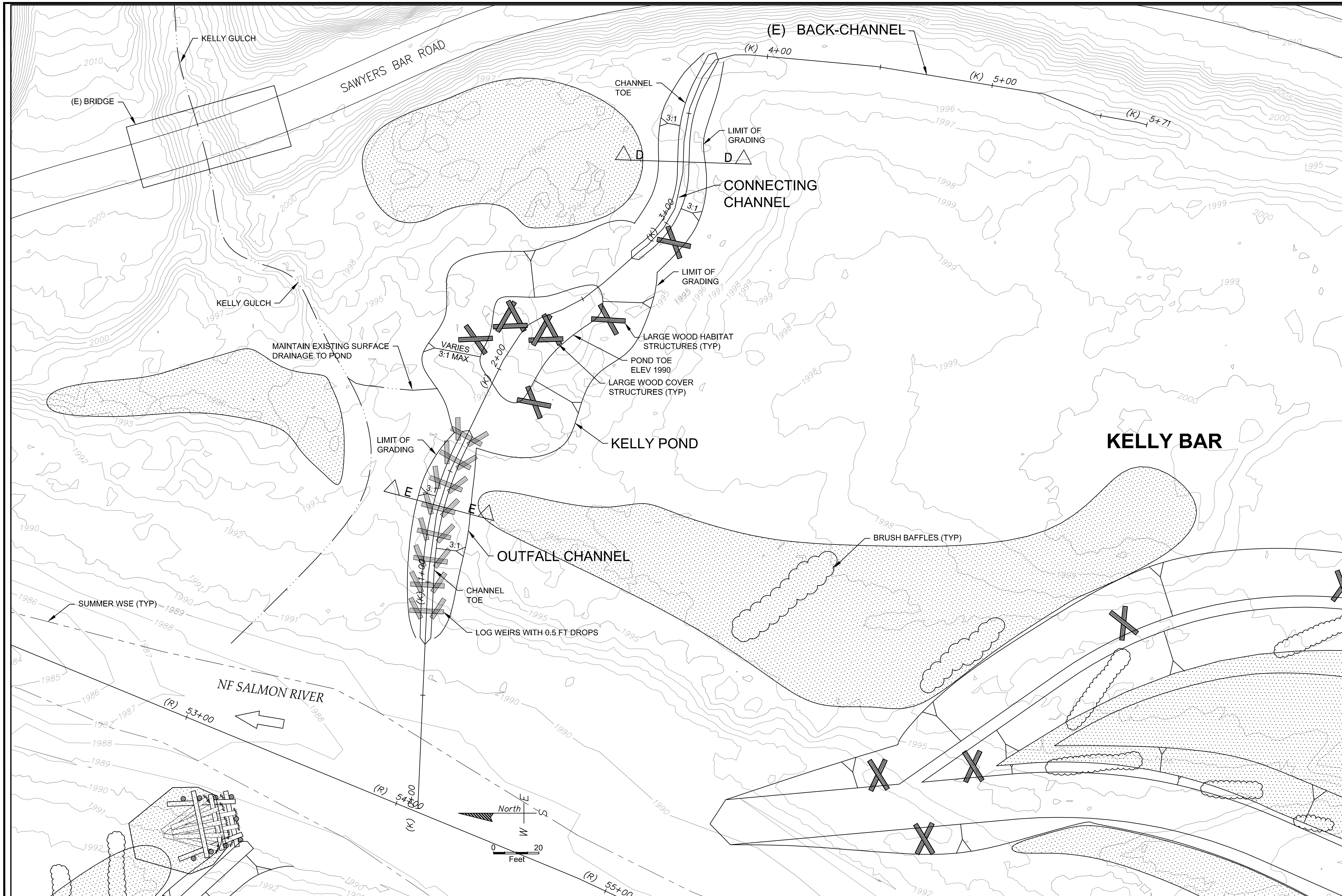

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FISHERIES AND RIPARIAN HABITAT DESIGN

KELLY GULCH POND AND OUTFLOW CHANNEL PLAN

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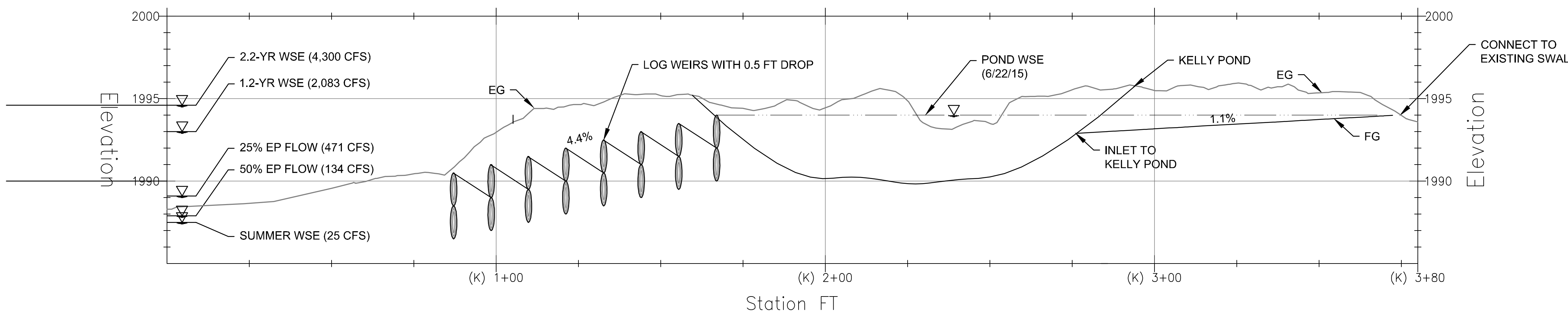

KELLY POND OUTLET CHANNEL
PROFILE ALONG (K) ALIGNMENT

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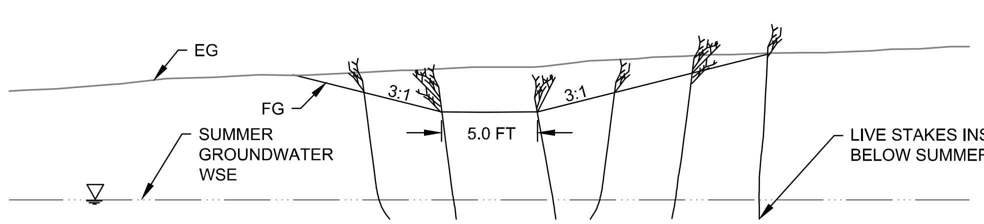
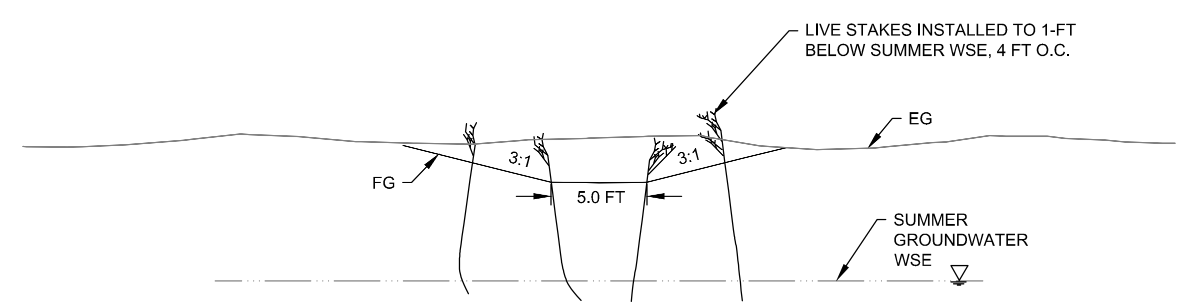
VERTICAL SCALE: 0 2 4 Feet



E KELLY POND OUTFALL CHANNEL SECTION
TYPICAL **NTS**



D CONNECTING CHANNEL SECTION
TYPICAL **NTS**

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KELLY BAR OFF-CHANNEL
FISHERIES AND RIPARIAN HABITAT DESIGN

KELLY GULCH POND PROFILE AND SECTION

DATE	OCT. 2015
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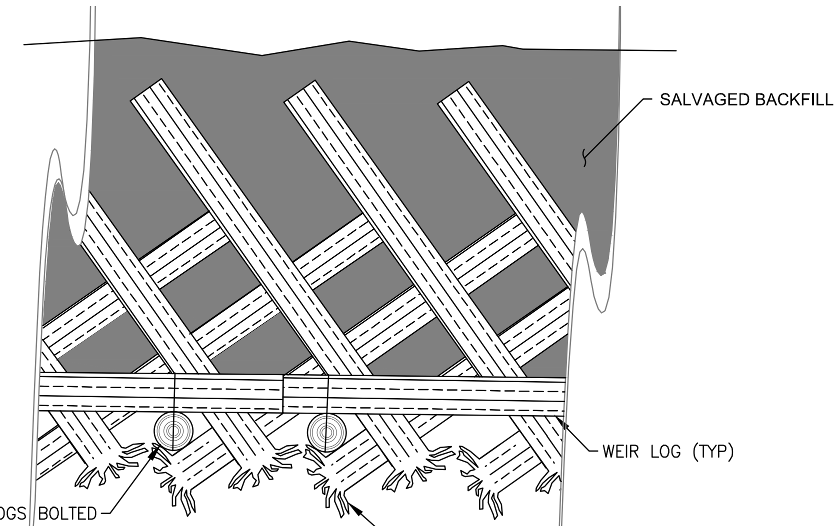
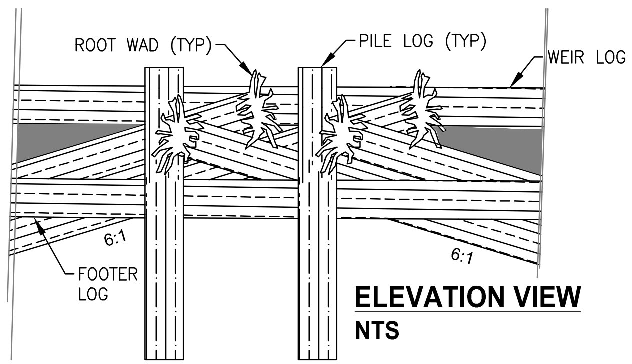
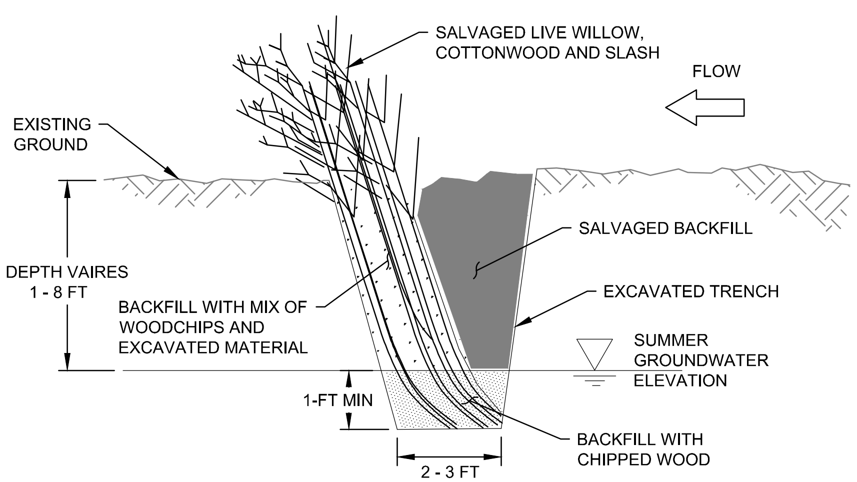


PLAN
NTS

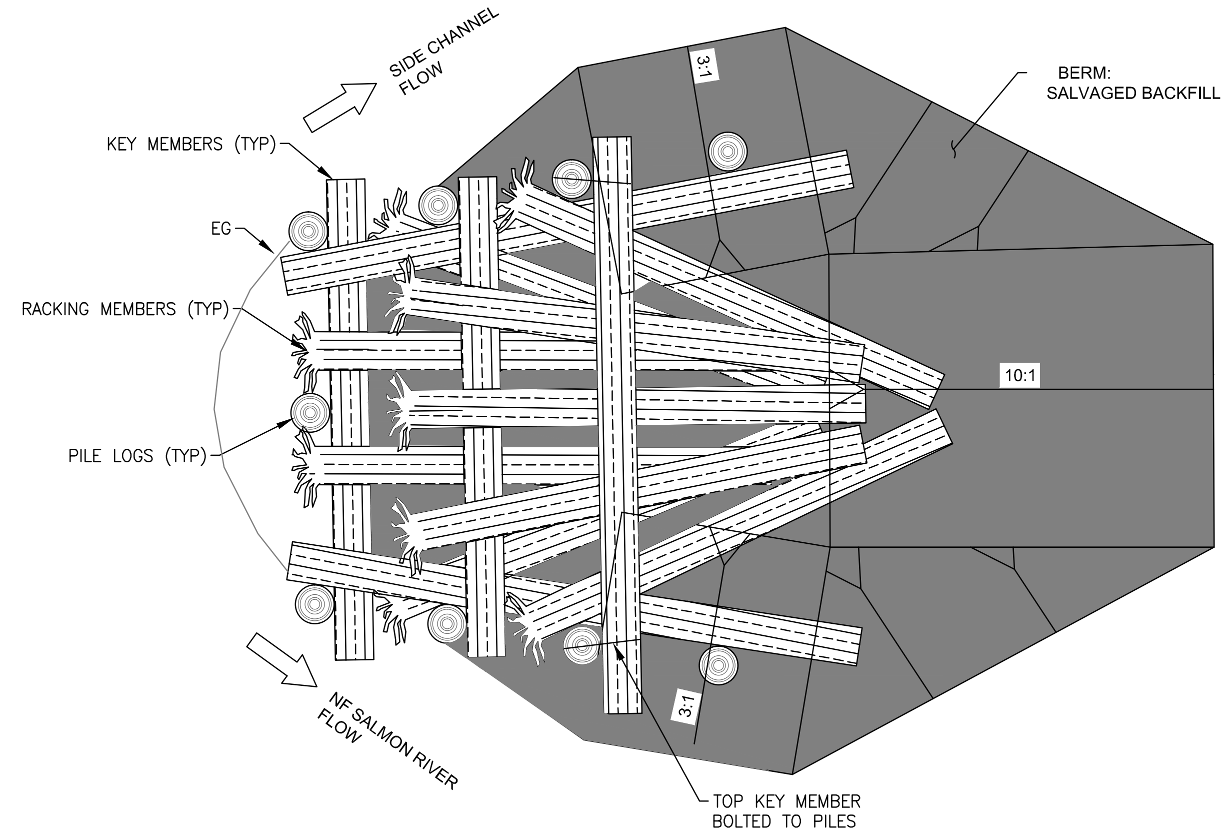


ELEVATION VIEW
NTS

1 INLET WEIR
TYPICAL NTS



2 BRUSH BAFFLES
SECTION NTS



PLAN
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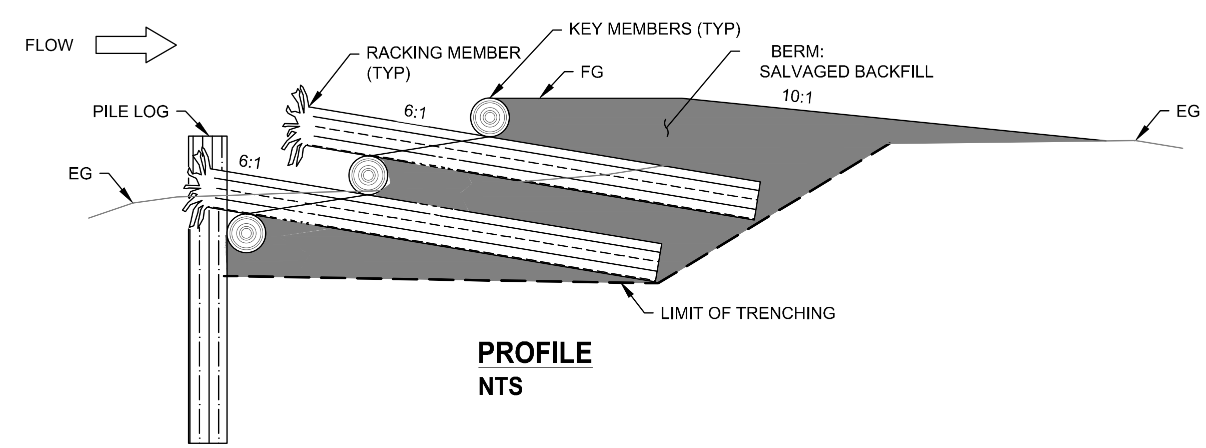

PROFILE
NTS

3 APEX BAR/ABUTMENT JAM
TYPICAL

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FISHERIES AND RIPARIAN HABITAT DESIGN

DETAILS

DATE	OCT. 2015
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SHEET	11 of 11

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Appendix B

Geologic Report

Date: January 20, 2015

To: Lyra Cressey and Karuna Greenberg
Salmon River Restoration Council
PO Box 1089, Sawyers Bar, CA 96027

Cc: Michael Love, PE
Michael Love & Associates, Inc.
427 F Street, Suite 223, Eureka CA 95501

From: William Randy Lew, Professional Geologist (#7872)
Pacific Watershed Associates Inc.
P.O. Box 4433, Arcata CA, 95518-4433
Randyl@pacificwatershed.com / 707-839-5130

Subject: Geologic Investigation Technical Memorandum for the Kelly Gulch Off-Channel Fisheries and Riparian Habitat Design Project

Introduction and Background

The *Kelly Gulch Off-Channel Fisheries and Riparian Habitat Design Project* is located within the North Fork Salmon River watershed, approximately 2.3 miles northwest of Sawyers Bar, in northern California (Map 1). The project area is located within the USGS Sawyers Bar 7.5-minute quadrangle in Township 40N Range 12W Section 24, Siskiyou County, California. The Cal Watershed HUC 8 is 18010210.

All 4 species of anadromous salmonids, as well as the Pacific lamprey and green sturgeon, are present in the Salmon River watershed. Currently the fluvial system is significantly modified from its natural configuration in part because of historic land management activities. Modifications resulted in floodplain/side channel disconnection due to placer mining along the alluvial channel corridor as well as accelerated sediment production due to hydraulic mining and forest management practices.
Whereas salmonid populations have evolved and flourished with the natural processes of rainfall and erosion in the area, the impact of anthropogenically induced habitat fragmentation and erosion (e.g., mining, timber production and road construction) has resulted in the degradation of salmonid habitat, loss of riparian function and accelerated sediment delivery to streams in this important watershed.

In part because of the observable decline in anadromous fish populations in northern California, the California Department of Fish and Wildlife (CDFW) and U.S. Fish and Wildlife Service (USFWS), among others, have funded numerous watershed and fisheries restoration projects throughout northern California over the last several decades. These efforts have included instream habitat restoration projects, many of which have been focused on providing rearing habitat in these watershed systems. Increasing the available rearing habitat for juvenile salmonids is of great importance for the future of coho salmon in the Salmon River watershed. Because coho salmon require slow water refugia and summer cold water temperatures for rearing habitat, increasing side channel habitat as well as riparian forest canopy are especially beneficial to the future health of these important species.

The *Kelly Gulch Off-Channel Fisheries and Riparian Habitat Design Project (KGFRHDP)* is intended to provide winter off-channel habitat for juvenile salmonids where they can find velocity refuge and more effectively mature and prepare for their oceanic life stage. The project area is located along a tributary confluence and floodplain/bar complex approximately 14 river miles up the North Fork Salmon River (NFSR) from its confluence with the South Fork. Kelly Gulch, an anadromous tributary within the project area, enters this bar complex from the right bank (facing downstream) of the NFSR and discharges across the floodplain bar before entering the main channel (Map 2). The entire KGFRHDP area is located on United States Forest Service (USFS) property, within Klamath National Forest.

The goal of the project as stated in the project proposal is to enhance side channel habitat, increase channel complexity, connect and enhance disconnected alcoves as off-channel ponds where viable, increase riparian shading and LWD recruitment, and increase and improve coho winter rearing habitat on an important reach of the NFSR. Depending upon final design outcomes, additional project benefits may include the re-connection of Kelly Gulch stream channel into the constructed off-channel habitat where additional summer cold water refugia would be created. Using ongoing, long-term hydrologic data coupled with shorter term site specific data from the proposed restoration site, the project engineer will design a plan that allows for predictable seasonal flows into the side channel(s) and alcove areas. This report summarizes the subsurface geologic investigation that was conducted to inform the project engineer of geologic conditions within the proposed project area.

Scope of Work

The scope of this part of the larger KGFRHDP was limited to the installation of on-site shallow groundwater monitoring wells, characterization of the subsurface stratigraphy observed during the well installations, and identification/characterization of potential project constraints, based largely on subsurface geologic conditions. Specifically, the project tasks included:

(1) Pre-field work meetings with the project engineer and Salmon River Restoration Council (SRRC) staff to review site conditions and proposed trench/well locations.

(2) Analyzing backhoe exploratory pit/trenches and characterizing the subsurface stratigraphy at 6 monitoring well locations.

(3) Installation of shallow groundwater monitoring wells at 6 locations identified by the project engineer.

(4) Post-field work communication to discuss preliminary stratigraphic findings.

(5) Description and analysis of data collected at pit/well locations.

(6) Preparing a technical memorandum summary report and recommendations pertaining to the proposed restoration project.

Geologic and Geomorphic Setting

The regional geology of the Salmon River watershed is composed of diverse rock groups including several distinct metamorphic belts, intrusive granitic batholiths, alluvial terrace deposits, colluvial deposits, and recent alluvial deposits. The Salmon River watershed is part of the greater regional physiographic Klamath Mountain province. Poorly consolidated and sheared metamorphic rocks as well as deeply weathered granitic rocks that are particularly susceptible to erosion and mass wasting during periods of sustained or heavy rainfall are exposed throughout the watershed.

Published geologic mapping of the area (Ernst, 1998; Wagner and Saucedo, 1987) shows that the primary project area is underlain by Quaternary alluvium (Qal), while the adjacent forming hillslopes are composed of metabasalts and metadiabases in addition to serpentinites from the Western Paleozoic and Triassic Belt (Map 3). A characterization of subsurface materials within the project area identified alluvial deposits consistent with these published California Division of Mines and Geology (DMG) maps. A detailed description of subsurface materials is included in Figures 1a & 1b.

The geomorphic setting of the KGFRHDP area is dominated by channel and floodplain processes along the North Fork Salmon River (NFSR), located approximately 14 river miles upstream from its (NFSR) confluence with the South Fork (Map 1). The project area consists of approximately 12 acres of a mostly barren, large alluvial floodplain with several sparsely vegetated, discontinuous remnant high-flow side channels and vegetated alluvial terraces, and is contained on the left side by mainstem NFSR and on the right by Sawyers Bar Road and the adjacent hillslope. Much of the alluvial bar has been reworked by historic placer mining activities as well as by channel dredging near Kelly Gulch creek mouth. On the alluvial bar several discontinuous high-flow side channels are mostly devoid of vegetation and are largely dry throughout the late summer and fall. These high-flow side channels contained within the active floodplain are inundated annually to semi-annually.

Methods

Our geologic investigation consisted of three parts: (1) excavating exploratory trenches/pits at 6 locations to log and characterize the subsurface stratigraphic conditions that will be encountered at well sites within the project area; (2) the installation of groundwater monitoring wells according to the typical specification illustrated in Figure 2 at locations identified by the project engineer; and (3) analyzing and reporting on the results. The exploratory trenches/pits were excavated using a backhoe that wheel-walked along the dry alluvial bar to reach the well locations. Once the excavation trenches were completed to the desired depth, detailed logs of the subsurface stratigraphy were compiled, then the well casings were backfilled with alluvial materials removed during the excavation. Field classification method ASTM D 2488-00 (Visual-Manual Procedure) was used to describe and identify the soils and alluvial materials logged during the borings. Soil descriptions were classified according to the Unified Soil Classification System (Figures 1a & 1b).

Discussion

Characterization of subsurface stratigraphy

The subsurface stratigraphy in all of the trenches was fairly consistent. In general, subsurface materials consisted entirely of course-grained alluvium from sand to boulder sized particles (Figures 1a & 1b). In the only exception, trench KG-1 exhibited minor amounts of fine-grained silt throughout the column. All trenches contained a mixture of sand, gravel, cobble and boulder. Several columns (KG-1 & KG-5) exhibited no obvious or apparent sedimentary structures but rather a heterogeneous mix of particles throughout. The remaining trench columns exhibited a varying degree of discernable sedimentary structures including clast imbrication and alternating beds with well defined to partially defined bedding and lamination planes. All of the materials observed were unconsolidated and are considered to be cohesionless alluvial soils (Figures 1a and 1b).

Interpretation of subsurface stratigraphy

Geomorphic and geologic observations indicate the stratigraphy within the project area is consistent with channel, bar and floodplain deposits typical of high-energy fluvial environments. However, anthropogenic activities (i.e., placer mining, road construction, channel dredging) have likely redistributed upper unit materials in places along Kelly's Bar over time. This is potentially observed in exploratory trenches KG-1 and KG-5, where no sedimentary structures or discernable fluvial stratigraphy is prevalent. There is no age control on the deposition (natural and anthropogenic) of these sediments so the actual timing of deposition is equivocal. However, giving the geomorphic nature of the active KGFRHDP area channel/bar/floodplain complex, it is likely the deposits observed in the exploratory trenches are of recent and historic (< 200 years) origin.

The intrinsic permeability of the substrate encountered during the subsurface investigation is relatively high given the coarse nature of materials encountered throughout the exploratory trenches. The sands, gravels, cobbles and boulders encountered during the subsurface exploration are typical of high-energy channel, bar and floodplain deposits found along the NFSR. These deposits are likely to allow for the rapid lateral movement of groundwater from the side channel(s) to NFSR and conversely, depending on river flow levels and seasonal groundwater fluctuations. Depending upon side channel excavation depths, these high permeability units are likely to pose the most significant challenge to managing groundwater during construction. Because the trenches terminated at relatively shallow depths, the extent or thickness of these alluvial units is undetermined.

Potential project constraints and recommendations

1) **North Fork Salmon River Lateral Channel Migration:** Historical aerial photo research conducted during previous studies suggest that the NFSR channel thalwag has undergone periodic lateral migration within the project reach (PWA, 2012). In the 1944 and 1955 photo sets the mainstem NFSR is located approximately 200 ft to the southeast of its current configuration. The riparian vegetation is sparse and appears to be recolonizing the right bank bar between the 1944 and 1955 photos. Likely as a result of the 1964 flood, the 1965 photo set shows the channel having avulsed northwest, significantly eroding the left bank/hillslope and reestablishing a new thalweg. Mature streambank riparian vegetation previously containing the left bank was left intact but due to significant erosion and channel avulsion, these mature riparian trees became the seasonal right bank of the NFSR. Much of the alluvial bar vegetation was lost during the 1964 flood. The 1975 photos show the channel occupying nearly the same location as the current NFSR channel. Riparian vegetation had begun to colonize the low flow channel margins longitudinally along the right bank. The 1980 photos show that the channel appears to be slowly migrating to the east (right bank) at the downstream end of the project reach. The riparian vegetation has continued to mature along the channel margins while still remaining sparse over the greater alluvial bar area along the right side. No photo pair was available for 1995. The Google Earth and NAIP images for 1993 to 2011 confirm that the NFSR channel is occupying

nearly the same location as the 1980 photos indicate. Riparian vegetation continues to slowly mature and expand around the same locations as the 1980 photos (PWA, 2012)

Based upon historical aerial photo evidence, the NFSR channel thalweg appears now to be in relative equilibrium within the project reach since the 70s. However, historical evidence also suggests the potential for major periodic shifts in channel location. These could occur as a result of major flood or mass wasting events typical within the watershed.

Recommendations:

- Engineering design considerations should account for possibility of significant lateral channel shifts or migration for the design life of the project.

2) **Soil and Groundwater Constraints during Construction:** The proposed restoration project calls to excavate new channels, alcoves and/or depressions that will reconnect to NFSR during design flow events. During side channel/alcove excavation and construction, saturated soils and groundwater piping are likely to be encountered. Excavation of saturated materials is likely to cause significant turbidity; therefore, preventing sediment discharge to NFSR will require special care. In the upper portions of the side channel(s) excavation column, cohesionless strata consisting of relatively dry sands, gravels, cobbles and boulders are likely to be encountered (Figures 1a & 1b). However, in the lower portions of the excavation column, a saturated mix of sands, gravels, cobbles and boulders may be locally encountered (Figures 1a & 1b). These materials may be subject to slumping and calving during construction, particularly as groundwater sapping occurs during initial drawdown.

Recommendations:

- During side channel/alcove excavation and construction, hydraulic pumps, sumps and/or coffer dams may need to be utilized for water and sediment control.
- An erosion and sediment control plan should be developed by a qualified professional prior to the beginning of construction. Among other things, the plan should specifically address the disposal or treatment of turbid water and liquefied silt and sandy sediment.
- The project engineer, in consultation with the project geologist when deemed necessary, should evaluate exposed excavated materials in determining final as-built slope grades. In general, final slope grades in the excavated side channel banks should be no steeper than 3:1 (H:V), and perhaps less depending upon design and modeling considerations.

3) **Placement of Spoils:** The excavation and removal of soils for the construction of the side channel(s) and alcove(s) will likely generate excess spoil material that will need to be disposed of or reused in the construction of designed landforms. Excess spoil material should be suitable for even distribution along the adjacent floodplain areas, away from any watercourses or wetland areas that are not part of designed landforms. The distribution may require some soil conditioning to allow for sufficient drying prior to the final regrading of the materials. Based on

our subsurface investigation, it is likely that minor amounts of organic debris will be excavated during the channel excavations.

Recommendations:

- Organic debris should not be buried or distributed within the fill material being spread throughout the project area or where spoils may be stockpiled. However, organic debris can be used as a final surface treatment on top of finish grade slopes or for in-channel habitat benefits; when and where agency permits allow.
- The final graded spoil material should be mulched, seeded and planted as necessary to prevent surface erosion and any potential for sediment delivery.

4) **Suitability of Excavated/Dredge Materials for Structural Fills:** If structural fills or embankments are incorporated into the final project design, special care should be taken in the use of excavated/dredge materials. Some of the excavated materials generated on-site may be suitable for structural fills. However, some portion of the excavated materials will be unsuitable for structural fill construction because of their composition, grain size, grain shape and/or moisture content. Excavated materials that are composed of, or incorporate, organic debris or other deleterious materials are unsuitable for construction. Additionally, materials that are saturated may require soil conditioning if they are to be used for construction. Some alluvial materials may not be suitable for achieving required rates of compaction.

Recommendations:

- Use only excavated/dredge materials that are free from organic debris or other deleterious materials, and of proper soil moisture, to construct structural fills.
- Prior to construction, develop relative compaction and optimum moisture content standards based on site specific soils and project design criteria.
- Import additional engineered fill material as necessary to construct structural fills.
- Condition (spread and air dry) saturated soils to specified moisture content standard prior to use in structural fills.

5) **Additional General Recommendations:**

- Grazing livestock should be excluded from any proposed channel(s) or pond excavation areas as they can and will browse stabilizing riparian vegetation, destabilize channel banks, produce turbidity, increase erosion rates, and accelerate infilling of the ponds.
- Prior to construction, develop a revegetation plan that incorporates native aquatic and terrestrial plants suitable to the project area and implement the plan following construction. Planting with willows and/or other fast growing, deep-rooted native plants should be incorporated into the revegetation plan. However, given the seasonally dry nature of the soils within the project area, irrigation may need to be incorporated into the plan.

References

Ernst, W.G., 1998, DMG Map Sheet 47, Geology of the Sawyers Bar area, Klamath Mountains, Northern California, scale 1:48,000.

Wagner, D.L. and Saucedo, G.J., 1987, DMG Map NO. 4A, Geologic Map of the Weed Quadrangle, California, scale 1:250,000.

Pacific Watershed Associates (PWA), 2012, Salmon River Riparian Assessment Pilot Planning Project and Conceptual Design for Fisheries and Riparian Vegetation Enhancement, Prepared for Salmon River Restoration Council, Sawyers Bar, California.

Certification and Limitations

This report, entitled *Geologic Investigation Technical Memorandum for the Kelly Gulch Off-Channel Fisheries and Riparian Habitat Design Project* was prepared by or under the direction of a licensed professional geologist at Pacific Watershed Associates Inc. (PWA), and all information herein is based on data and information collected by PWA staff. The subsurface investigation analysis for the project, as well as engineering design recommendations, were similarly conducted by, or under the responsible charge of, a California licensed professional geologist at PWA.

The interpretations and recommendations presented in this report are based on a study of inherently limited scope. Observations are qualitative, or semi-quantitative, and confined to surface expressions of limited extent and shallow borings of subsurface materials. Interpretations of problematic geologic and geomorphic constraints and erosion processes are based on the information available at the time of the study, and on the nature and distribution of existing features.

The recommendations contained in this report are professional opinions derived in accordance with current standards of professional practice, and are valid as of the submittal date. No other warranty, expressed or implied, is made. PWA is not responsible for changes in the conditions of the property with the passage of time, whether due to natural processes or to the works of man, or changing conditions on adjacent areas. Furthermore, to be consistent with existing conditions, information contained in this report should be re-evaluated after a period of no more than three years. It is the responsibility of the project engineer and project proponent to ensure that all recommendations in this report are reviewed and implemented according to the conditions existing at the time of construction. Also, PWA, including the licensed professionals, are not responsible for recommendations implemented outside of their professional oversight. Finally, PWA is not responsible for changes in applicable or appropriate standards beyond our control, such as those arising from changes in legislation or the broadening of knowledge, which may invalidate any of our findings.

Certified by:

____

William R. Lew, California PG #7872
Associate Geologist
Pacific Watershed Associates Inc.

Attachments:

Map 1. Location map for the geologic investigation of the Kelly Gulch Off-Channel Fisheries and Riparian Habitat Design Project, Siskiyou County, California

Map 2. Core locations for the geologic investigation of the Kelly Gulch Off-Channel Fisheries and Riparian Habitat Design Project, Siskiyou County, California

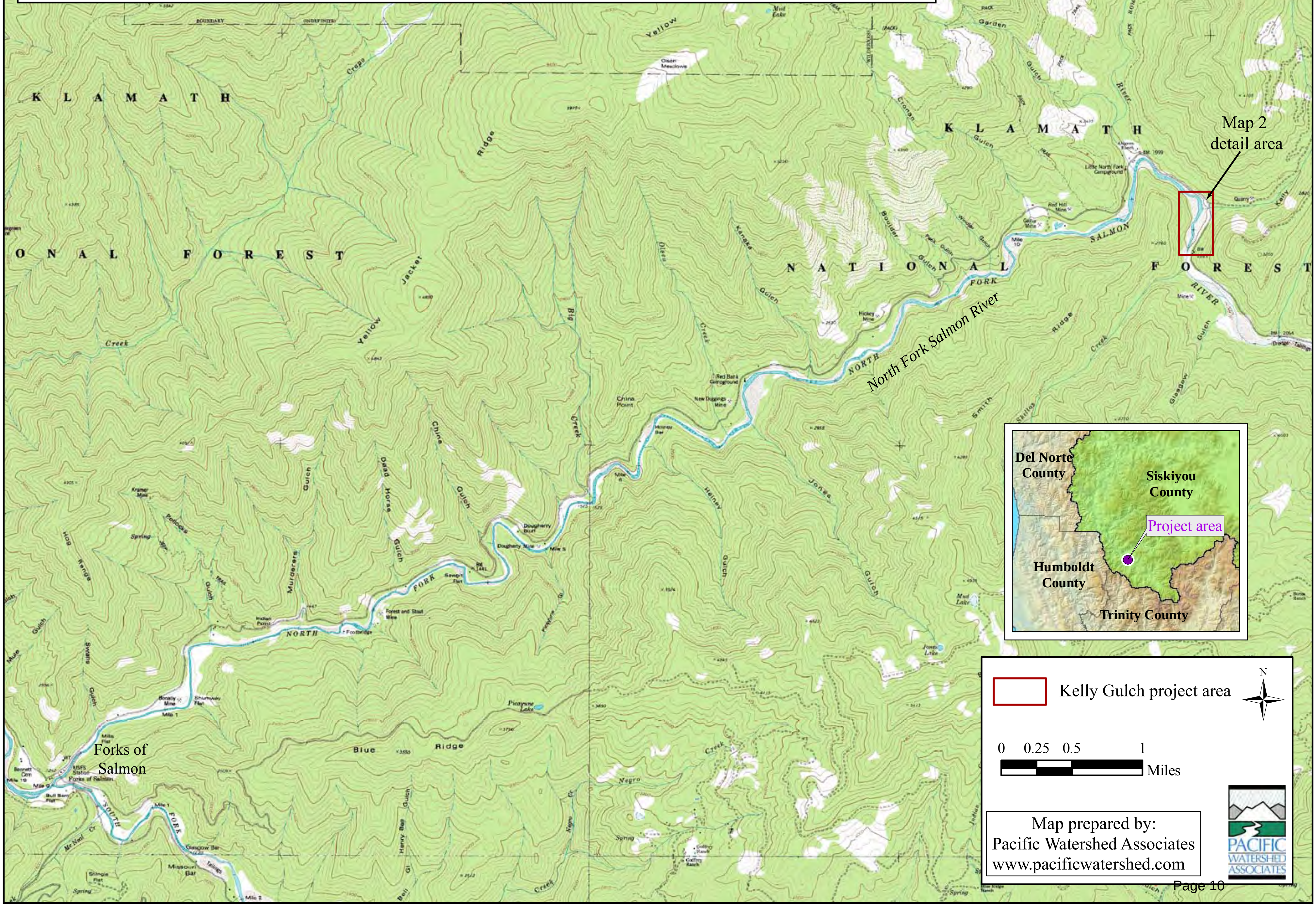
Map 3. Geologic Map of the Kelly Gulch Off-Channel Fisheries and Riparian Habitat Design Project, Siskiyou County, California

Figure 1a. Core logs KG-1 through KG-4 for the geologic investigation of the Kelly Gulch Off-Channel Fisheries and Riparian Habitat Design Project, Siskiyou County, California

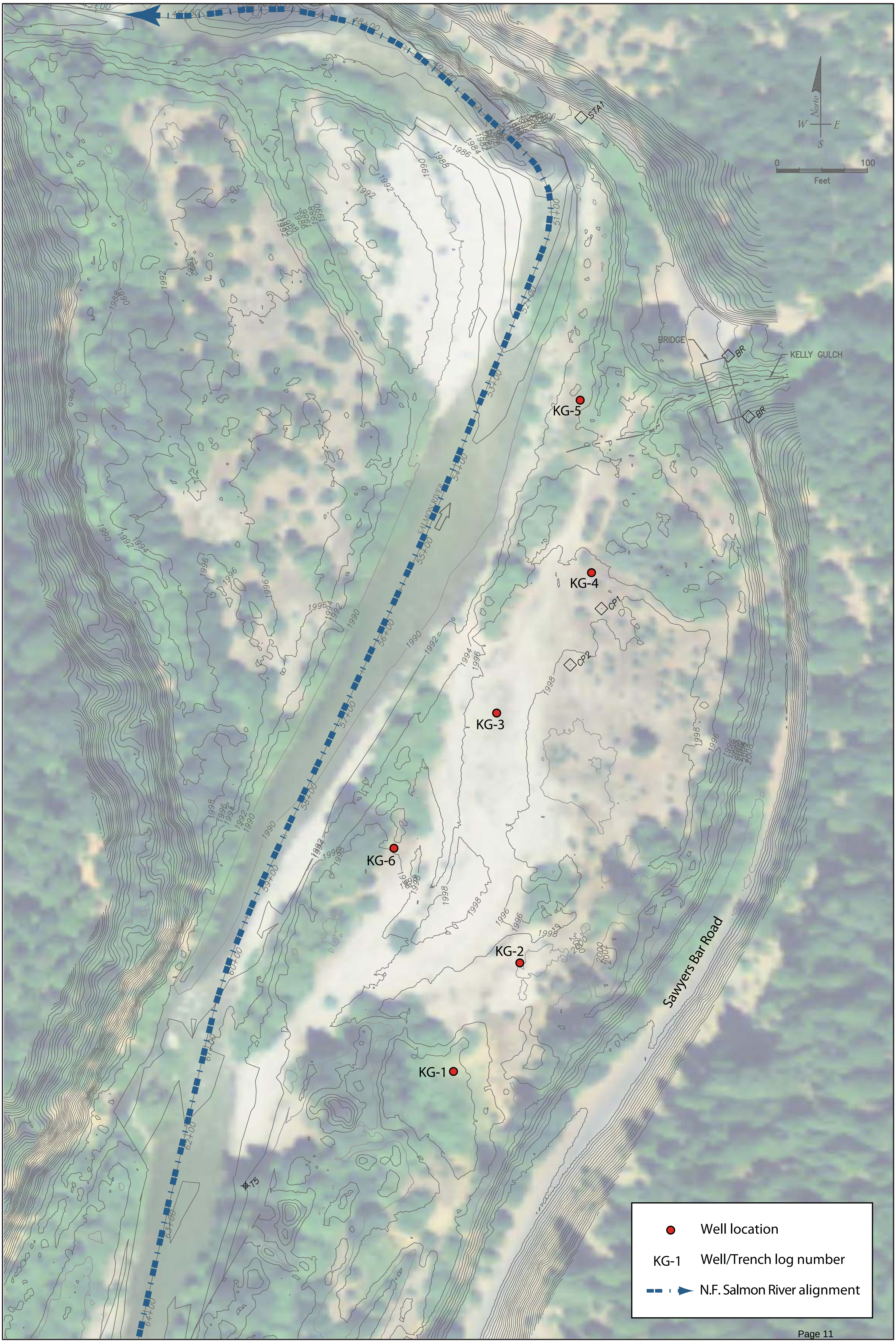
Figure 1b. Core logs KG-5 through KG-6 for the geologic investigation of Kelly Gulch Off-Channel Fisheries and Riparian Habitat Design Project, Siskiyou County, California

Figure 2. Groundwater monitoring well typical design used for the Kelly Gulch Off-Channel Fisheries and Riparian Habitat Design Project, Siskiyou County, California

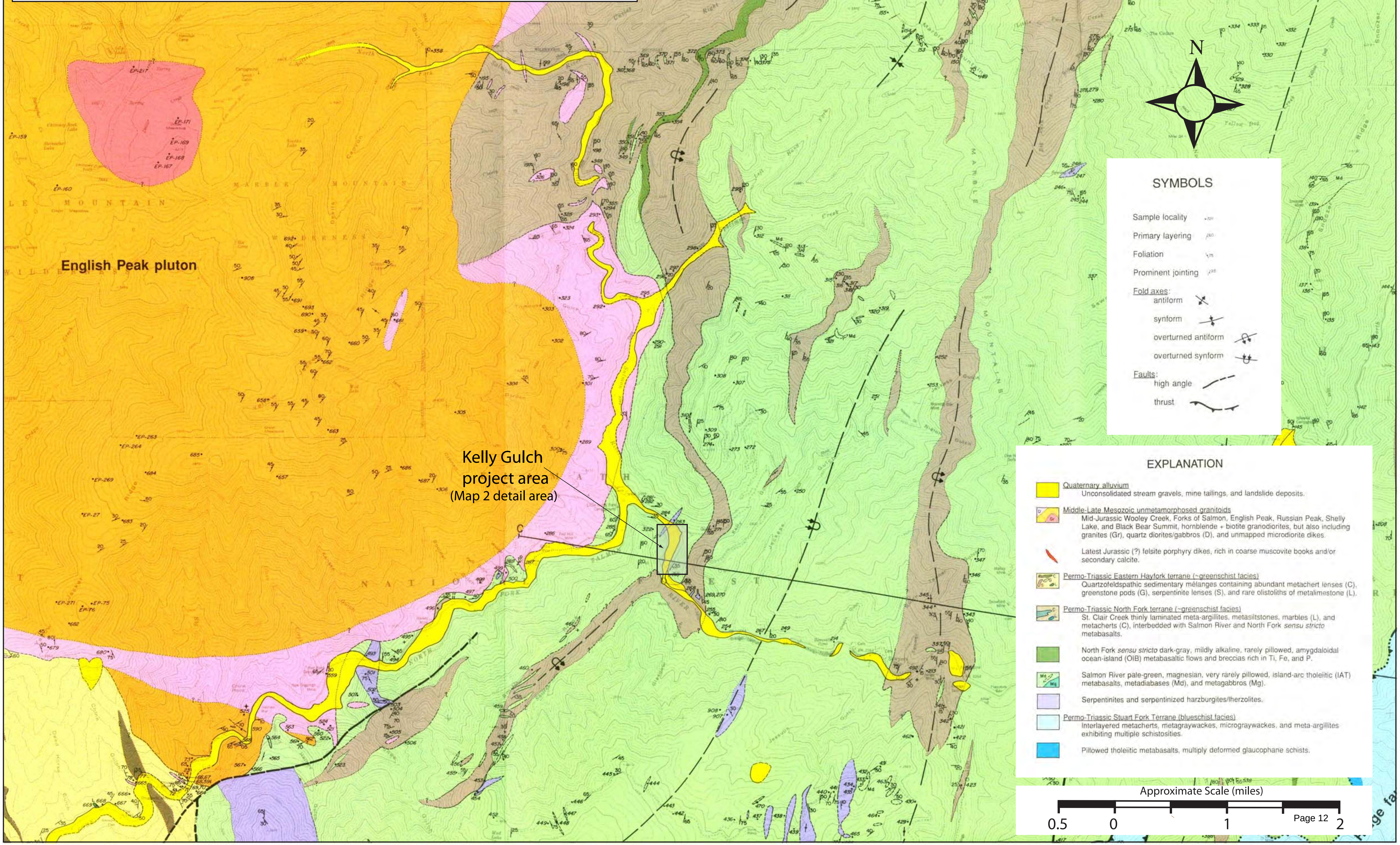
Map 1. General location map for the geologic investigation of the Kelly Gulch Off-Channel Fisheries and Riparian Habitat Design Project, Siskiyou County, California. Sawyers Bar USGS 7.5 Minute Quadrangle.



Map 2. Groundwater monitoring well and trench log locations for the geologic investigation of the Kelly Gulch Off-Channel Fisheries and Riparian Habitat Design Project, Siskiyou County California. Base mapping provided by Michael Love and Associates, 2014.



Map 3. Geologic map of the Kelly Gulch Off-Channel Fisheries and Riparian Habitat Design Project area. Map modified from California Division of Mines and Geology Map Sheet 47 (Ernst, 1998).



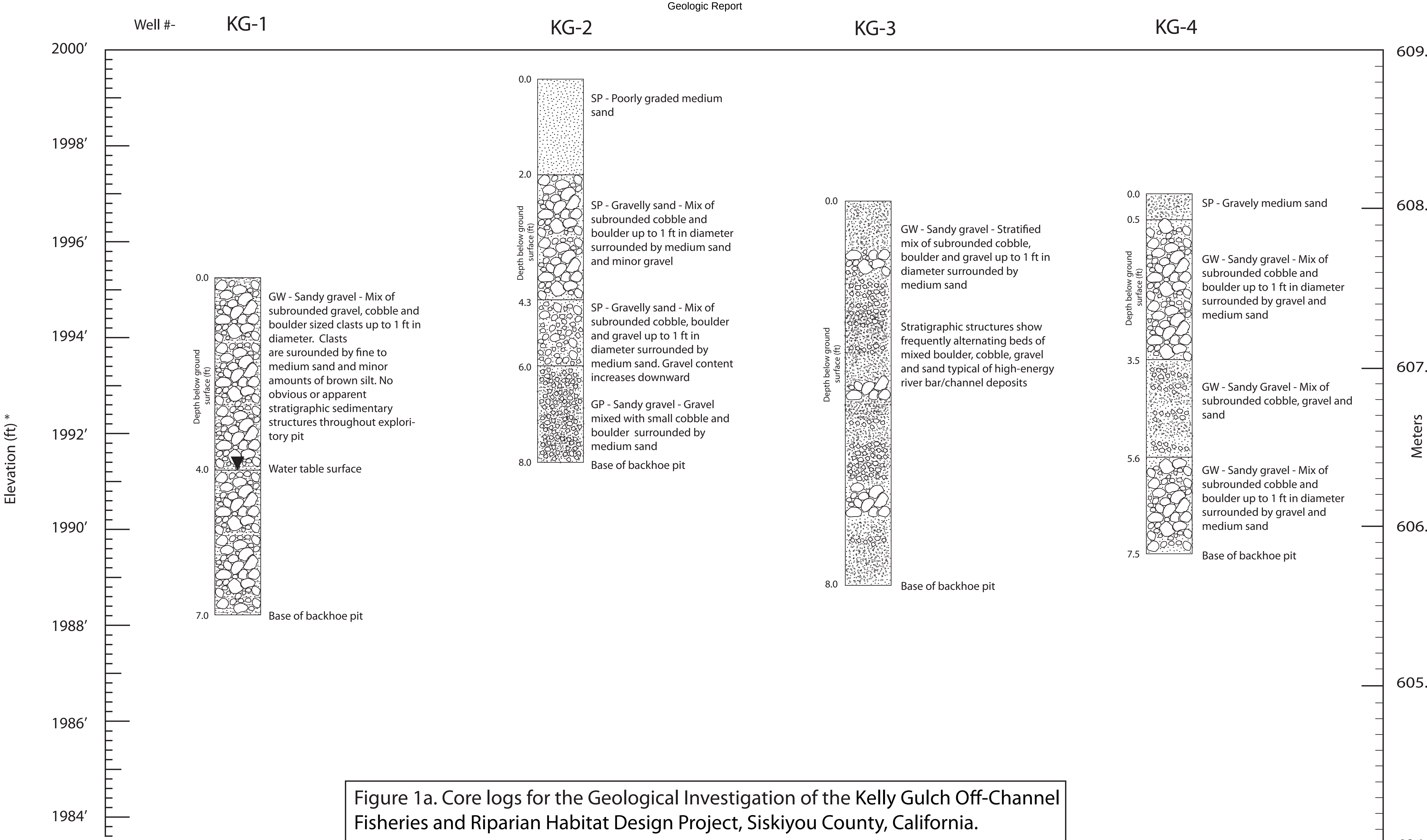


Figure 1a. Core logs for the Geological Investigation of the Kelly Gulch Off-Channel Fisheries and Riparian Habitat Design Project, Siskiyou County, California.

*Elevation in feet (NADV 1988) based on survey conducted by Michael Love and Associates, 2014

Note: Soil cores described using field classification method ASTM D 2488-00 (Visual-Manual Proceedure)

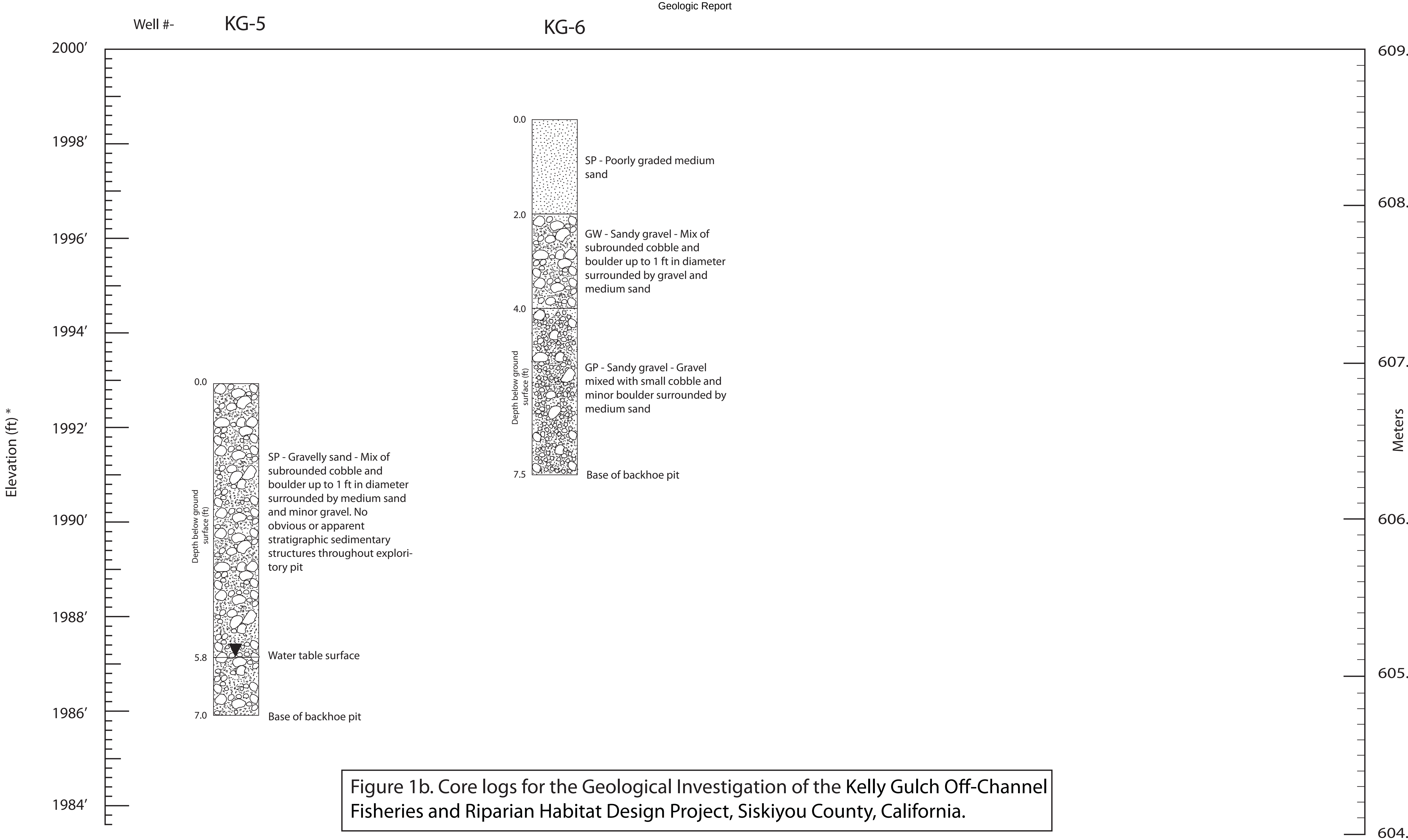
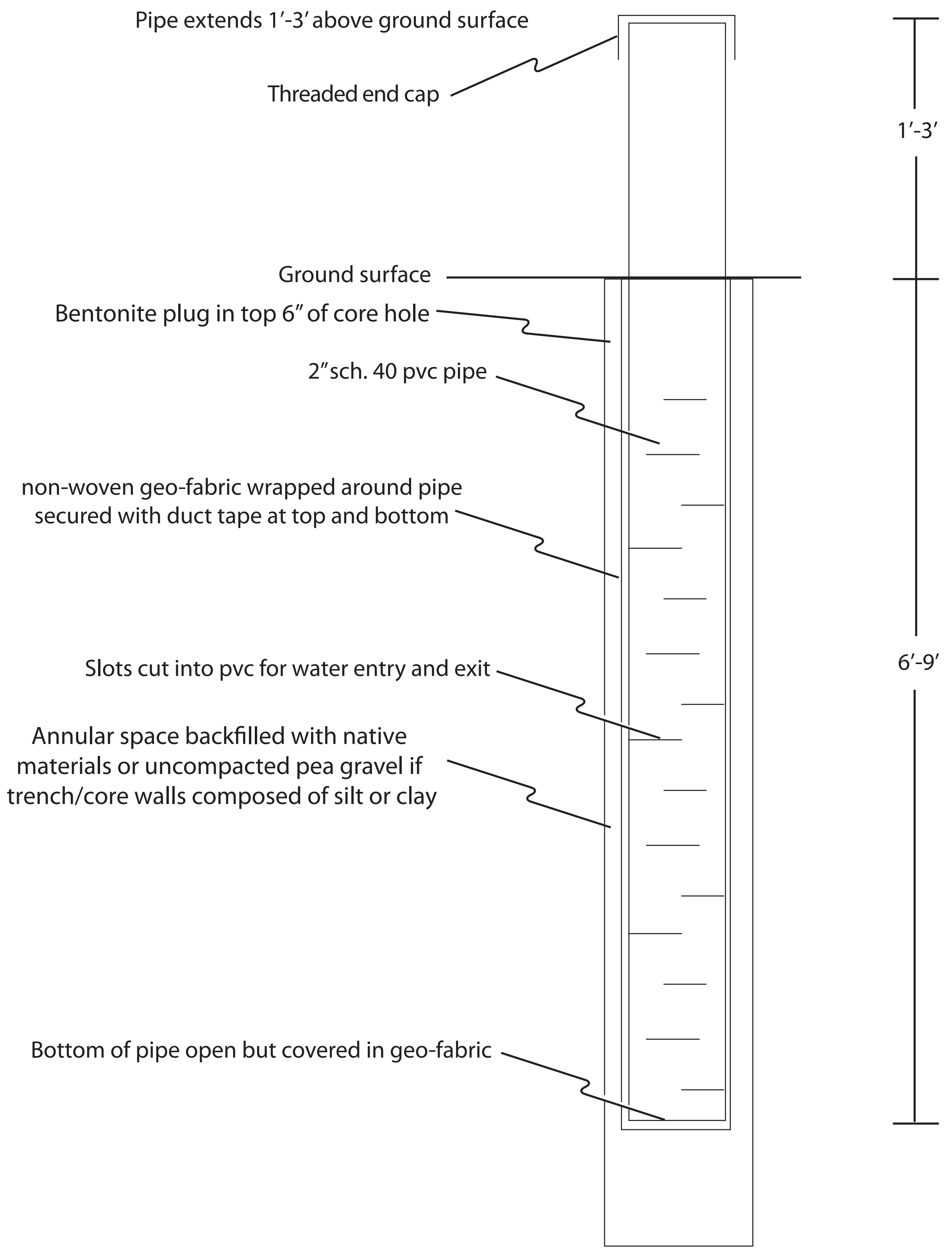


Figure 1b. Core logs for the Geological Investigation of the Kelly Gulch Off-Channel Fisheries and Riparian Habitat Design Project, Siskiyou County, California.

*Elevation in feet (NADV 1988) based on survey conducted by Michael Love and Associates, 2014

Note: Soil cores described using field classification method ASTM D 2488-00 (Visual-Manual Proceedure)

Figure 2. Groundwater monitoring well typical design used in the Kelly Gulch Off-Channel Fisheries and Riparian Habitat Design Project, Siskiyou County, CA



Drawing not to scale

Appendix C

Hydrology

Estimated Peak Flows on the NF Salmon River at Kelly Gulch and Kelly Gulch using (USGS, 1982).

NF Salmon Drainage Area at Kelly Gulch	145.8	square miles
DA of Kelly Gulch	1.6	square miles

Return Period	Flow/mi^2	NF Salmon at Kelly Gulch	Kelly Gulch
Years	**cfs/mi^2**	**cfs**	**cfs**
1.2	14	2,036	22
1.5	20	2,966	33
1.8	25	3,620	40
2	27	3,983	44
2.33	31	4,493	49
2.4	32	4,605	51
2.6	34	4,905	54
2.8	36	5,178	57
3	37	5,426	60
3.5	41	5,960	65
4	44	6,394	70
5	48	7,056	77
10	65	9,514	104
25	90	13,086	144
50	110	16,079	176
100	133	19,353	212

Data is based on averaged results of LPIII analyses of the Salmon River at Somes Bar (USGS Gage No. 11522500) and the South Fork of the Salmon River Near Forks (USGS Gage No. 11522300).

Flood Frequency based on Annual Maximum Series

USGS 11522500 SALMON R A SOMES BAR CA

Drainage area **751** mi^2

Generalized Skew=	**-0.3**		A=	-0.32804
Station Skewness (log Q)=	0.02		B=	0.93364
Station Mean (log Q)=	4.28		MSE (station skew) =	0.06234
Station Std Dev (log Q)=	0.30			
Weighted Skewness (Gw)=	**-0.03**			

Annual Maxima Series WY	Date of Peak	Discharge (cfs)	RANK	Recurrence Interval (years)	Discharge (cfs)	Discharge (cms)	Log-discharge (cfs)	
	2/17/1912	**23,800**	1	88.00	133000	3766.16	5.12	
	12/31/1913	**23,500**	2	44.00	84000	2378.63	4.92	
	2/1/1915	**17,400**	3	29.33	70800	2004.84	4.85	
	1927-02-00	**49,000**	4	22.00	67500	1911.40	4.83	
	3/26/1928	**21,200**	5	17.60	63500	1798.13	4.80	
	5/21/1929	**3,770**	6	14.67	56900	1611.24	4.76	
	3/18/1931	**7,250**	7	12.57	51700	1463.99	4.71	
	3/19/1932	**19,300**	8	11.00	49000	1387.53	4.69	
	6/10/1933	**7,750**	9	9.78	45900	1299.75	4.66	
	3/28/1934	**10,600**	10	8.80	42600	1206.30	4.63	
	4/29/1935	**5,880**	11	8.00	41300	1169.49	4.62	
	1/14/1936	**21,600**	12	7.33	39100	1107.19	4.59	
	4/13/1937	**19,400**	13	6.77	37100	1050.56	4.57	
	12/11/1937	**27,000**	14	6.29	34700	982.60	4.54	
	3/13/1939	**7,660**	15	5.87	34400	974.10	4.54	
	2/28/1940	**21,200**	16	5.50	33000	934.46	4.52	
	12/21/1940	**8,100**	17	5.18	32500	920.30	4.51	
	12/2/1941	**21,100**	18	4.89	32100	908.98	4.51	
	12/27/1942	**22,400**	19	4.63	32000	906.14	4.51	
	3/10/1944	**4,420**	20	4.40	31700	897.65	4.50	
	2/13/1945	**15,700**	21	4.19	30600	866.50	4.49	
	12/28/1945	**33,000**	22	4.00	27000	764.56	4.43	
	11/19/1946	**8,120**	23	3.83	26300	744.74	4.42	
	1/7/1948	**32,500**	24	3.67	25900	733.41	4.41	
	2/22/1949	**6,730**	25	3.52	25700	727.75	4.41	
	3/17/1950	**12,300**	26	3.38	25500	722.08	4.41	
	2/5/1951	**25,500**	27	3.26	24400	690.93	4.39	
	2/2/1952	**22,500**	28	3.14	23800	673.94	4.38	
	1/18/1953	**45,900**	29	3.03	23700	671.11	4.37	
	11/24/1953	**19,500**	30	2.93	23600	668.28	4.37	
	12/31/1954	**7,500**	31	2.84	23500	665.45	4.37	
	12/22/1955	**84,000**	32	2.75	22700	642.80	4.36	
	2/26/1957	**22,700**	33	2.67	22500	637.13	4.35	
	1/29/1958	**34,400**	34	2.59	22400	634.30	4.35	
	1/12/1959	**21,000**	35	2.51	21700	614.48	4.34	
	2/8/1960	**25,900**	36	2.44	21600	611.65	4.33	
	2/11/1961	**16,700**	37	2.38	21600	611.65	4.33	
	12/19/1961	**13,100**	38	2.32	21200	600.32	4.33	
	12/2/1962	**37,100**	39	2.26	21200	600.32	4.33	
	1/20/1964	**19,300**	40	2.20	21100	597.49	4.32	
	12/22/1964	**133,000**	41	2.15	21000	594.66	4.32	
	1/6/1966	**23,600**	42	2.10	21000	594.66	4.32	
	1/29/1967	**21,000**	43	2.05	20800	588.99	4.32	
	2/23/1968	**32,100**	44	2.00	20600	583.33	4.31	
	1/21/1969	**21,700**	45	1.96	20400	577.67	4.31	
	1/22/1970	**42,600**	46	1.91	20200	572.00	4.31	
	1/18/1971	**51,700**	47	1.87	19500	552.18	4.29	
	3/2/1972	**56,900**	48	1.83	19400	549.35	4.29	
	1/13/1973	**10,900**	49	1.80	19300	546.52	4.29	
	1/16/1974	**63,500**	50	1.76	19300	546.52	4.29	
	3/18/1975	**20,400**	51	1.73	19300	546.52	4.29	
	11/15/1975	**10,500**	52	1.69	18800	532.36	4.27	
	9/29/1977	**1,810**	53	1.66	17600	498.38	4.25	
	12/14/1977	**31,700**	54	1.63	17400	492.72	4.24	
	1/11/1979	**14,700**	55	1.60	16700	472.89	4.22	
	1/12/1980	**30,600**	56	1.57	16000	453.07	4.20	
	12/2/1980	**12,900**	57	1.54	15700	444.58	4.20	
	12/19/1981	**41,300**	58	1.52	15300	433.25	4.18	
	12/16/1982	**25,700**	59	1.49	15100	427.59	4.18	
	12/14/1983	**17,600**	60	1.47	14700	416.26	4.17	
	11/12/1984	**14,600**	61	1.44	14600	413.43	4.16	
	2/18/1986	**39,100**	62	1.42	13700	387.94	4.14	
	3/12/1987	**7,560**	63	1.40	13200	373.78	4.12	
	12/10/1987	**20,200**	64	1.38	13100	370.95	4.12	
	11/22/1988	**24,400**	65	1.35	12900	365.29	4.11	
	1/8/1990	**20,600**	66	1.33	12300	348.30	4.09	
	3/4/1991	**5,830**	67	1.31	12200	345.47	4.09	
	4/17/1992	**8,660**	68	1.29	10900	308.66	4.04	
	3/17/1993	**20,800**	69	1.28	10900	308.66	4.04	
	12/8/1993	**3,210**	70	1.26	10900	308.66	4.04	
	1/31/1995	**32,000**	71	1.24	10800	305.82	4.03	
	12/30/1995	**19,300**	72	1.22	10600	300.16	4.03	
	1/1/1997	**70,800**	73	1.21	10500	297.33	4.02	
	3/23/1998	**34,700**	74	1.19	8660	245.23	3.94	
	11/21/1998	**15,300**	75	1.17	8120	229.93	3.91	
	2/14/2000	**10,900**	76	1.16	8100	229.37	3.91	
	5/15/2001	**4,180**	77	1.14	7750	219.46	3.89	
	1/6/2002	**13,200**	78	1.13	7660	216.91	3.88	
	12/28/2002	**23,700**	79	1.11	7560	214.08	3.88	
	2/17/2004	**18,800**	80	1.10	7500	212.38	3.88	
	12/9/2004	**13,700**	81	1.09	7250	205.30	3.86	
	12/30/2005	**67,500**	82	1.07	6730	190.57	3.83	
	12/13/2006	**16,000**	83	1.06	5880	166.50	3.77	
	10/19/2007	**10,800**	84	1.05	5830	165.09	3.77	
	5/5/2009	**10,900**	85	1.04	4420	125.16	3.65	
	6/4/2010	**15,100**	86	1.02	4180	118.37	3.62	
	3/16/2011	**12,200**	87	1.01	3770	106.76	3.58	
	3/30/2012	**21,600**	88	1.00	3210	90.90	3.51	Outlier discarded
	12/2/2012	**26,300**	89	0.99	1810	51.25	3.26	Outlier discarded

Sample Size, n =	**87**		
Skewness =	2.80	2.80	0.02
Mean=	24217	686	4.28
Std Dev=	19478	552	0.298
Outliers			
Kn=	**2.970**		
Q-low =	**2483 cfs**		
Q-high =	**147,134 cfs**		

Log Pearson Type III Distribution

Return Period (years)	**Exceedence Probability**	**Log-Pearson K**	**Predicicted Discharge (cfs)**	**Discharge/Mi^2 (cfs/mi^2)**
1.2	0.833	-0.98824	9,691	13
1.5	0.667	-0.42987	14,224	19
1.8	0.556	-0.13574	17,410	23
2.0	0.500	0.00516	19,181	26
2.33	0.429	0.18232	21,664	29
2.4	0.417	0.21841	22,208	30
2.6	0.385	0.31080	23,663	32
2.8	0.357	0.39000	24,987	33
3	0.333	0.45864	26,194	35
3.5	0.286	0.59592	28,785	38
4	0.250	0.69887	30,896	41
5.0	0.200	0.84301	34,113	45
10	0.100	1.27808	46,000	61
25	0.040	1.73985	63,179	84
50	0.020	2.03697	77,491	103
100	0.010	2.30343	93,063	124

Values From K-Table for Linear interpolation

Weighted Skewness =	-0.10	0.00	-0.03	
P	K	K	K	Return Period (Years)
0.9	-1.29178	-1.28155	-1.28473	1.1
0.8	-0.83639	-0.84162	-0.84000	1.3
0.7	-0.51207	-0.52440	-0.52057	1.4
0.6	-0.23763	-0.25335	-0.24847	1.7
0.500	0.01662	0.00000	0.00516	2.0
0.429	0.19339	0.17733	0.18232	2.3
0.200	0.84611	0.84162	0.84301	5.0
0.100	1.27037	1.28155	1.27808	10.0
0.040	1.71580	1.75069	1.73985	25.0
0.020	1.99973	2.05375	2.03697	50.0
0.010	2.25258	2.32635	2.30343	100.0

Flood Frequency based on Annual Maximum Series

USGS 11522300 SF SALMON R NR FORKS OF SALMON CA

Drainage area **252** mi^2

Annual Maxima Series WY	Date of Peak	Discharge (cfs)	RANK	Recurrence Interval (years)	Discharge (cfs)	Discharge (cms)	Log-discharge (cfs)	
	12/22/1964	**31400**	1	26.00	31,400	889.15	4.50	
	12/22/1955	**24200**	2	13.00	24,200	685.27	4.38	
	1/16/1974	**18400**	3	8.67	18,400	521.03	4.26	
	3/2/1972	**13100**	4	6.50	13,100	370.95	4.12	
	1/22/1970	**12700**	5	5.20	12,700	359.63	4.10	
	1/17/1971	**12500**	6	4.33	12,500	353.96	4.10	
	12/2/1962	**10600**	7	3.71	10,600	300.16	4.03	
	2/23/1968	**9290**	8	3.25	9,290	263.06	3.97	
	1/20/1964	**8110**	9	2.89	8,110	229.65	3.91	
	1/29/1958	**7970**	10	2.60	7,970	225.69	3.90	
	3/18/1975	**7750**	11	2.36	7,750	219.46	3.89	
	1/12/1959	**7690**	12	2.17	7,690	217.76	3.89	
	1/4/1966	**7590**	13	2.00	7,590	214.93	3.88	
	1/29/1967	**7360**	14	1.86	7,360	208.41	3.87	
	2/8/1960	**7330**	15	1.73	7,330	207.56	3.87	
	2/11/1961	**5630**	16	1.63	5,630	159.42	3.75	
	11/24/1953	**5400**	17	1.53	5,400	152.91	3.73	
	1/20/1969	**4840**	18	1.44	4,840	137.05	3.68	
	11/15/1975	**4420**	19	1.37	4,420	125.16	3.65	
	1/13/1973	**3470**	20	1.30	3,470	98.26	3.54	
	12/19/1961	**3230**	21	1.24	3,230	91.46	3.51	
	12/31/1954	**2800**	22	1.18	2,800	79.29	3.45	
	12/14/1977	**2630**	23	1.13	2,630	74.47	3.42	
	2/26/1957	**2600**	24	1.08	2,600	73.62	3.41	
	5/26/1977	**360**	25	1.04	360	10.19	2.56	Outlier discarded

Sample Size, n =	**25**		
Skewness =	1.89	1.89	0.27
Mean=	9209	261	4
Std Dev=	6992	198	0.292
Outliers			
Kn=	**2.486**		
Q-low =	**1382 cfs**		
Q-high =	**39,152 cfs**		

Generalized Skew=	**-0.3**	A=	-0.30838
Station Skewness (log Q)=	0.27	B=	0.86975
Station Mean (log Q)=	3.87	MSE (station skew) =	0.22157
Station Std Dev (log Q)=	0.29		
Weighted Skewness (G_W)=	**0.03**		

Log Pearson Type III Distribution

Return Period (years)	**Exceedence Probability**	**Log-Pearson K**	**Predicicted Discharge (cfs)**	**Discharge/Mi^2 (cfs/mi^2)**
1.2	0.833	-0.98805	3,785	15
1.5	0.667	-0.43782	5,480	22
1.8	0.556	-0.14537	6,671	26
2.0	0.500	-0.00480	7,332	29
2.33	0.429	0.17264	8,262	33
2.4	0.417	0.20910	8,467	34
2.6	0.385	0.30244	9,015	36
2.8	0.357	0.38245	9,514	38
3	0.333	0.45179	9,968	40
3.5	0.286	0.59048	10,942	43
4	0.250	0.69449	11,735	47
5.0	0.200	0.84011	12,943	51
10	0.100	1.28451	17,451	69
25	0.040	1.76050	24,036	95
50	0.020	2.06913	29,580	117
100	0.010	2.34752	35,671	142

Values From K-Table for Linear interpolation

Weighted Skewness =	0.00	0.10	0.03	
P	K	K	K	Return Period (Years)
0.9	-1.28155	-1.27037	-1.27832	1.1
0.8	-0.84162	-0.84611	-0.84292	1.3
0.7	-0.52440	-0.53624	-0.52782	1.4
0.6	-0.25335	-0.26882	-0.25782	1.7
0.500	0.00000	-0.01662	-0.00480	2.0
0.429	0.17733	0.16111	0.17264	2.3
0.200	0.84162	0.83639	0.84011	5.0
0.100	1.28155	1.29178	1.28451	10.0
0.040	1.75069	1.78462	1.76050	25.0
0.020	2.05375	2.10697	2.06913	50.0
0.010	2.32635	2.39961	2.34752	100.0

Exceedence flows for North Fork of the Salmon River at Kelly Gulch and Kelly Gulch.

Percent Time Flow is Equalled or Exceeded	SF Salmon River at Kelly Gulch	Kelly Gulch
	Annual Exceedance Flow	Annual Exceedance Flows
	cfs	cfs
1%	2366.2	26.0
2%	1522.3	16.7
5%	970.5	10.7
10%	731.7	8.0
15%	599.9	6.6
20%	516.6	5.7
25%	452.8	5.0
30%	390.2	4.3
35%	338.2	3.7
40%	293.7	3.2
45%	247.8	2.7
50%	197.0	2.2
55%	151.3	1.7
60%	117.9	1.3
65%	90.8	1.0
70%	67.1	0.7
75%	50.9	0.6
80%	41.5	0.5
85%	34.3	0.4
90%	29.6	0.3
95%	26.4	0.3
98%	22.9	0.3
99.5%	21.6	0.2
99.8%	21.3	0.2

Data is based on averaged results of LPIII analyses of the Salmon River at Somes Bar (USGS Gage No. 11522500) and the South Fork of the Salmon River Near Forks (USGS Gage No. 11522300).

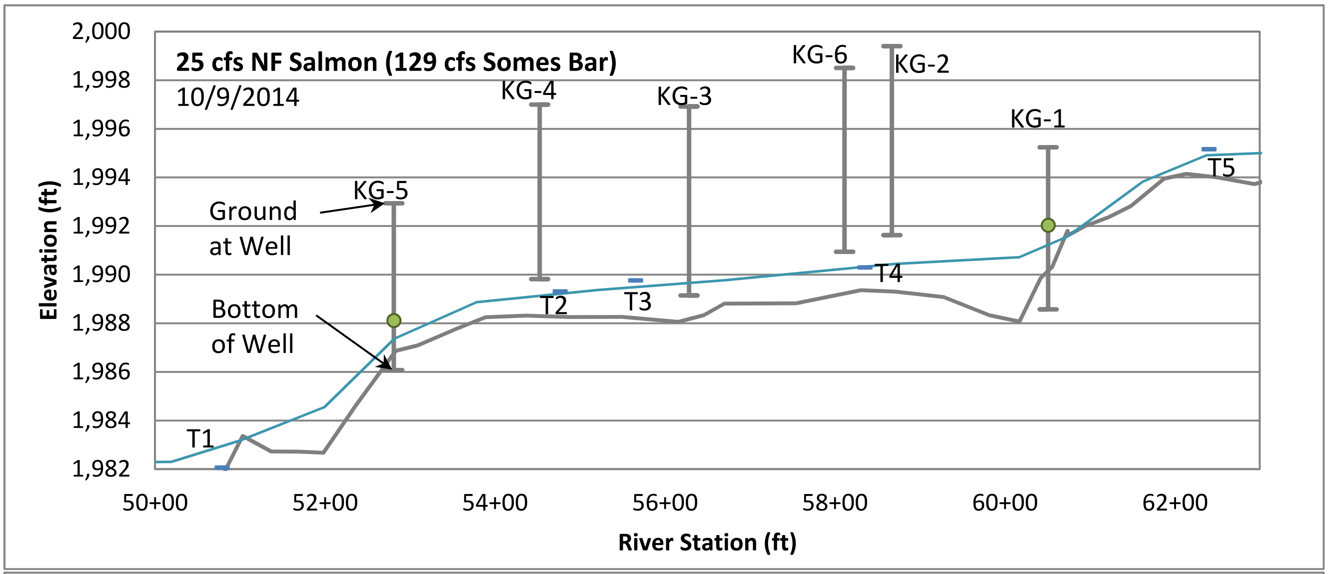
USGS 11522500 SALMON R A SOMES BAR CA												
00060, Discharge, cubic feet per second,												
YEAR	**Monthly mean in ft3/s (Calculation Period: 1911-10-01 -> 2015-03-31)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1911										217.3	298.7	289.9
1912	3,590	3,942	1,539	1,608	4,994	3,223	765.4	341.6	403.8	298.2	2,203	1,583
1913	1,977	2,002	1,737	3,209	4,346	2,400	843.4	350.9	276.8	351.3	1,100	1,499
1914	6,834	4,000	4,500	4,500	4,500	3,500	900	328	227.5	1,170	900	1,100
1915	1,753	4,754	3,740	5,236	4,377	3,610	1,152	352.5	210.1			
1927										240	1,300	928.3
1928	1,600	1,850	3,380	4,127	3,000	966.7	355	177.7	166.6	211.5	488.2	791.1
1929	936.1	790.5	1,050	1,447	2,256	1,300	300	142.5	113.1	150	150	2,800
1930	1,000	2,500	2,300	1,707	1,162	583.3	206.4	118.3	116.4	132.9	296.7	373.2
1931	788.5	767.6	1,982	1,681	1,083	433.1	146	81.6	83.1	274.9	499	869.1
1932	1,389	1,116	3,769	2,667	3,739	2,090	510.5	196.9	120.6	138.7	391.2	509.7
1933	671.5	820	2,315	3,015	3,106	4,214	1,091	299.8	211.5	212.6	232.9	886.2
1934	2,061	1,137	1,878	1,482	877.1	426.9	189.6	117.7	106.9	312.3	1,745	1,436
1935	1,665	2,418	1,745	3,538	3,573	1,663	451.5	205.7	155	208.4	293	603.8
1936	4,727	2,536	2,566	2,947	2,771	1,442	490.1	196.7	139.4	117.6	129.9	175.5
1937	190.2	542.4	1,842	4,590	4,535	3,001	729.1	229.2	153.3	291.1	3,051	3,782
1938	3,021	4,105	5,668	5,741	6,174	3,750	1,046	321.5	192	269.4	679.5	1,266
1939	813	1,227	2,950	2,518	1,599	737	270.2	129.5	113.7	141.7	139.3	1,332
1940	2,374	4,504	4,872	3,706	2,445	1,014	339.9	164.7	197	309.5	537.3	1,829
1941	2,482	2,560	2,482	2,969	4,161	2,140	916.6	360.8	267.5	213.3	559.1	4,165
1942	2,928	3,661	1,473	1,878	3,162	2,646	823.4	296.2	193.8	187.5	2,185	5,290
1943	5,440	3,569	2,857	3,626	2,662	1,810	650	312.8	217.4	386.9	639.7	510
1944	838.3	1,083	1,535	1,426	2,155	1,161	393.5	199.5	144.1	159.9	1,005	1,149
1945	1,725	4,098	1,955	2,826	3,622	1,565	475.9	217.7	161.3	253.8	1,622	4,402
1946	3,982	2,072	2,885	3,287	3,777	1,831	650.4	230.3	178	229.8	1,108	956.2
1947	642.8	1,912	2,645	2,342	1,525	901.5	294.1	172.1	133.2	757.5	622.4	477.9
1948	3,899	1,637	1,540	3,224	3,757	3,198	821.6	302.1	239.6	286.6	609.2	1,516
1949	738.5	1,552	2,493	3,383	3,305	1,308	380.3	186.1	141.7	190.6	390.8	375.6
1950	2,254	2,293	4,026	3,511	3,603	1,960	589.6	227.1	180	1,846	3,043	5,525
1951	3,782	5,791	2,219	3,432	2,546	1,155	382.2	194.1	155.4	388.2	1,325	3,904
1952	1,979	5,494	3,093	5,429	5,477	3,382	1,331	406.2	239.4	195.4	233.7	1,228
1953	8,041	3,604	2,138	3,173	4,223	4,354	1,906	565.4	312.6	362.8	2,033	2,139
1954	3,788	5,059	3,817	4,142	2,935	1,417	571.6	272.5	232.1	223.3	500.1	753.7
1955	897.6	836.5	878.5	1,242	2,489	1,294	334.3	157	144.1	174.7	949	8,465
1956	8,090	3,238	3,008	3,909	4,338	2,559	902.7	289	189.8	507.3	783.2	1,234
1957	747	2,804	5,035	3,029	3,189	1,480	469.3	212.4	196.6	871.3	1,961	3,033
1958	4,832	11,190	3,215	3,666	5,106	2,695	839.8	355.5	240.4	206.4	578	548.8
1959	3,296	2,576	2,369	3,260	2,021	1,127	347.5	179.3	189.5	183.7	160	197.8
1960	391.7	2,595	3,034	2,756	3,254	2,316	452	214.3	160.9	174.7	945	1,543
1961	766.1	3,991	3,475	3,089	3,045	2,298	472.2	226.4	169.5	237.9	599.7	1,661
1962	951.4	2,305	1,978	3,471	2,265	1,554	454.7	320	180	2,297	2,025	3,980
1963	979.4	4,923	1,782	5,115	4,730	1,680	598.7	297.6	218.4	414.3	2,483	1,303
1964	3,045	2,564	1,695	2,187	2,337	1,708	504.2	238	167.7	157.5	686.9	10,480
1965	5,813	3,114	1,897	3,522	2,808	1,406	447.6	269	190.9	186.4	520.8	579.9
1966	3,029	1,227	2,932	4,321	3,379	1,285	478.3	223.3	185.2	167.8	877.2	2,397
1967	2,836	2,405	2,059	1,681	4,333	2,755	836.4	303.7	213.6	300.8	352.2	698.7
1968	2,100	5,137	2,461	1,572	1,559	852	315.1	250.9	178.9	315	1,249	2,110
1969	4,833	2,652	2,259	3,972	6,081	2,778	698.1	281.6	200.5	296.6	362.5	2,854
1970	11,260	3,021	2,787	1,328	2,370	1,268	387.5	209.5	151.3	182.1	4,388	3,875
1971	9,489	2,902	5,631	3,786	4,907	3,498	1,247	381.7	293.7	342.2	1,212	1,800
1972	5,164	3,266	9,615	2,940	2,826	1,760	537.5	290.1	204.6	204	367.9	1,983
1973	2,751	1,829	1,666	2,193	2,557	898.9	325.7	168.9	237.8	768.2	5,961	6,806
1974	9,036	3,268	5,323	4,925	4,005	3,304	1,024	355.9	207.7	181.5	274.5	717.6
1975	1,643	3,379	4,838	3,233	5,077	4,032	1,260	399.1	223.6	620.5	1,725	2,025
1976	1,645	1,843	2,259	1,956	2,321	1,077	421.6	426.9	227.6	190.5	218.7	186.6
1977	218.2	254.9	448.3	710	786.3	603	152.2	97.5	205.8	270.7	1,747	4,566
1978	3,743	2,971	2,688	2,558	2,357	1,759	754.4	281.8	498.9	206	256.3	571

USGS 11522500 SALMON R A SOMES BAR CA												
	00060, Discharge, cubic feet per second,											
YEAR	**Monthly mean in ft3/s (Calculation Period: 1911-10-01 -> 2015-03-31)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1979	1,180	1,331	2,466	1,884	3,046	940.3	380.5	205.5	190.2	745.9	1,722	2,001
1980	5,409	3,211	2,896	2,707	2,397	1,376	621.1	236.8	192.3	206.5	374.9	2,320
1981	1,223	2,602	1,681	1,676	1,260	704.8	272.6	151.3	149.1	457.3	3,519	7,686
1982	3,452	7,840	3,369	4,544	4,294	2,356	875.6	336.7	234.3	606.2	1,185	4,505
1983	3,465	5,905	6,065	4,211	5,298	4,280	1,777	838.6	527.8	322.4	3,270	6,921
1984	3,091	2,916	3,839	2,971	3,893	2,023	678.9	309.2	236.9	414.1	3,550	1,727
1985	968.8	1,853	1,258	3,271	1,926	1,167	344.6	198	216.5	341.3	463.1	944
1986	2,561	9,140	5,458	2,174	2,070	1,156	371.6	188.6	323.6	412.3	521.4	631.1
1987	1,349	2,163	2,492	2,334	1,709	570.2	249.6	144.6	126.3	117.3	198.5	2,412
1988	2,222	1,489	1,206	1,232	1,468	1,704	444.2	219.8	156.2	152.6	1,894	1,304
1989	1,799	1,761	5,241	3,998	2,117	1,242	449.4	259.8	231.3	436.1	375.8	555.6
1990	1,825	1,245	2,313	1,730	1,734	1,974	454.3	260	206.1	204	252.4	331.3
1991	733.8	940.5	1,420	1,437	1,566	869.8	332.6	173.7	139.3	153.8	328.2	557.2
1992	539.5	1,450	1,119	2,312	990.4	401.6	246.6	116.2	102.5	172.3	640	1,002
1993	2,246	2,041	4,695	4,474	5,296	3,808	931.3	404.4	241.4	237.4	214.7	585.3
1994	1,119	891.3	1,253	1,209	1,351	508.5	212.6	121.8	103.6	123.6	372.4	905
1995	5,283	5,675	6,053	4,374	4,308	3,159	1,296	407.5	245.5	208.5	273.8	3,562
1996	4,122	6,113	3,882	4,057	4,056	1,787	695.3	306.2	253	338.2	1,491	7,662
1997	8,139	2,639	1,979	2,429	1,866	969.6	471.8	265.6	260.1	433.2	870.9	1,253
1998	6,066	4,955	6,508	3,930	4,141	4,105	1,576	445.9	247.7	256.6	2,178	2,717
1999	3,219	4,286	3,807	3,297	4,201	2,976	883.5	376.5	228.5	239	624.6	848.7
2000	2,685	3,068	2,759	2,996	2,552	1,466	453.5	217.9	184.2	212.1	290	389.6
2001	361.9	434.3	1,071	1,074	1,282	408	186.3	91.7	80.2	102.4	736.9	2,143
2002	3,453	2,509	1,966	3,010	2,027	1,127	359.2	171	124.8	122.3	408.1	3,085
2003	5,294	2,553	3,471	3,594	3,954	2,247	608.6	300.1	194.6	163.5	294.7	1,658
2004	2,352	3,627	3,618	3,133	2,743	1,444	543.4	252.8	165.5	321	317.2	1,768
2005	1,652	1,352	1,688	2,845	4,345	1,942	763.6	296.4	192.8	214.5	1,093	8,663
2006	9,539	5,791	2,877	3,662	4,665	2,304	767.8	334.7	203.1	189.7	1,051	3,784
2007	2,375	1,978	3,896	2,443	2,204	860.9	352.3	183.5	141.6	738.5	698.3	1,451
2008	2,209	2,480	2,806	2,558	4,140	1,768	521.2	231	149.9	209.1	747.8	924.5
2009	1,835	1,578	2,782	2,205	2,891	985.2	347.6	181.1	126.6	246	404.4	708.7
2010	2,363	1,837	2,042	3,470	3,567	4,339	1,114	367.2	269.6	661.1	1,273	4,122
2011	3,148	1,630	4,147	4,656	3,713	4,051	1,603	457.9	232.6	379.5	469.3	576.5
2012	2,260	1,434	3,944	5,317	3,423	1,490	572.6	259.9	175.9	223.4	869.9	3,649
2013	1,693	1,373	1,775	2,578	1,387	635.7	279.8	177.5	313.7	318.9	266.3	268.2
2014	315.2	2,398	3,461	1,526	892.8	388.2	206.7	133.5	133	550.6	1,005	3,177
2015	1,638	4,529	1,329	*1060*	*696*	*443*	*244*	*154*	-	-	-	-
Mean of Monthly Discharge	2,920	2,900	2,920	3,010	3,100	1,900	621	261		341	1,040	2,230
Min. Monthly Dischage	190	255	448	710	696	388	146	82	80	102	130	176
Max. Monthly Dischage	11,260	11,260	11,260	11,260	11,260	11,260	11,260	11,260	11,260	11,260	11,260	11,260
2014-2015 WY % of Historical Mean	56%	156%	46%	35%	22%	23%	39%	59%	-	161%	97%	142%

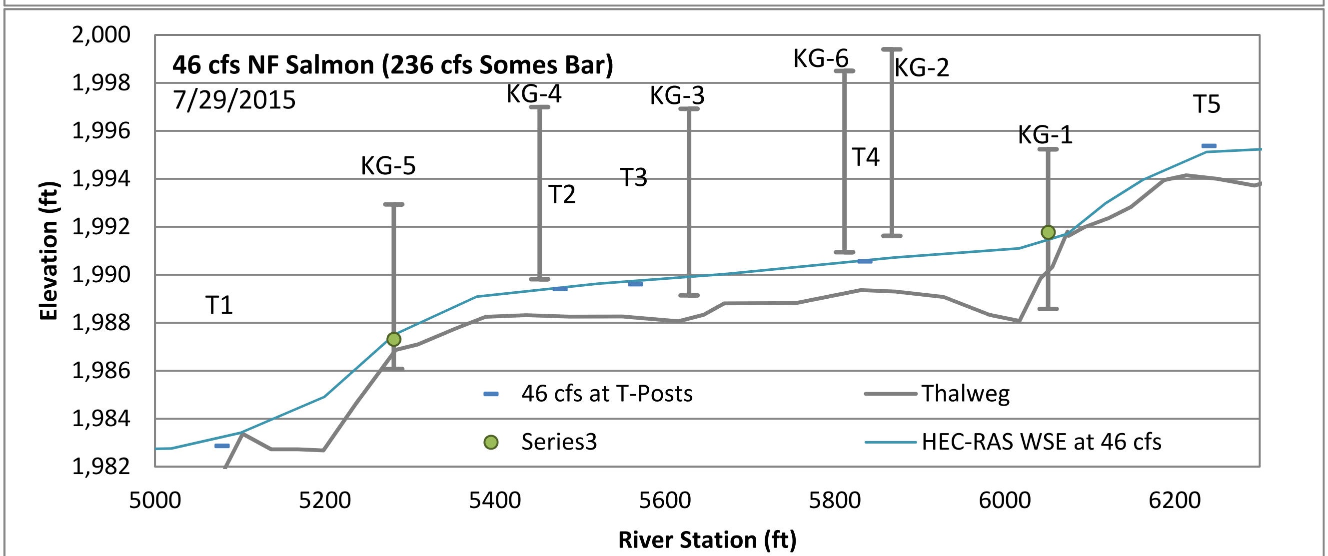
** Italicized values computed by MLA from 15-minute provisional data*

Appendix D

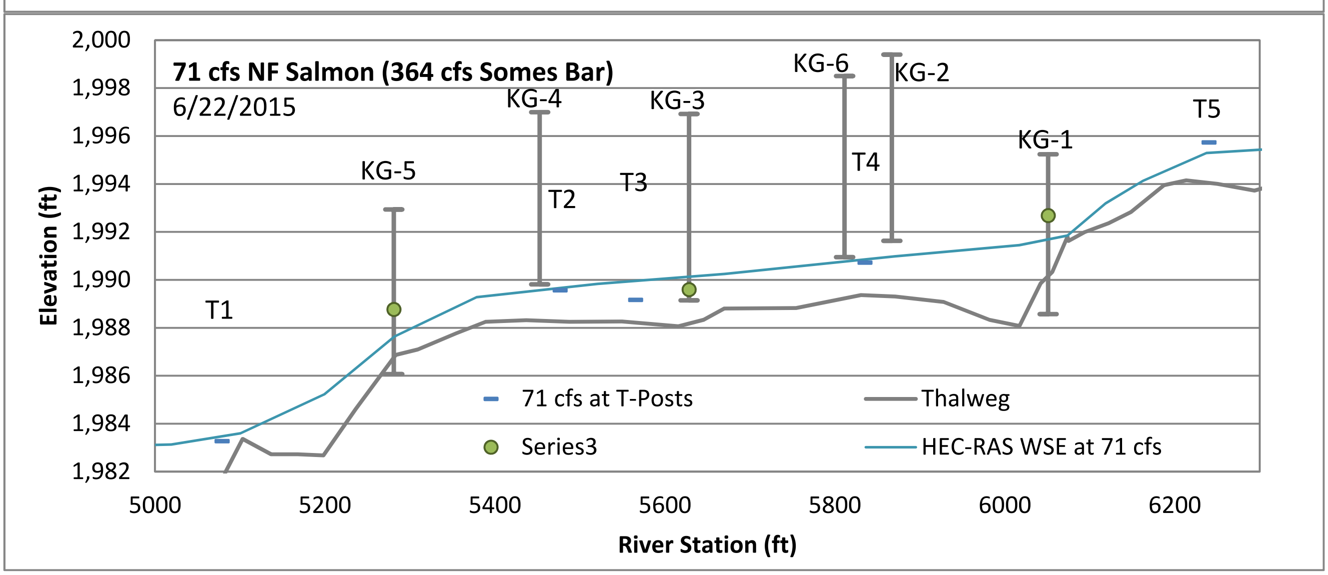
Groundwater and Surface Water Monitoring Results



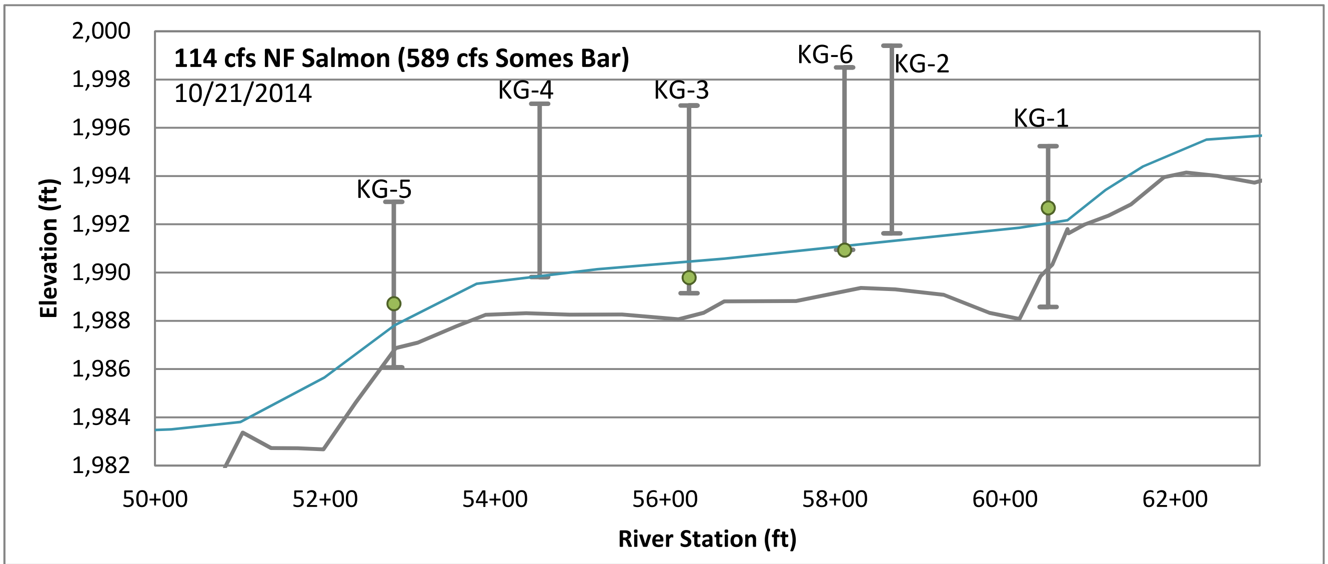
25 cfs NF Salmon (129 cfs Somes Bar)
10/9/2014
Elevation (ft)
River Station (ft)
Ground at Well
Bottom of Well
KG-1
KG-2
KG-3
KG-4
KG-5
KG-6
T1
T2
T3
T4
T5

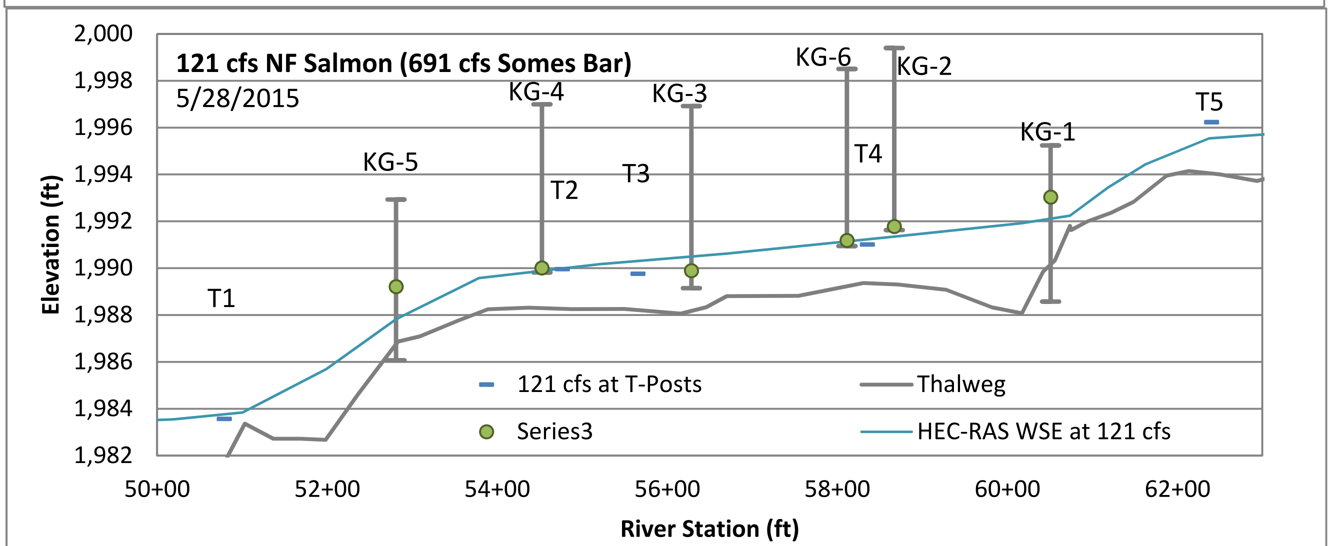


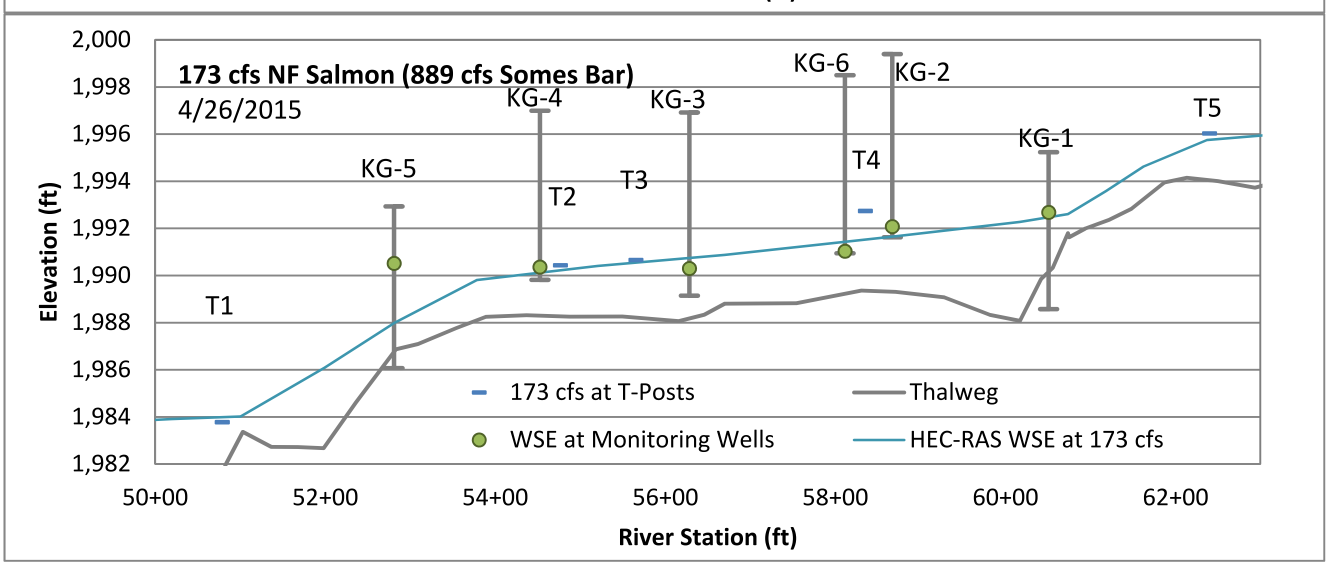
46 cfs NF Salmon (236 cfs Somes Bar)
7/29/2015
Elevation (ft)
River Station (ft)
46 cfs at T-Posts
Series3
Thalweg
HEC-RAS WSE at 46 cfs

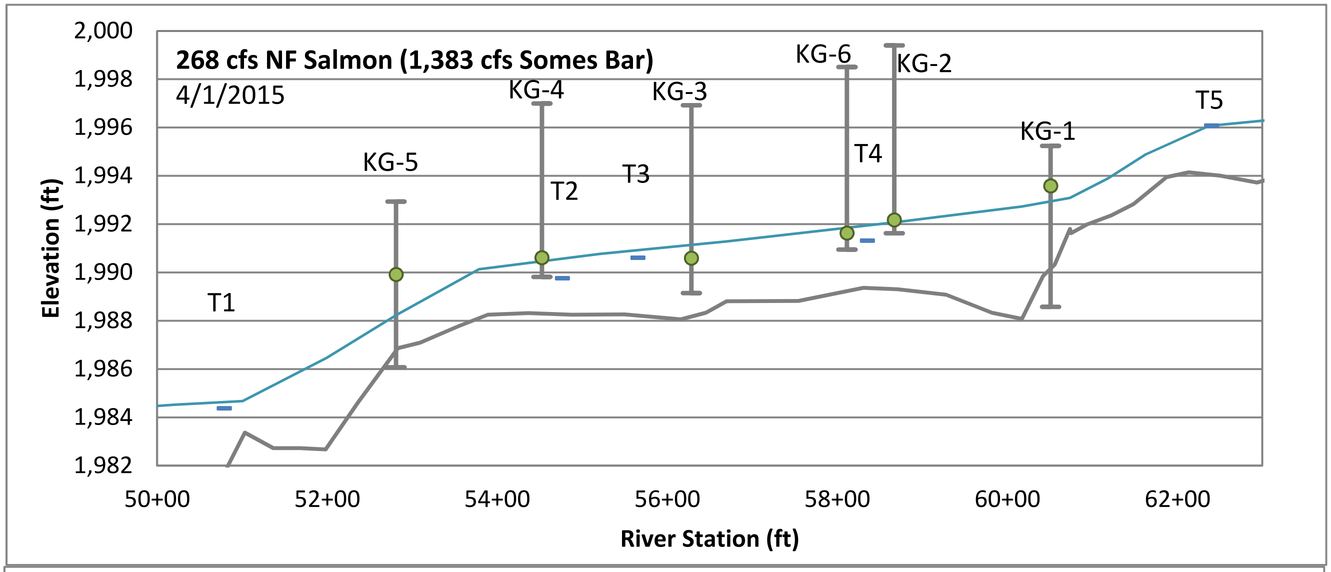


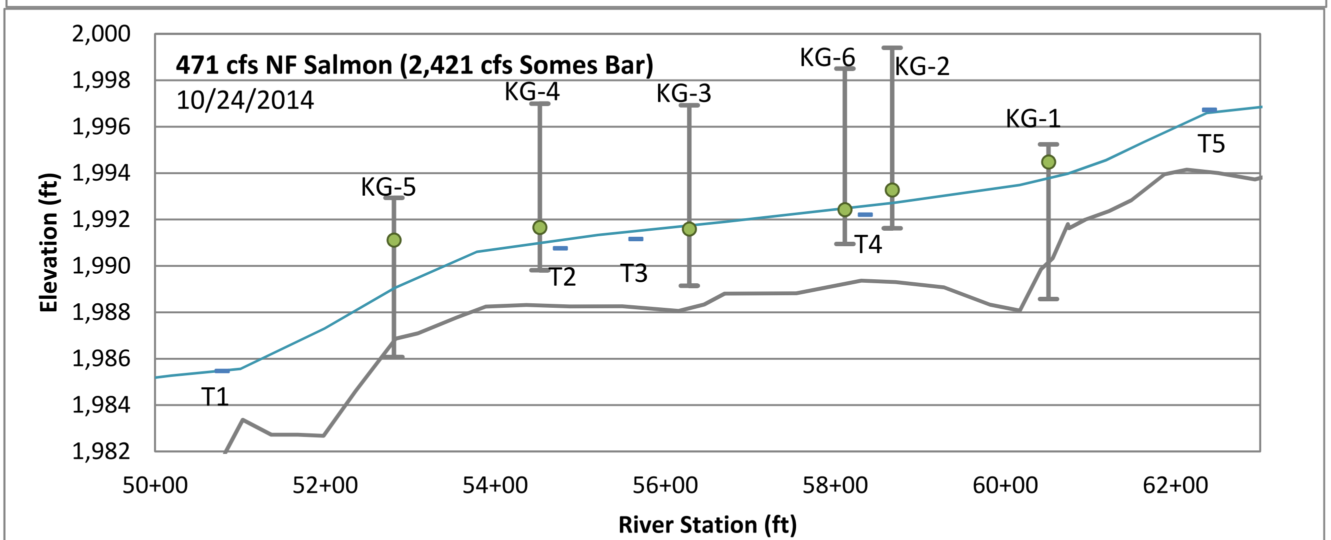
71 cfs NF Salmon (364 cfs Somes Bar)
6/22/2015
Elevation (ft)
River Station (ft)
71 cfs at T-Posts
Series3
Thalweg
HEC-RAS WSE at 71 cfs

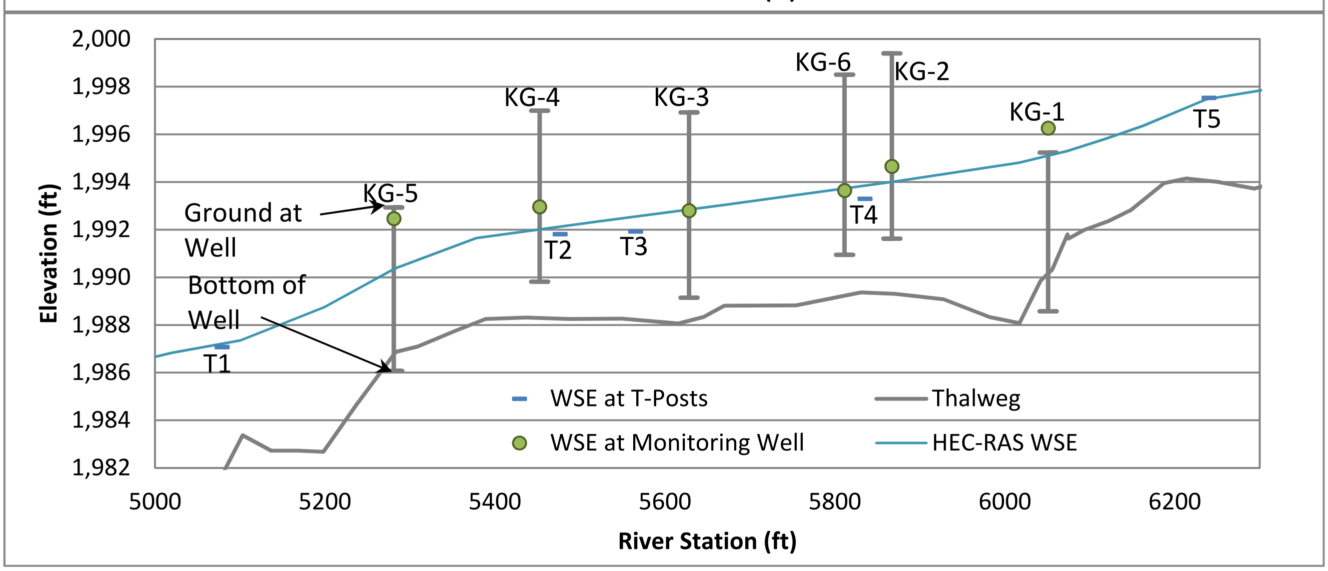

114 cfs NF Salmon (589 cfs Somes Bar)
10/21/2014
KG-5
KG-4
KG-3
KG-6
KG-2
KG-1
Elevation (ft)
River Station (ft)
2,000
1,998
1,996
1,994
1,992
1,990
1,988
1,986
1,984
1,982
50+00
52+00
54+00
56+00
58+00
60+00
62+00

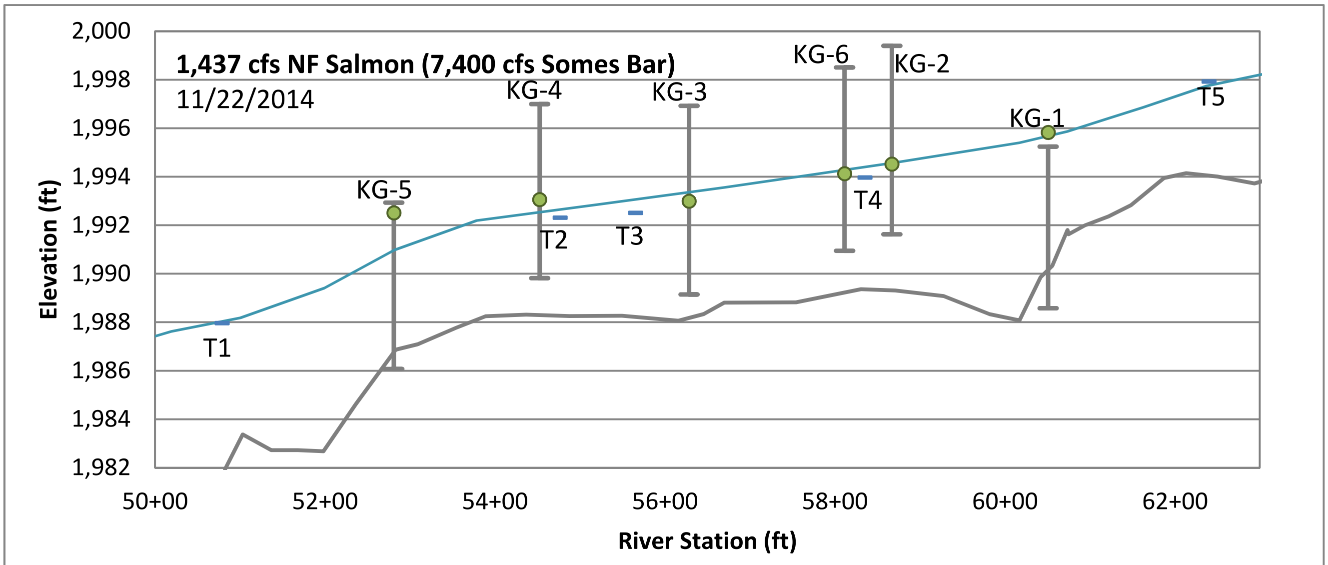

121 cfs NF Salmon (691 cfs Somes Bar)
5/28/2015
KG-5
KG-4
KG-3
KG-6
KG-2
KG-1
T1
T2
T3
T4
T5
121 cfs at T-Posts
Series3
Thalweg
HEC-RAS WSE at 121 cfs
Elevation (ft)
River Station (ft)
2,000
1,998
1,996
1,994
1,992
1,990
1,988
1,986
1,984
1,982
50+00
52+00
54+00
56+00
58+00
60+00
62+00

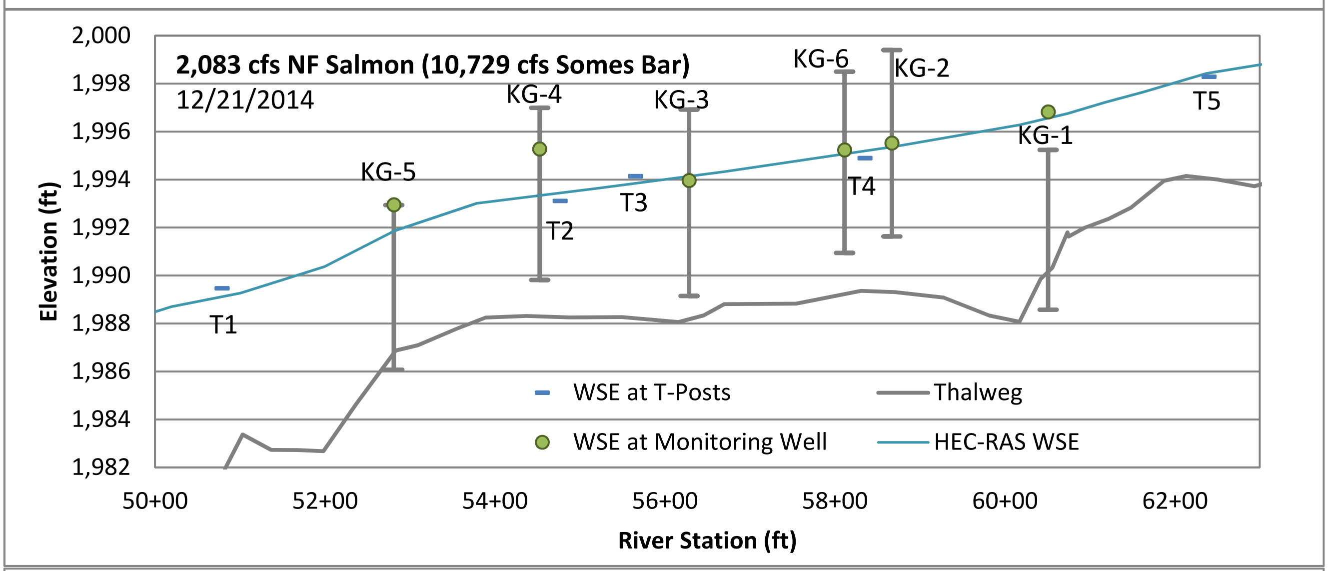

173 cfs NF Salmon (889 cfs Somes Bar)
4/26/2015
KG-5
KG-4
KG-3
KG-6
KG-2
KG-1
T1
T2
T3
T4
T5
173 cfs at T-Posts
WSE at Monitoring Wells
Thalweg
HEC-RAS WSE at 173 cfs
Elevation (ft)
River Station (ft)
2,000
1,998
1,996
1,994
1,992
1,990
1,988
1,986
1,984
1,982
50+00
52+00
54+00
56+00
58+00
60+00
62+00

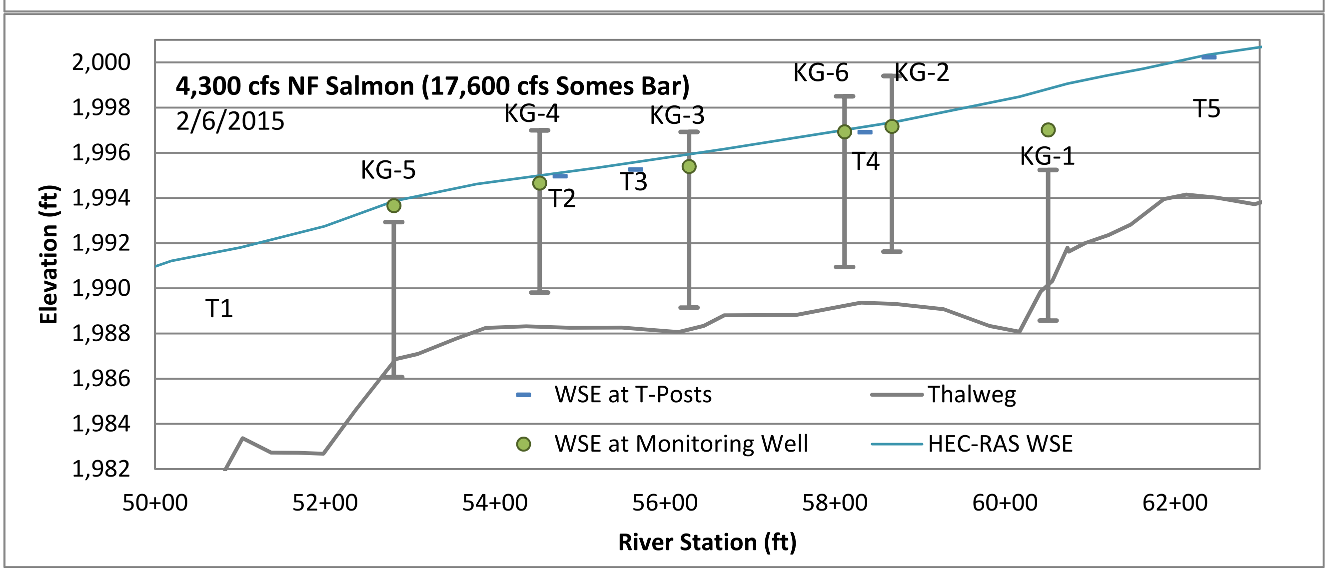

268 cfs NF Salmon (1,383 cfs Somes Bar)
4/1/2015
Elevation (ft)
River Station (ft)
KG-1
KG-2
KG-3
KG-4
KG-5
KG-6
T1
T2
T3
T4
T5
2,000
1,998
1,996
1,994
1,992
1,990
1,988
1,986
1,984
1,982
50+00
52+00
54+00
56+00
58+00
60+00
62+00


471 cfs NF Salmon (2,421 cfs Somes Bar)
10/24/2014
Elevation (ft)
River Station (ft)
KG-1
KG-2
KG-3
KG-4
KG-5
KG-6
T1
T2
T3
T4
T5
2,000
1,998
1,996
1,994
1,992
1,990
1,988
1,986
1,984
1,982
50+00
52+00
54+00
56+00
58+00
60+00
62+00


Elevation (ft)
River Station (ft)
Ground at Well
Bottom of Well
KG-1
KG-2
KG-3
KG-4
KG-5
KG-6
T1
T2
T3
T4
T5
WSE at T-Posts
WSE at Monitoring Well
Thalweg
HEC-RAS WSE
2,000
1,998
1,996
1,994
1,992
1,990
1,988
1,986
1,984
1,982
5000
5200
5400
5600
5800
6000
6200


1,437 cfs NF Salmon (7,400 cfs Somes Bar)
11/22/2014
KG-6
KG-2
KG-4
KG-3
KG-5
KG-1
T1
T2
T3
T4
T5
Elevation (ft)
River Station (ft)
2,000
1,998
1,996
1,994
1,992
1,990
1,988
1,986
1,984
1,982
50+00
52+00
54+00
56+00
58+00
60+00
62+00


2,083 cfs NF Salmon (10,729 cfs Somes Bar)
12/21/2014
KG-6
KG-2
KG-4
KG-3
KG-5
KG-1
T1
T2
T3
T4
T5
WSE at T-Posts
Thalweg
WSE at Monitoring Well
HEC-RAS WSE
Elevation (ft)
River Station (ft)
2,000
1,998
1,996
1,994
1,992
1,990
1,988
1,986
1,984
1,982
50+00
52+00
54+00
56+00
58+00
60+00
62+00


4,300 cfs NF Salmon (17,600 cfs Somes Bar)
2/6/2015
KG-6
KG-2
KG-4
KG-3
KG-5
KG-1
T1
T2
T3
T4
T5
WSE at T-Posts
Thalweg
WSE at Monitoring Well
HEC-RAS WSE
Elevation (ft)
River Station (ft)
2,000
1,998
1,996
1,994
1,992
1,990
1,988
1,986
1,984
1,982
50+00
52+00
54+00
56+00
58+00
60+00
62+00

Appendix E

Water Quality Monitoring Results

Data Collectors	Date	Start Time:	Stop Time:	Somes Bar Flow (cfs)	Flow Scaled To Salmon at Kelly Bar (cfs)	River Temp (°C)	Kelly Gulch Temp (°C)
Llanos/Nickerson	10/9/2014	15:30	17:30	128.67	24.98	16.20	

General Comments/Notes: T-Posts and well rims surveyed by MLA.

Monitoring Well Data

Well #	Depth to Water from rim (ft)	Calculated WSE (ft)	Temp (°C)	D.O. (mg/L)	Comments
1	4.65	1,992.03	17.2	4.24	
2	-	-	-	-	Well dry
3	-	-	-	-	Well dry
4	-	-	-	-	Well dry
5	7	1,988.11	13.4	5.50	
6	-	-	-	-	Well dry

T-Post Data

T-Post #	Dist A (ft)	Dist B (ft)	WSE (ft)		Comments
1	3.75	5.56	1,982.06	-	
2	0.96	6.19	1,989.31	-	
3	1.92	5.38	1,989.76	-	
4	1.00	7.02	1,990.29	-	
5	0.67	5.40	1,995.16	-	25 cfs WSE at T-Posts

Data Collectors	Date	Start Time:	Stop Time:	Somes Bar Flow (cfs)	Flow Scaled To Salmon at Kelly Bar (cfs)	River Temp (°C)	Kelly Gulch Temp (°C)
Hotaling/Cressey	10/21/2014	14:30	16:30	588.67	114.28	12.5	12.0

General Comments/Notes: Cloudy day, Hobo temps not downloaded. I-Phone level used to measure WSEs (not accurate)

Monitoring Well Data

Well #	Depth to Water from rim (ft)	Calculated WSE (ft)	Temp (°C)	D.O. (mg/L)	Comments
1	4	1,992.68	16.0	-	
2	-	-	-	-	
3	8.5	1,989.79	18.0	-	Air Temp? Wet at bottom
4	-	-	-	-	
5	6.4	1,988.71	12.0	-	
6	9.1	1,990.93	18.0	-	Air Temp? Wet at bottom

T-Post Data

T-Post #	Dist A (ft)	Dist B (ft)	WSE (ft)		Comments
1	3.95	3.35	1,984.07	-	114 cfs at T-posts
2	0.0	5.4	1,991.06	-	
3	0.0	5.5	1,991.56	-	
4	0.0	5.4	1,992.91	-	
5	0.0	5.0	1,996.23	-	

Data Collectors	Date	Start Time:	Stop Time:	Somes Bar Flow (cfs)	Flow Scaled To Salmon at Kelly Bar (cfs)	River Temp (°C)	Kelly Gulch Temp (°C)
Cressey/Hotaling	10/24/2014	10:30	14:15	2421.25	470.06	11.0	12.0

General Comments/Notes: Cloudy, clearing. River dropping from past days rain. Kelly Gulch up and flowing well - flowing into off-channel alcove for first time this year. Standing water around well 1.

Monitoring Well Data

Well #	Depth to Water from rim (ft)	Calculated WSE (ft)	Temp (°C)	D.O. (mg/L)	Comments
1	2.2	1,994.48	13	-	
2	7.5	1,993.27	16.8	-	
3	6.7	1,991.59	17	-	
4	7.2	1,991.66	17	-	
5	4	1,991.11	12.5	-	
6	7.6	1,992.43	17	-	

T-Post Data

T-Post #	Dist A (ft)	Dist B (ft)	WSE (ft)		Comments
1	0.0	5.9	1,985.47	-	470 cfs at T-Posts
2	0.0	5.7	1,990.76	-	
3	0.0	5.9	1,991.16	-	
4	0.0	6.10	1,992.21	-	
5	0.0	4.50	1,996.73	-	

Data Collectors	Date	Start Time:	Stop Time:	Somes Bar Flow (cfs)	Flow Scaled To Salmon at Kelly Bar (cfs)	River Temp (°C)	Kelly Gulch Temp (°C)
Cressey/Hotaling	11/22/2014	12:30	13:40	7400.00	1436.64	9.0	10.0

General Comments/Notes: (Cloudy - Clearing) Heavy rain overnight - 3-inches. River ~ 8,000-cfs @ gauge. Already dropping on the North Fork, back alcove at well #1 Inundated, but not connected to the river. High water channels not wetted,

Monitoring Well Data

Well #	Depth to Water from rim (ft)	Calculated WSE (ft)	Temp (°C)	D.O. (mg/L)	Comments
1	0.85	1,995.83	12.5	-	Alcove Inundated
2	6.25	1,994.52	12	-	1437 cfs at T-Posts
3	5.3	1,992.99	13.5	-	
4	5.8	1,993.06	14	-	
5	2.6	1,992.51	10	-	
6	5.9	1,994.13	12.5	-	

T-Post Data

T-Post #	Dist A (ft)	Dist B (ft)	WSE (ft)		Comments
1	0.0	3.4	1,987.97	-	Post in Water, 1-ft
2	0.0	4.15	1,992.31	-	Post in Water
3	0.0	4.55	1,992.51	-	Post just at edge of water
4	0.0	4.35	1,993.96	-	post in 2" of water
5	0.0	3.30	1,997.93	-	Post in 6" of water

Data Collectors	Date	Start Time:	Stop Time:	Somes Bar Flow (cfs)	Flow Scaled To Salmon at Kelly Bar (cfs)	River Temp (°C)	Kelly Gulch Temp (°C)
Cressey/Hotaling	12/12/2014	10:00	11:00	5524.00	1072.44	8.0	10.0

General Comments/Notes: Alcove inundated to ~1.5-ft, partly cloudy

Monitoring Well Data	Well #	Depth to Water from rim (ft)	Calculated WSE (ft)	Temp (°C)	D.O. (mg/L)	Comments
	1	0.42	1,996.26	9	-	1072 cfs at T-Posts
	2	6.12	1,994.65	10	-	
	3	5.5	1,992.79	11.5	-	
	4	5.9	1,992.96	11	-	
	5	2.65	1,992.46	9.9	-	
	6	6.39	1,993.64	10	-	

T-Post Data	T-Post #	Dist A (ft)	Dist B (ft)	WSE (ft)		Comments
	1	0.0	4.3	1,987.07	-	Post at water edge
	2	0.0	4.65	1,991.81	-	
	3	0.0	5.14	1,991.92	-	
	4	0.0	5.02	1,993.29	-	
	5	0.0	3.70	1,997.53	-	Post in 2" of water

Data Collectors	Date	Start Time:	Stop Time:	Somes Bar Flow (cfs)	Flow Scaled To Salmon at Kelly Bar (cfs)	River Temp (°C)	Kelly Gulch Temp (°C)
Sarahtt & Rex	12/21/2014	10:45	12:00	10728.6	2082.9	9.0	11.0

General Comments/Notes: Bases of all T-Posts were submerged, measurement on Well # 1 taken from cap, not rim. Temp for well 1 taken in surrounding surface water.

Monitoring Well Data	Well #	Depth to Water from rim (ft)	Calculated WSE (ft)	Temp (°C)	D.O. (mg/L)	Comments
	1	-0.15	1,996.82	10.5	-	Cap Submerged
	2	5.25	1,995.52	10.0	-	
	3	4.33	1,993.96	11.0	-	
	4	3.58	1,995.27	10.1	-	HOBO Logger Gone
	5	2.17	1,992.95	10.1	-	
	6	4.79	1,995.24	10.0	-	

T-Post Data	T-Post #	Dist A (ft)	Dist B (ft)	WSE (ft)		Comments
	1	1.9	0	1,989.47	-	Bases of all T-Posts
	2	3.4	0	1,993.11	-	Submerged
	3	2.9	0.0	1,994.14	-	2083 cfs at T-Posts
	4	3.4	0.0	1,994.89	-	Assumed that Dist B given
	5	2.9	0.0	1,998.29	-	was not valid-zeroed (nn)

Data Collectors	Date	Start Time:	Stop Time:	Somes Bar Flow (cfs)	Flow Scaled To Salmon at Kelly Bar (cfs)	River Temp (°C)	Kelly Gulch Temp (°C)
Lyra & Sareh	2/6/2015	13:15	14:30	17600	3417	10.0	

General Comments/Notes: Rainy. Side Channels Flowing, river still rising. Flow increased to over 25,000 cfs.
Note that flow determined by Calibration is 4300 cfs

Monitoring Well Data

Well #	Depth to Water from rim (ft)	Calculated WSE (ft)	Temp (°C)	D.O. (mg/L)	Comments
1	-0.33333333	1,997.01	8	11.2	under water by 4"
2	3.6	1,997.17	8	9.8	
3	2.9	1,995.39	8.5	8.7	
4	4.2	1,994.66	9.5	9.1	
5	1.45	1,993.66	10	-	too turbid
6	3.1	1,996.93	8	11.9	

T-Post Data

T-Post #	Dist A (ft)	Dist B (ft)	WSE (ft)		Comments
1			1,991.37	-	Under water
2		1.50	1,994.96	-	
3		1.80	1,995.26	-	Approximately
4		1.40	1,996.91	-	Calbirated 4,500 cfs at T-posts
5		1.00	2,000.23	-	Approximately

Data Collectors	Date	Start Time:	Stop Time:	Somes Bar Flow (cfs)	Flow Scaled To Salmon at Kelly Bar (cfs)	River Temp (°C)	Kelly Gulch Temp (°C)
Hotaling, Hugdahl	4/1/2015	9:45	11:30	1382.50	268.40	9.0	7.5

General Comments/Notes: Clear day, air temp 9.5ºC D.O. Meter not working, used handheld thermometer for temperature readings. *Need to move

Monitoring Well Data

Well #	Depth to Water from rim (ft)	Calculated WSE (ft)	Temp (°C)	D.O. (mg/L)	Comments
1	3.1	1,993.58	10.2	-	"Flashlight not bright
2	8.6	1,992.17	9.5	-	enough to see water
3	7.7	1,990.59	9.5	-	had to use sound test"
4	8.25	1,990.61	10.5	-	268 cfs at T-Posts
5	5.2	1,989.91	11.0	-	
6	8.4	1,991.63	9.0	-	

T-Post Data

T-Post #	Dist A (ft)	Dist B (ft)	WSE (ft)	Comments
1	1.4	5.6	1,984.37	
2	0.9	5.8	1,989.76	
3	1.1	5.35	1,990.61	
4	1.4	5.60	1,991.31	
5	0.0	5.15	1,996.08	

Data Collectors	Date	Start Time:	Stop Time:	Somes Bar Flow (cfs)	Flow Scaled To Salmon at Kelly Bar (cfs)	River Temp (°C)	Kelly Gulch Temp (°C)
Hugdahl/Van S.	4/26/2015	10:20	-	889.00	172.59	9.5	

General Comments/Notes: Overcast Day

Monitoring Well Data

Well #	Depth to Water from rim (ft)	Calculated WSE (ft)	Temp (°C)	D.O. (mg/L)	Comments
1	4	1,992.68	10.8	2.98	12:00 HOBO out
2	8.7	1,992.07	10.0	8.13	12:09 Hobo Out
3	8	1,990.29	10.2	6.77	11:02 HOBO Out
4	8.5	1,990.36	11.2	5.75	
5	4.6	1,990.51	11.0	5.80	10:29 HOBO Out
6	9	1,991.03	10.4	5.56	173 cfs at T-Posts

T-Post Data

T-Post #	Dist A (ft)	Dist B (ft)	WSE (ft)		Comments
1	0.0	7.6	1,983.77	12.29	D.O. in river
2	0.0	6.0	1,990.43		
3	0.0	6.4	1,990.65		
4	1.15	4.4	1,992.73		onders if A or B was recorded w
5	0.0	5.2	1,996.03		

Data Collectors	Date	Start Time:	Stop Time:	Somes Bar Flow (cfs)	Flow Scaled To Salmon at Kelly Bar (cfs)	River Temp (°C)	Kelly Gulch Temp (°C)
Hotaling/Bennett	5/28/2015	10:25		622.50	120.85	15.5	13.5

General Comments/Notes: Sunny / Hot Kelly Gulch Alcove (Willow Pond) temp = 14.0 C D.O. 10.55 ppm depth 0.95-Ft max (photos) Kelly Gulch Temp 10.66 ppm. Camera time is one hour behind

Monitoring Well Data

Well #	Depth to Water from rim (ft)	Calculated WSE (ft)	Temp (°C)	D.O. (mg/L)	Comments
1	3.65	1,993.03	12.5	3	
2	9	1,991.77	13.0	6.92	
3	8.4	1,989.89	13.0	4.85	
4	8.85	1,990.01	12.5	6.3	
5	5.9	1,989.21	12.0	5.40	
6	8.85	1,991.18	12.5	6.2	121 cfs at T-Posts

T-Post Data

T-Post #	Dist A (ft)	Dist B (ft)	WSE (ft)		Comments
1	2.2	5.6	1,983.57		
2	1.8	4.7	1,989.96	10.66	D.O. in Kelly Gulch
3	2.3	5.0	1,989.76	10.55	D.O. in Kelly Gulch Pond
4	2.6	4.7	1,991.01	10.36	D.O. in river
5	1.9	3.1	1,996.23		

Data Collectors	Date	Start Time:	Stop Time:	Somes Bar Flow (cfs)	Flow Scaled To Salmon at Kelly Bar (cfs)	River Temp (°C)	Kelly Gulch Temp (°C)
Hotaling/Bennett	6/22/2015	11:00	12:30	363.67	70.60	19.0	14.7

General Comments/Notes: Sunny and warm day. Creek pond 15.1°C, 10.28 PPM D.O.

Monitoring Well Data

Well #	Depth to Water from rim (ft)	Calculated WSE (ft)	Temp (°C)	D.O. (mg/L)	Comments
1	4	1,992.68	15.6	2.61	
2	-	-	-	-	
3	8.7	1,989.59	14.6	4.66	
4	-	-	-	-	
5	6.35	1,988.76	15.0	4.49	
6	-	-	-	-	71 cfs at T-Posts

T-Post Data

T-Post #	Dist A (ft)	Dist B (ft)	WSE (ft)		Comments
1	4.0	4.1	1,983.27	8.45	D.O. in river
2	4.0	2.9	1,989.56	10.15	D.O. in Kelly Gulch
3	3.9	4.0	1,989.16	10.28	D.O. in Kelly Gulch Pond
4	4.3	3.3	1,990.71		
5	3.6	1.9	1,995.73		

Data Collectors	Date	Start Time:	Stop Time:	Somes Bar Flow (cfs)	Flow Scaled To Salmon at Kelly Bar (cfs)	River Temp (°C)	Kelly Gulch Temp (°C)
Hotaling/Bennett	7/29/2015	11;00	12:30	236.00	45.82	21.0	16.7

General Comments/Notes: Hot and Sunny, HOBO Loggers downloaded,

Monitoring Well Data

Well #	Depth to Water from rim (ft)	Calculated WSE (ft)	Temp (°C)	D.O. (mg/L)	Comments
1	4.9	1,991.78	19.1	0.7	HOBO 10315169
2	-	-	-	-	HOBO 9772371
3	-	-	-	-	HOBO 1271751
4	-	-	-	-	
5	7.8	1,987.31	17.2	5.30	HOBO 10109942
6	-	-	-	-	46 cfs at T-Posts

T-Post Data

T-Post #	Dist A (ft)	Dist B (ft)	WSE (ft)		Comments
1	3.6	4.9	1,982.87	8.92	D.O. in river
2	3.6	3.5	1,989.41	9.75	D.O. in Kelly Gulch
3	3.5	4.0	1,989.61	9.75	D.O. in Kelly Gulch Pond
4	2.8	5.0	1,990.56		
5	0.2	5.7	1,995.38		

Data Collectors	Date	Start Time:	Stop Time:	Somes Bar Flow (cfs)	Flow Scaled To Salmon at Kelly Bar (cfs)	River Temp (°C)	Kelly Gulch Temp (°C)
Tom	9/22/2015	NA	NA	NA	NA	18.5	11.2

General Comments/Notes: Kelly Pond Temp 14C, DS 10.99 PPM, River temp 18.5C, DO 12.04 PPM, Kelly Gulch Temp. 13C, 11.15 PPM. Fish utilizing kelly pond, though vegetation impacted by grazing.

Monitoring Well Data

Well #	Depth to Water from rim (ft)	Calculated WSE (ft)	Temp (°C)	D.O. (mg/L)	Comments
1					
2					
3					
4					
5					
6					

T-Post Data

T-Post #	Dist A (ft)	Dist B (ft)	WSE (ft)	Comments

Appendix F

HEC-RAS Calibration Modeling

Kelly Bar HEC-RAS Calibration Modeling													
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Obs WS	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
E-CH-ALIGI	6748.27	Lidar 296-cfs	296	1996.92	1998.98	1998.74	1998.321	1999.122	0.011969	3.02	97.93	92.67	0.52
E-CH-ALIGI	6748.27	10/9 25-cfs	25	1996.92	1997.503		1997.304	1997.548	0.012905	1.71	14.61	34.57	0.46
E-CH-ALIGI	6748.27	10/24 471-cfs	471	1996.92	1999.378		1998.852	1999.566	0.010728	3.48	135.46	95.65	0.51
E-CH-ALIGI	6748.27	11/22 1437-cfs	1437	1996.92	2000.974		1999.896	2001.344	0.008442	4.88	294.4	103.88	0.51
E-CH-ALIGI	6748.27	12/12 1072 cfs	1072	1996.92	2000.441		1999.539	2000.751	0.008867	4.46	240.11	100.64	0.51
E-CH-ALIGI	6748.27	12/21 2083 cfs	2083	1996.92	2001.767		2000.432	2002.234	0.008548	5.48	379.91	113.62	0.53
E-CH-ALIGI	6748.27	10/21 114 cfs	114	1996.92	1998.208		1997.785	1998.303	0.009909	2.48	46.05	50.73	0.46
E-CH-ALIGI	6748.27	2/6 4300 cfs	4300	1996.92	2003.759		2001.962	2004.506	0.008431	6.94	619.84	128.43	0.56
E-CH-ALIGI	6748.27	4/1/15 268 cfs	268	1996.92	1998.909		1998.259	1999.042	0.012278	2.93	91.36	92.16	0.52
E-CH-ALIGI	6748.27	4/26/15 173 cfs	173	1996.92	1998.481		1998.015	1998.61	0.009639	2.89	59.95	51.04	0.47
E-CH-ALIGI	6748.27	5/28/15 121 cfs	121	1996.92	1998.243		1997.823	1998.342	0.009857	2.53	47.83	50.74	0.46
E-CH-ALIGI	6748.27	6/22/15 71 cfs	71	1996.92	1997.949		1997.594	1998.021	0.011583	2.16	32.95	50.67	0.47
E-CH-ALIGI	6748.27	7/29/15 46 cfs	46	1996.92	1997.716		1997.454	1997.78	0.012499	2.04	22.55	39.89	0.48
E-CH-ALIGI	6623.96	Lidar 296-cfs	296	1996.14	1997.97	1997.88	1997.276	1998.067	0.006061	2.51	117.97	88.53	0.38
E-CH-ALIGI	6623.96	10/9 25-cfs	25	1996.14	1996.819		1996.486	1996.831	0.003114	0.88	28.35	62.71	0.23
E-CH-ALIGI	6623.96	10/24 471-cfs	471	1996.14	1998.399		1997.573	1998.539	0.006215	3.01	156.5	90.77	0.4
E-CH-ALIGI	6623.96	11/22 1437-cfs	1437	1996.14	2000.088		1998.66	2000.407	0.00627	4.53	317.05	99.58	0.45
E-CH-ALIGI	6623.96	12/12 1072 cfs	1072	1996.14	1999.545		1998.309	1999.802	0.006222	4.07	263.69	97.1	0.43
E-CH-ALIGI	6623.96	12/21 2083 cfs	2083	1996.14	2000.831		1999.241	2001.269	0.006781	5.31	392.26	102.78	0.48
E-CH-ALIGI	6623.96	10/21 114 cfs	114	1996.14	1997.373		1996.836	1997.417	0.005012	1.7	67.25	79.39	0.32
E-CH-ALIGI	6623.96	2/6 4300 cfs	4300	1996.14	2003.11		2000.811	2003.538	0.004477	5.66	978.79	241.18	0.42
E-CH-ALIGI	6623.96	4/1/15 268 cfs	268	1996.14	1997.892		1997.23	1997.982	0.00602	2.41	111.09	88.05	0.38
E-CH-ALIGI	6623.96	4/26/15 173 cfs	173	1996.14	1997.591		1996.994	1997.655	0.005742	2.03	85.02	84.31	0.36
E-CH-ALIGI	6623.96	5/28/15 121 cfs	121	1996.14	1997.398		1996.855	1997.445	0.005141	1.75	69.25	79.61	0.33
E-CH-ALIGI	6623.96	6/22/15 71 cfs	71	1996.14	1997.166		1996.696	1997.196	0.004004	1.38	51.3	69.45	0.28
E-CH-ALIGI	6623.96	7/29/15 46 cfs	46	1996.14	1997.018		1996.6	1997.037	0.003287	1.12	41.23	66.57	0.25
E-CH-ALIGI	6506.97	Lidar 296-cfs	296	1995.27	1997.059	1997	1996.478	1997.189	0.009161	2.9	102.23	84.8	0.46
E-CH-ALIGI	6506.97	10/9 25-cfs	25	1995.27	1995.669		1995.669	1995.777	0.07175	2.64	9.47	42.95	0.99
E-CH-ALIGI	6506.97	10/24 471-cfs	471	1995.27	1997.58		1996.784	1997.738	0.007374	3.19	147.74	89.84	0.44
E-CH-ALIGI	6506.97	11/22 1437-cfs	1437	1995.27	1999.342		1997.946	1999.654	0.006489	4.48	320.56	105.92	0.45
E-CH-ALIGI	6506.97	12/12 1072 cfs	1072	1995.27	1998.806		1997.587	1999.06	0.006412	4.05	264.98	101.36	0.44
E-CH-ALIGI	6506.97	12/21 2083 cfs	2083	1995.27	1999.993		1998.519	2000.433	0.007521	5.32	391.3	111.43	0.5
E-CH-ALIGI	6506.97	10/21 114 cfs	114	1995.27	1996.264		1996.049	1996.376	0.018247	2.69	42.31	66.13	0.59
E-CH-ALIGI	6506.97	2/6 4300 cfs	4300	1995.27	2002.037		2000.083	2002.737	0.007452	6.73	654.95	147.56	0.53
E-CH-ALIGI	6506.97	4/1/15 268 cfs	268	1995.27	1996.958		1996.439	1997.085	0.009673	2.86	93.82	82.84	0.47
E-CH-ALIGI	6506.97	4/26/15 173 cfs	173	1995.27	1996.568		1996.219	1996.682	0.012466	2.72	63.63	73.49	0.51
E-CH-ALIGI	6506.97	5/28/15 121 cfs	121	1995.27	1996.304		1996.066	1996.416	0.017185	2.69	44.97	67.32	0.58
E-CH-ALIGI	6506.97	6/22/15 71 cfs	71	1995.27	1995.972		1995.895	1996.103	0.034414	2.9	24.51	55.52	0.77
E-CH-ALIGI	6506.97	7/29/15 46 cfs	46	1995.27	1995.782		1995.782	1995.935	0.065899	3.14	14.67	48.14	1
E-CH-ALIGI	6378.72	Lidar 296-cfs	296	1993.97	1996.652	1996.33	1995.285	1996.697	0.001738	1.7	174.45	93.62	0.22
E-CH-ALIGI	6378.72	10/9 25-cfs	25	1993.97	1995.106		1994.384	1995.11	0.000641	0.55	45.2	61.87	0.11
E-CH-ALIGI	6378.72	10/24 471-cfs	471	1993.97	1997.162		1995.628	1997.231	0.002005	2.12	222.5	94.79	0.24
E-CH-ALIGI	6378.72	11/22 1437-cfs	1437	1993.97	1998.781		1996.719	1999.005	0.003401	3.79	379.19	100.76	0.34
E-CH-ALIGI	6378.72	12/12 1072 cfs	1072	1993.97	1998.304		1996.373	1998.466	0.002878	3.23	332.27	97.48	0.31
E-CH-ALIGI	6378.72	12/21 2083 cfs	2083	1993.97	1999.239		1997.296	1999.613	0.004945	4.91	426	103.95	0.42
E-CH-ALIGI	6378.72	10/21 114 cfs	114	1993.97	1995.872		1994.788	1995.891	0.001316	1.1	103.7	86.88	0.18
E-CH-ALIGI	6378.72	2/6 4300 cfs	4300	1993.97	2001.111		1998.84	2001.852	0.006131	6.95	654.45	134.89	0.49
E-CH-ALIGI	6378.72	4/1/15 268 cfs	268	1993.97	1996.549		1995.223	1996.59	0.001712	1.63	164.85	93.38	0.22
E-CH-ALIGI	6378.72	4/26/15 173 cfs	173	1993.97	1996.172		1994.988	1996.2	0.001488	1.33	130.21	89.99	0.19
E-CH-ALIGI	6378.72	5/28/15 121 cfs	121	1993.97	1995.912		1994.815	1995.932	0.001338	1.13	107.16	87.29	0.18
E-CH-ALIGI	6378.72	6/22/15 71 cfs	71	1993.97	1995.595		1994.633	1995.608	0.001122	0.89	80.13	82.35	0.16
E-CH-ALIGI	6378.72	7/29/15 46 cfs	46	1993.97	1995.37		1994.516	1995.378	0.000881	0.73	62.74	71.43	0.14
E-CH-ALIGI	6237.42	Lidar 296-cfs	296	1993.8	1996.157	1996.26	1995.29	1996.231	0.007746	2.18	136.07	96.88	0.32
E-CH-ALIGI	6237.42	10/9 25-cfs	25	1993.8	1994.911	1955.2	1994.516	1994.92	0.00428	0.78	31.89	67.78	0.2
E-CH-ALIGI	6237.42	10/24 471-cfs	471	1993.8	1996.59	1996.7	1995.588	1996.696	0.008732	2.61	180.42	106.78	0.35
E-CH-ALIGI	6237.42	11/22 1437-cfs	1437	1993.8	1997.74	1997.93	1996.675	1998.058	0.015865	4.53	317.38	128.43	0.51
E-CH-ALIGI	6237.42	12/12 1072 cfs	1072	1993.8	1997.467	1997.53	1996.339	1997.69	0.012662	3.79	282.6	126.18	0.45
E-CH-ALIGI	6237.42	12/21 2083 cfs	2083	1993.8	1998.432	1998.29	1997.233	1998.632	0.007642	3.59	580	191.04	0.36
E-CH-ALIGI	6237.42	10/21 114 cfs	114	1993.8	1995.509		1994.88	1995.542	0.006054	1.46	77.85	83.71	0.27
E-CH-ALIGI	6237.42	2/6 4300 cfs	4300	1993.8	2000.328	2000.23	1997.868	2000.641	0.006803	4.49	957.57	206.18	0.37
E-CH-ALIGI	6237.42	4/1/15 268 cfs	268	1993.8	1996.068		1995.236	1996.136	0.007392	2.1	127.66	92.59	0.32
E-CH-ALIGI	6237.42	4/26/15 173 cfs	173	1993.8	1995.753		1995.036	1995.8	0.006847	1.75	98.95	89.34	0.29
E-CH-ALIGI	6237.42	5/28/15 121 cfs	121	1993.8	1995.542		1994.903	1995.577	0.006141	1.5	80.63	84.46	0.27
E-CH-ALIGI	6237.42	6/22/15 71 cfs	71	1993.8	1995.285		1994.732	1995.307	0.005236	1.19	59.66	78.65	0.24
E-CH-ALIGI	6237.42	7/29/15 46 cfs	46	1993.8	1995.116		1994.633	1995.131	0.004647	0.99	46.7	74.83	0.22

Kelly Bar HEC-RAS Calibration Modeling													
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Obs WS	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
E-CH-ALIGI	6162.66	Lidar 296-cfs	296	1993.23	1994.947	1995.45	1994.671	1995.123	0.034383	3.37	87.83	99.21	0.63
E-CH-ALIGI	6162.66	10/9 25-cfs	25	1993.23	1993.831		1993.831	1993.946	0.138354	2.71	9.21	41.14	1.01
E-CH-ALIGI	6162.66	10/24 471-cfs	471	1993.23	1995.326		1994.952	1995.533	0.031052	3.65	129.02	119.71	0.62
E-CH-ALIGI	6162.66	11/22 1437-cfs	1437	1993.23	1996.864		1995.929	1997.102	0.014298	3.92	367	171.25	0.47
E-CH-ALIGI	6162.66	12/12 1072 cfs	1072	1993.23	1996.358		1995.659	1996.581	0.017731	3.8	282.47	162.53	0.51
E-CH-ALIGI	6162.66	12/21 2083 cfs	2083	1993.23	1997.654		1996.334	1997.915	0.011249	4.1	507.5	184.01	0.44
E-CH-ALIGI	6162.66	10/21 114 cfs	114	1993.23	1994.403		1994.225	1994.524	0.044832	2.79	40.81	74.84	0.67
E-CH-ALIGI	6162.66	2/6 4300 cfs	4300	1993.23	1999.724		1997.456	2000.078	0.007749	4.78	900.32	195.47	0.39
E-CH-ALIGI	6162.66	4/1/15 268 cfs	268	1993.23	1994.882		1994.607	1995.05	0.034888	3.29	81.45	96.46	0.63
E-CH-ALIGI	6162.66	4/26/15 173 cfs	173	1993.23	1994.624		1994.416	1994.761	0.036093	2.97	58.21	82.51	0.62
E-CH-ALIGI	6162.66	5/28/15 121 cfs	121	1993.23	1994.431		1994.246	1994.555	0.043509	2.82	42.9	75.82	0.66
E-CH-ALIGI	6162.66	6/22/15 71 cfs	71	1993.23	1994.126		1994.065	1994.27	0.0743	3.04	23.34	55.03	0.82
E-CH-ALIGI	6162.66	7/29/15 46 cfs	46	1993.23	1993.96		1993.953	1994.109	0.113992	3.1	14.85	47.03	0.97
E-CH-ALIGI	6118.61	Lidar 296-cfs	296	1991.08	1993.989	1994.53	1993.42	1994.104	0.015577	2.73	108.5	92.09	0.44
E-CH-ALIGI	6118.61	10/9 25-cfs	25	1991.08	1992.704		1992.129	1992.727	0.008528	1.22	20.45	36.47	0.29
E-CH-ALIGI	6118.61	10/24 471-cfs	471	1991.08	1994.562		1993.704	1994.688	0.011626	2.85	165.2	105.49	0.4
E-CH-ALIGI	6118.61	11/22 1437-cfs	1437	1991.08	1996.367		1994.816	1996.575	0.009474	3.66	393.07	148.51	0.4
E-CH-ALIGI	6118.61	12/12 1072 cfs	1072	1991.08	1995.806		1994.45	1995.986	0.009712	3.41	314.07	133.93	0.39
E-CH-ALIGI	6118.61	12/21 2083 cfs	2083	1991.08	1997.232		1995.345	1997.472	0.008446	3.93	530.24	165.01	0.39
E-CH-ALIGI	6118.61	10/21 114 cfs	114	1991.08	1993.417		1992.841	1993.474	0.013581	1.91	59.81	78.3	0.38
E-CH-ALIGI	6118.61	2/6 4300 cfs	4300	1991.08	1999.413		1996.734	1999.76	0.006508	4.73	920.15	198	0.37
E-CH-ALIGI	6118.61	4/1/15 268 cfs	268	1991.08	1993.898		1993.349	1994.009	0.016096	2.67	100.26	89.9	0.45
E-CH-ALIGI	6118.61	4/26/15 173 cfs	173	1991.08	1993.587		1993.069	1993.673	0.016842	2.35	73.48	82.38	0.44
E-CH-ALIGI	6118.61	5/28/15 121 cfs	121	1991.08	1993.437		1992.875	1993.498	0.014188	1.97	61.39	79	0.39
E-CH-ALIGI	6118.61	6/22/15 71 cfs	71	1991.08	1993.187		1992.592	1993.228	0.010351	1.62	43.95	60.04	0.33
E-CH-ALIGI	6118.61	7/29/15 46 cfs	46	1991.08	1992.976		1992.387	1993.008	0.009637	1.43	32.28	50.37	0.31
E-CH-ALIGI	6073.71	Lidar 296-cfs	296	1991.1	1993.212	1993.56	1992.549	1993.367	0.016388	3.15	93.9	66.5	0.47
E-CH-ALIGI	6073.71	10/9 25-cfs	25	1991.1	1991.57		1991.57	1991.702	0.127451	2.91	8.58	32.24	1
E-CH-ALIGI	6073.71	10/24 471-cfs	471	1991.1	1993.977		1992.891	1994.127	0.012893	3.1	151.72	91.72	0.43
E-CH-ALIGI	6073.71	11/22 1437-cfs	1437	1991.1	1995.871		1994.338	1996.115	0.010206	3.96	362.71	127.41	0.41
E-CH-ALIGI	6073.71	12/12 1072 cfs	1072	1991.1	1995.297		1993.947	1995.508	0.011011	3.68	291.07	120.85	0.42
E-CH-ALIGI	6073.71	12/21 2083 cfs	2083	1991.1	1996.751		1994.911	1997.042	0.00966	4.32	481.65	142.17	0.41
E-CH-ALIGI	6073.71	10/21 114 cfs	114	1991.1	1992.174		1992.026	1992.354	0.050511	3.41	33.43	49.48	0.73
E-CH-ALIGI	6073.71	2/6 4300 cfs	4300	1991.1	1999.056		1996.406	1999.43	0.007692	4.92	883.89	191.96	0.39
E-CH-ALIGI	6073.71	4/1/15 268 cfs	268	1991.1	1993.089		1992.489	1993.241	0.016991	3.12	85.89	63.5	0.47
E-CH-ALIGI	6073.71	4/26/15 173 cfs	173	1991.1	1992.61		1992.229	1992.75	0.023946	3.01	57.5	58.5	0.53
E-CH-ALIGI	6073.71	5/28/15 121 cfs	121	1991.1	1992.235		1992.063	1992.406	0.044477	3.31	36.51	51.24	0.69
E-CH-ALIGI	6073.71	6/22/15 71 cfs	71	1991.1	1991.847		1991.847	1992.069	0.100643	3.78	18.8	40.09	0.97
E-CH-ALIGI	6073.71	7/29/15 46 cfs	46	1991.1	1991.714		1991.714	1991.891	0.113819	3.38	13.62	37.68	0.99
E-CH-ALIGI	6017.1	Lidar 296-cfs	296	1988.12	1992.837	1992.56	1990.941	1992.904	0.003943	2.09	141.9	61.59	0.24
E-CH-ALIGI	6017.1	10/9 25-cfs	25	1988.12	1990.717		1989.172	1990.724	0.000873	0.65	38.53	32.02	0.1
E-CH-ALIGI	6017.1	10/24 471-cfs	471	1988.12	1993.49		1991.479	1993.587	0.006497	2.5	188.38	92.09	0.31
E-CH-ALIGI	6017.1	11/22 1437-cfs	1437	1988.12	1995.397		1993.179	1995.607	0.007322	3.68	390.51	117.36	0.36
E-CH-ALIGI	6017.1	12/12 1072 cfs	1072	1988.12	1994.805		1992.605	1994.977	0.007411	3.33	321.95	113.52	0.35
E-CH-ALIGI	6017.1	12/21 2083 cfs	2083	1988.12	1996.283		1994.012	1996.556	0.007343	4.2	496.45	122.53	0.37
E-CH-ALIGI	6017.1	10/21 114 cfs	114	1988.12	1991.864		1990.024	1991.891	0.002321	1.33	85.94	50.35	0.18
E-CH-ALIGI	6017.1	2/6 4300 cfs	4300	1988.12	1998.477		1995.55	1998.951	0.007501	5.54	793.18	159.87	0.4
E-CH-ALIGI	6017.1	4/1/15 268 cfs	268	1988.12	1992.728		1990.833	1992.789	0.003678	1.98	135.29	60.26	0.23
E-CH-ALIGI	6017.1	4/26/15 173 cfs	173	1988.12	1992.272		1990.397	1992.312	0.002969	1.59	108.63	57.8	0.2
E-CH-ALIGI	6017.1	5/28/15 121 cfs	121	1988.12	1991.92		1990.078	1991.949	0.002394	1.36	88.8	51.14	0.18
E-CH-ALIGI	6017.1	6/22/15 71 cfs	71	1988.12	1991.449		1989.716	1991.467	0.001773	1.07	66.35	43.97	0.15
E-CH-ALIGI	6017.1	7/29/15 46 cfs	46	1988.12	1991.104		1989.463	1991.116	0.001379	0.88	52.14	38.33	0.13
E-CH-ALIGI	5870.54	Lidar 296-cfs	296	1989.33	1992.185	1991.57	1991.241	1992.267	0.004681	2.29	129.38	92.72	0.34
E-CH-ALIGI	5870.54	10/9 25-cfs	25	1989.33	1990.444	1990.3	1990.011	1990.469	0.004354	1.27	19.61	32.16	0.29
E-CH-ALIGI	5870.54	10/24 471-cfs	471	1989.33	1992.728	1992.2	1991.606	1992.834	0.004118	2.6	180.87	96.87	0.34
E-CH-ALIGI	5870.54	11/22 1437-cfs	1437	1989.33	1994.579	1993.96	1992.765	1994.813	0.004063	3.88	370.16	107.33	0.37
E-CH-ALIGI	5870.54	12/12 1072 cfs	1072	1989.33	1994.021	1993.29	1992.412	1994.205	0.003878	3.45	311.08	104.28	0.35
E-CH-ALIGI	5870.54	12/21 2083 cfs	2083	1989.33	1995.383	1994.89	1993.295	1995.703	0.004492	4.54	458.83	113.31	0.4
E-CH-ALIGI	5870.54	10/21 114 cfs	114	1989.33	1991.316		1990.583	1991.372	0.005565	1.91	59.57	63.44	0.35
E-CH-ALIGI	5870.54	2/6 4300 cfs	4300	1989.33	1997.356	1997.91	1994.837	1997.948	0.005573	6.18	696	126.95	0.46
E-CH-ALIGI	5870.54	4/1/15 268 cfs	268	1989.33	1992.086		1991.167	1992.163	0.004847	2.23	120.22	91.95	0.34
E-CH-ALIGI	5870.54	4/26/15 173 cfs	173	1989.33	1991.664		1990.855	1991.73	0.005312	2.05	84.22	77.9	0.35
E-CH-ALIGI	5870.54	5/28/15 121 cfs	121	1989.33	1991.363		1990.609	1991.421	0.005531	1.93	62.62	65.4	0.35
E-CH-ALIGI	5870.54	6/22/15 71 cfs	71	1989.33	1990.983		1990.363	1991.03	0.005492	1.74	40.79	49.61	0.34

Kelly Bar HEC-RAS Calibration Modeling													
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Obs WS	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
E-CH-ALIGI	5870.54	7/29/15 46 cfs	46	1989.33	1990.716		1990.202	1990.755	0.005083	1.58	29.04	38.42	0.32
E-CH-ALIGI	5669.96	Lidar 296-cfs	296	1988.82	1991.389	1990.87	1990.252	1991.466	0.003423	2.23	132.84	77.09	0.3
E-CH-ALIGI	5669.96	10/9 25-cfs	25	1988.82	1989.77	1989.8	1989.349	1989.783	0.002716	0.91	27.58	53.09	0.22
E-CH-ALIGI	5669.96	10/24 471-cfs	471	1988.82	1991.895	1991.2	1990.593	1992.009	0.004093	2.71	174.05	86.31	0.34
E-CH-ALIGI	5669.96	11/22 1437-cfs	1437	1988.82	1993.556	1992.51	1991.932	1993.819	0.005963	4.12	349.17	123.16	0.43
E-CH-ALIGI	5669.96	12/12 1072 cfs	1072	1988.82	1993.036	1991.92	1991.502	1993.252	0.005725	3.73	287.47	113.93	0.41
E-CH-ALIGI	5669.96	12/21 2083 cfs	2083	1988.82	1994.329	1994.14	1992.623	1994.666	0.005912	4.66	447.29	130.21	0.44
E-CH-ALIGI	5669.96	10/21 114 cfs	114	1988.82	1990.577		1989.773	1990.613	0.002657	1.52	75.21	64.99	0.25
E-CH-ALIGI	5669.96	2/6 4300 cfs	4300	1988.82	1996.173	1995.26	1994.087	1996.651	0.006606	5.56	800.65	251.35	0.48
E-CH-ALIGI	5669.96	4/1/15 268 cfs	268	1988.82	1991.283		1990.185	1991.355	0.003355	2.15	124.79	75.43	0.29
E-CH-ALIGI	5669.96	4/26/15 173 cfs	173	1988.82	1990.879		1989.952	1990.93	0.003046	1.81	95.49	69.48	0.27
E-CH-ALIGI	5669.96	5/28/15 121 cfs	121	1988.82	1990.616		1989.79	1990.654	0.002716	1.56	77.76	65.58	0.25
E-CH-ALIGI	5669.96	6/22/15 71 cfs	71	1988.82	1990.252		1989.626	1990.278	0.002635	1.29	54.88	60.15	0.24
E-CH-ALIGI	5669.96	7/29/15 46 cfs	46	1988.82	1990.032		1989.494	1990.051	0.002502	1.1	41.97	56.92	0.22
E-CH-ALIGI	5520.76	Lidar 296-cfs	296	1988.28	1990.859	1990.49	1989.862	1990.919	0.003777	1.97	150.1	114.5	0.3
E-CH-ALIGI	5520.76	10/9 25-cfs	25	1988.28	1989.37	1989.3	1988.88	1989.383	0.002695	0.93	26.92	49.92	0.22
E-CH-ALIGI	5520.76	10/24 471-cfs	471	1988.28	1991.325	1990.8	1990.198	1991.405	0.003742	2.27	207.67	127.54	0.31
E-CH-ALIGI	5520.76	11/22 1437-cfs	1437	1988.28	1992.849	1992.31	1991.28	1993.038	0.00406	3.49	411.55	140.43	0.36
E-CH-ALIGI	5520.76	12/12 1072 cfs	1072	1988.28	1992.343	1991.81	1990.967	1992.496	0.004043	3.14	341.53	136.36	0.35
E-CH-ALIGI	5520.76	12/21 2083 cfs	2083	1988.28	1993.638	1993.11	1991.743	1993.883	0.003985	3.97	524.34	145.18	0.37
E-CH-ALIGI	5520.76	10/21 114 cfs	114	1988.28	1990.136		1989.37	1990.168	0.003259	1.43	79.58	88.23	0.27
E-CH-ALIGI	5520.76	2/6 4300 cfs	4300	1988.28	1995.343	1994.96	1992.979	1995.807	0.004798	5.47	796.46	180.15	0.43
E-CH-ALIGI	5520.76	4/1/15 268 cfs	268	1988.28	1990.766		1989.809	1990.823	0.003665	1.92	139.68	108.57	0.3
E-CH-ALIGI	5520.76	4/26/15 173 cfs	173	1988.28	1990.408		1989.575	1990.451	0.003283	1.66	104.11	92.63	0.28
E-CH-ALIGI	5520.76	5/28/15 121 cfs	121	1988.28	1990.171		1989.41	1990.204	0.003259	1.46	82.67	88.7	0.27
E-CH-ALIGI	5520.76	6/22/15 71 cfs	71	1988.28	1989.834		1989.187	1989.859	0.003012	1.26	56.16	70.92	0.25
E-CH-ALIGI	5520.76	7/29/15 46 cfs	46	1988.28	1989.631		1989.03	1989.649	0.002964	1.09	42.18	65.86	0.24
E-CH-ALIGI	5378.5	Lidar 296-cfs	296	1988.13	1990.212	1989.71	1989.424	1990.291	0.005085	2.25	131.85	104.58	0.35
E-CH-ALIGI	5378.5	10/9 25-cfs	25	1988.13	1988.871		1988.532	1988.889	0.004596	1.09	23.03	50.46	0.28
E-CH-ALIGI	5378.5	10/24 471-cfs	471	1988.13	1990.609		1989.748	1990.718	0.00617	2.65	177.83	127.22	0.39
E-CH-ALIGI	5378.5	11/22 1437-cfs	1437	1988.13	1992.188		1990.798	1992.399	0.004828	3.68	390.33	141.44	0.39
E-CH-ALIGI	5378.5	12/12 1072 cfs	1072	1988.13	1991.654		1990.512	1991.832	0.005179	3.39	316.06	136.6	0.39
E-CH-ALIGI	5378.5	12/21 2083 cfs	2083	1988.13	1993.007		1991.263	1993.265	0.004654	4.07	511.67	155.4	0.39
E-CH-ALIGI	5378.5	10/21 114 cfs	114	1988.13	1989.542		1988.974	1989.586	0.005018	1.68	67.96	82.74	0.33
E-CH-ALIGI	5378.5	2/6 4300 cfs	4300	1988.13	1994.619		1992.528	1995.091	0.005219	5.54	807.33	202.99	0.45
E-CH-ALIGI	5378.5	4/1/15 268 cfs	268	1988.13	1990.134		1989.375	1990.207	0.005053	2.17	123.75	103.12	0.35
E-CH-ALIGI	5378.5	4/26/15 173 cfs	173	1988.13	1989.813		1989.135	1989.868	0.005132	1.88	91.97	95.81	0.34
E-CH-ALIGI	5378.5	5/28/15 121 cfs	121	1988.13	1989.58		1988.993	1989.625	0.005011	1.7	71.14	84.72	0.33
E-CH-ALIGI	5378.5	6/22/15 71 cfs	71	1988.13	1989.283		1988.793	1989.317	0.004907	1.47	48.23	70.24	0.31
E-CH-ALIGI	5378.5	7/29/15 46 cfs	46	1988.13	1989.091		1988.663	1989.117	0.004793	1.3	35.52	61.61	0.3
E-CH-ALIGI	5281.81	Lidar 296-cfs	296	1986.84	1988.332	1988.57	1988.332	1988.761	0.121395	5.26	56.32	64.4	0.99
E-CH-ALIGI	5281.81	10/9 25-cfs	25	1986.84	1987.368		1987.368	1987.501	0.190968	2.92	8.55	33.13	1.01
E-CH-ALIGI	5281.81	10/24 471-cfs	471	1986.84	1989.053		1988.657	1989.355	0.044798	4.41	106.8	74.44	0.65
E-CH-ALIGI	5281.81	11/22 1437-cfs	1437	1986.84	1990.976		1989.933	1991.379	0.027135	5.09	282.28	108.69	0.56
E-CH-ALIGI	5281.81	12/12 1072 cfs	1072	1986.84	1990.356		1989.531	1990.73	0.030633	4.9	218.6	97.43	0.58
E-CH-ALIGI	5281.81	12/21 2083 cfs	2083	1986.84	1991.857		1990.551	1992.284	0.026623	5.25	397.36	149.22	0.56
E-CH-ALIGI	5281.81	10/21 114 cfs	114	1986.84	1987.81		1987.81	1988.086	0.145588	4.21	27.07	49.48	1
E-CH-ALIGI	5281.81	2/6 4300 cfs	4300	1986.84	1993.868		1992.18	1994.274	0.013584	5.39	904.63	398.99	0.44
E-CH-ALIGI	5281.81	4/1/15 268 cfs	268	1986.84	1988.246		1988.246	1988.675	0.125463	5.26	50.98	59.71	1
E-CH-ALIGI	5281.81	4/26/15 173 cfs	173	1986.84	1987.999		1987.999	1988.34	0.136413	4.68	36.95	54.86	1.01
E-CH-ALIGI	5281.81	5/28/15 121 cfs	121	1986.84	1987.835		1987.835	1988.119	0.144735	4.28	28.3	50.32	1
E-CH-ALIGI	5281.81	6/22/15 71 cfs	71	1986.84	1987.637		1987.637	1987.854	0.154526	3.73	19.02	43.58	1
E-CH-ALIGI	5281.81	7/29/15 46 cfs	46	1986.84	1987.512		1987.512	1987.684	0.163806	3.33	13.82	39.3	0.99
E-CH-ALIGI	5199.22	Lidar 296-cfs	296	1982.78	1986.566	1985.65	1985.082	1986.676	0.009071	2.66	111.14	49.67	0.31
E-CH-ALIGI	5199.22	10/9 25-cfs	25	1982.78	1984.55		1983.621	1984.562	0.003657	0.89	28.09	33.18	0.17
E-CH-ALIGI	5199.22	10/24 471-cfs	471	1982.78	1987.304		1985.561	1987.45	0.012799	3.07	153.55	72.07	0.37
E-CH-ALIGI	5199.22	11/22 1437-cfs	1437	1982.78	1989.411		1987.509	1989.709	0.014472	4.37	328.57	99.06	0.42
E-CH-ALIGI	5199.22	12/12 1072 cfs	1072	1982.78	1988.748		1986.788	1988.999	0.013988	4.02	266.78	87.58	0.41
E-CH-ALIGI	5199.22	12/21 2083 cfs	2083	1982.78	1990.372		1988.187	1990.737	0.01322	4.87	439.61	130.3	0.42
E-CH-ALIGI	5199.22	10/21 114 cfs	114	1982.78	1985.646		1984.374	1985.688	0.005176	1.65	69.17	41.8	0.23
E-CH-ALIGI	5199.22	2/6 4300 cfs	4300	1982.78	1992.739		1990.087	1993.236	0.010728	5.9	853.93	229.33	0.4
E-CH-ALIGI	5199.22	4/1/15 268 cfs	268	1982.78	1986.462		1984.994	1986.561	0.00848	2.53	106.04	48.74	0.3
E-CH-ALIGI	5199.22	4/26/15 173 cfs	173	1982.78	1986.087		1984.656	1986.146	0.005893	1.96	88.37	45.4	0.25
E-CH-ALIGI	5199.22	5/28/15 121 cfs	121	1982.78	1985.704		1984.411	1985.748	0.00527	1.69	71.62	42.26	0.23

Kelly Bar HEC-RAS Calibration Modeling													
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Obs WS	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
E-CH-ALIGI	5199.22	6/22/15 71 cfs	71	1982.78	1985.23		1984.088	1985.259	0.004509	1.35	52.48	38.53	0.2
E-CH-ALIGI	5199.22	7/29/15 46 cfs	46	1982.78	1984.911		1983.864	1984.931	0.004063	1.13	40.59	36.02	0.19
E-CH-ALIGI	5100.4	Lidar 296-cfs	296	1982.44	1984.839	1984.68	1984.353	1985.05	0.035046	3.69	80.29	61.36	0.57
E-CH-ALIGI	5100.4	10/9 25-cfs	25	1982.44	1983.184		1983.184	1983.374	0.160734	3.5	7.13	18.46	0.99
E-CH-ALIGI	5100.4	10/24 471-cfs	471	1982.44	1985.564		1984.741	1985.772	0.022431	3.66	128.79	71.19	0.48
E-CH-ALIGI	5100.4	11/22 1437-cfs	1437	1982.44	1988.177		1986.131	1988.424	0.011161	3.98	360.72	102.86	0.37
E-CH-ALIGI	5100.4	12/12 1072 cfs	1072	1982.44	1987.345		1985.688	1987.579	0.014441	3.88	276.07	99.82	0.41
E-CH-ALIGI	5100.4	12/21 2083 cfs	2083	1982.44	1989.274		1986.796	1989.573	0.009801	4.39	474.77	105.44	0.36
E-CH-ALIGI	5100.4	10/21 114 cfs	114	1982.44	1983.811		1983.811	1984.115	0.139505	4.42	25.79	42.37	1
E-CH-ALIGI	5100.4	2/6 4300 cfs	4300	1982.44	1991.813		1988.465	1992.254	0.008538	5.45	876.78	203.37	0.37
E-CH-ALIGI	5100.4	4/1/15 268 cfs	268	1982.44	1984.673		1984.29	1984.899	0.042067	3.81	70.36	58.73	0.61
E-CH-ALIGI	5100.4	4/26/15 173 cfs	173	1982.44	1984.018		1984.018	1984.391	0.134521	4.9	35.31	48.36	1.01
E-CH-ALIGI	5100.4	5/28/15 121 cfs	121	1982.44	1983.839		1983.839	1984.151	0.139279	4.48	27.01	43.45	1
E-CH-ALIGI	5100.4	6/22/15 71 cfs	71	1982.44	1983.598		1983.598	1983.85	0.144458	4.03	17.62	34.13	0.99
E-CH-ALIGI	5100.4	7/29/15 46 cfs	46	1982.44	1983.41		1983.41	1983.639	0.151273	3.84	11.98	25.83	0.99
E-CH-ALIGI	5019.2	Lidar 296-cfs	296	1976.56	1984.666	1984.4	1980.065	1984.69	0.000957	1.27	233.84	56.03	0.11
E-CH-ALIGI	5019.2	10/9 25-cfs	25	1976.56	1982.304	1982.1	1977.781	1982.305	0.000054	0.22	115.36	46.36	0.02
E-CH-ALIGI	5019.2	10/24 471-cfs	471	1976.56	1985.269	1985.5	1980.783	1985.316	0.001726	1.75	269.34	62.09	0.15
E-CH-ALIGI	5019.2	11/22 1437-cfs	1437	1976.56	1987.622	1987.97	1982.943	1987.781	0.004987	3.21	447.91	93.22	0.26
E-CH-ALIGI	5019.2	12/12 1072 cfs	1072	1976.56	1986.83	1987.07	1982.379	1986.955	0.003891	2.83	379.13	78.89	0.23
E-CH-ALIGI	5019.2	12/21 2083 cfs	2083	1976.56	1988.702	1989.47	1983.84	1988.924	0.005691	3.78	550.78	99.29	0.28
E-CH-ALIGI	5019.2	10/21 114 cfs	114	1976.56	1983.496		1978.892	1983.503	0.000331	0.66	172.84	49.98	0.06
E-CH-ALIGI	5019.2	2/6 4300 cfs	4300	1976.56	1991.21	1992	1986.473	1991.623	0.006687	5.22	873.39	146.01	0.32
E-CH-ALIGI	5019.2	4/1/15 268 cfs	268	1976.56	1984.521		1979.939	1984.543	0.000856	1.19	225.83	54.83	0.1
E-CH-ALIGI	5019.2	4/26/15 173 cfs	173	1976.56	1983.911		1979.356	1983.923	0.00054	0.89	193.81	51.18	0.08
E-CH-ALIGI	5019.2	5/28/15 121 cfs	121	1976.56	1983.551		1978.952	1983.558	0.000355	0.69	175.57	50.14	0.06
E-CH-ALIGI	5019.2	6/22/15 71 cfs	71	1976.56	1983.129		1978.465	1983.132	0.000179	0.46	154.66	48.92	0.05
E-CH-ALIGI	5019.2	7/29/15 46 cfs	46	1976.56	1982.756		1978.15	1982.758	0.00011	0.34	136.62	47.84	0.04
E-CH-ALIGI	4908.06	Lidar 296-cfs	296	1980.94	1984.364	1984.03	1982.984	1984.435	0.007681	2.14	138.03	74.62	0.28
E-CH-ALIGI	4908.06	10/9 25-cfs	25	1980.94	1982.263		1981.492	1982.278	0.004486	0.99	25.28	29.28	0.19
E-CH-ALIGI	4908.06	10/24 471-cfs	471	1980.94	1984.772		1983.341	1984.892	0.010487	2.78	169.6	78.55	0.33
E-CH-ALIGI	4908.06	11/22 1437-cfs	1437	1980.94	1986.466		1984.803	1986.798	0.015213	4.63	310.56	87.98	0.43
E-CH-ALIGI	4908.06	12/12 1072 cfs	1072	1980.94	1985.859		1984.382	1986.127	0.014822	4.15	258.24	84.56	0.42
E-CH-ALIGI	4908.06	12/21 2083 cfs	2083	1980.94	1987.45		1985.438	1987.849	0.015745	5.07	410.9	104.36	0.45
E-CH-ALIGI	4908.06	10/21 114 cfs	114	1980.94	1983.355		1982.163	1983.391	0.006299	1.53	74.64	57.94	0.24
E-CH-ALIGI	4908.06	2/6 4300 cfs	4300	1980.94	1989.775		1987.252	1990.446	0.014269	6.57	655.73	106.28	0.46
E-CH-ALIGI	4908.06	4/1/15 268 cfs	268	1980.94	1984.241		1982.871	1984.308	0.00749	2.08	129.07	71.81	0.27
E-CH-ALIGI	4908.06	4/26/15 173 cfs	173	1980.94	1983.707		1982.454	1983.758	0.006679	1.81	95.32	59.49	0.25
E-CH-ALIGI	4908.06	5/28/15 121 cfs	121	1980.94	1983.402		1982.203	1983.44	0.006334	1.56	77.35	58.14	0.24
E-CH-ALIGI	4908.06	6/22/15 71 cfs	71	1980.94	1983.039		1981.896	1983.063	0.005942	1.26	56.54	56.55	0.22
E-CH-ALIGI	4908.06	7/29/15 46 cfs	46	1980.94	1982.69		1981.695	1982.711	0.005277	1.16	39.49	40.37	0.21
E-CH-ALIGI	4788.28	Lidar 296-cfs	296	1979.78	1981.428	1982.28	1981.428	1981.886	0.122445	5.43	54.5	59.13	1
E-CH-ALIGI	4788.28	10/9 25-cfs	25	1979.78	1980.456		1980.456	1980.604	0.182015	3.09	8.09	27.82	1.01
E-CH-ALIGI	4788.28	10/24 471-cfs	471	1979.78	1982.279		1981.761	1982.558	0.043154	4.23	111.23	79.34	0.63
E-CH-ALIGI	4788.28	11/22 1437-cfs	1437	1979.78	1984.691		1983.061	1984.998	0.014558	4.45	322.97	93.69	0.42
E-CH-ALIGI	4788.28	12/12 1072 cfs	1072	1979.78	1983.938		1982.692	1984.215	0.017093	4.22	253.78	89.94	0.44
E-CH-ALIGI	4788.28	12/21 2083 cfs	2083	1979.78	1985.69		1983.66	1986.074	0.013802	4.97	418.83	98.4	0.42
E-CH-ALIGI	4788.28	10/21 114 cfs	114	1979.78	1980.943		1980.943	1981.213	0.142287	4.17	27.35	49.76	0.99
E-CH-ALIGI	4788.28	2/6 4300 cfs	4300	1979.78	1988.031		1985.322	1988.682	0.015009	6.47	664.1	111.05	0.47
E-CH-ALIGI	4788.28	4/1/15 268 cfs	268	1979.78	1981.364		1981.364	1981.798	0.127188	5.28	50.71	59.1	1.01
E-CH-ALIGI	4788.28	4/26/15 173 cfs	173	1979.78	1981.128		1981.128	1981.465	0.13686	4.66	37.1	55.3	1
E-CH-ALIGI	4788.28	5/28/15 121 cfs	121	1979.78	1980.968		1980.968	1981.246	0.141556	4.23	28.59	50.64	0.99
E-CH-ALIGI	4788.28	6/22/15 71 cfs	71	1979.78	1980.761		1980.761	1980.98	0.155118	3.76	18.88	42.84	1
E-CH-ALIGI	4788.28	7/29/15 46 cfs	46	1979.78	1980.618		1980.618	1980.805	0.166867	3.47	13.25	35.84	1.01
E-CH-ALIGI	4705.16	Lidar 296-cfs	296	1973.62	1981.255	1981.11	1975.503	1981.277	0.000671	1.17	253.97	51.24	0.09
E-CH-ALIGI	4705.16	10/9 25-cfs	25	1973.62	1979.355		1974.105	1979.355	0.000013	0.15	168.57	40.42	0.01
E-CH-ALIGI	4705.16	10/24 471-cfs	471	1973.62	1982.02		1976.093	1982.057	0.001386	1.55	303.06	69.95	0.13
E-CH-ALIGI	4705.16	11/22 1437-cfs	1437	1973.62	1984.174		1978.381	1984.318	0.00393	3.05	471.41	87.1	0.23
E-CH-ALIGI	4705.16	12/12 1072 cfs	1072	1973.62	1983.487		1977.645	1983.591	0.003063	2.59	414.01	80.88	0.2
E-CH-ALIGI	4705.16	12/21 2083 cfs	2083	1973.62	1985.049		1979.602	1985.266	0.005548	3.74	565.22	128.22	0.28
E-CH-ALIGI	4705.16	10/21 114 cfs	114	1973.62	1980.216		1974.695	1980.221	0.000163	0.55	205.5	43.97	0.05
E-CH-ALIGI	4705.16	2/6 4300 cfs	4300	1973.62	1987.266		1982.695	1987.687	0.007186	5.31	869.25	145.02	0.33
E-CH-ALIGI	4705.16	4/1/15 268 cfs	268	1973.62	1981.116		1975.374	1981.135	0.000561	1.08	247.13	48.38	0.08
E-CH-ALIGI	4705.16	4/26/15 173 cfs	173	1973.62	1980.601		1974.999	1980.61	0.000308	0.78	222.74	46.22	0.06

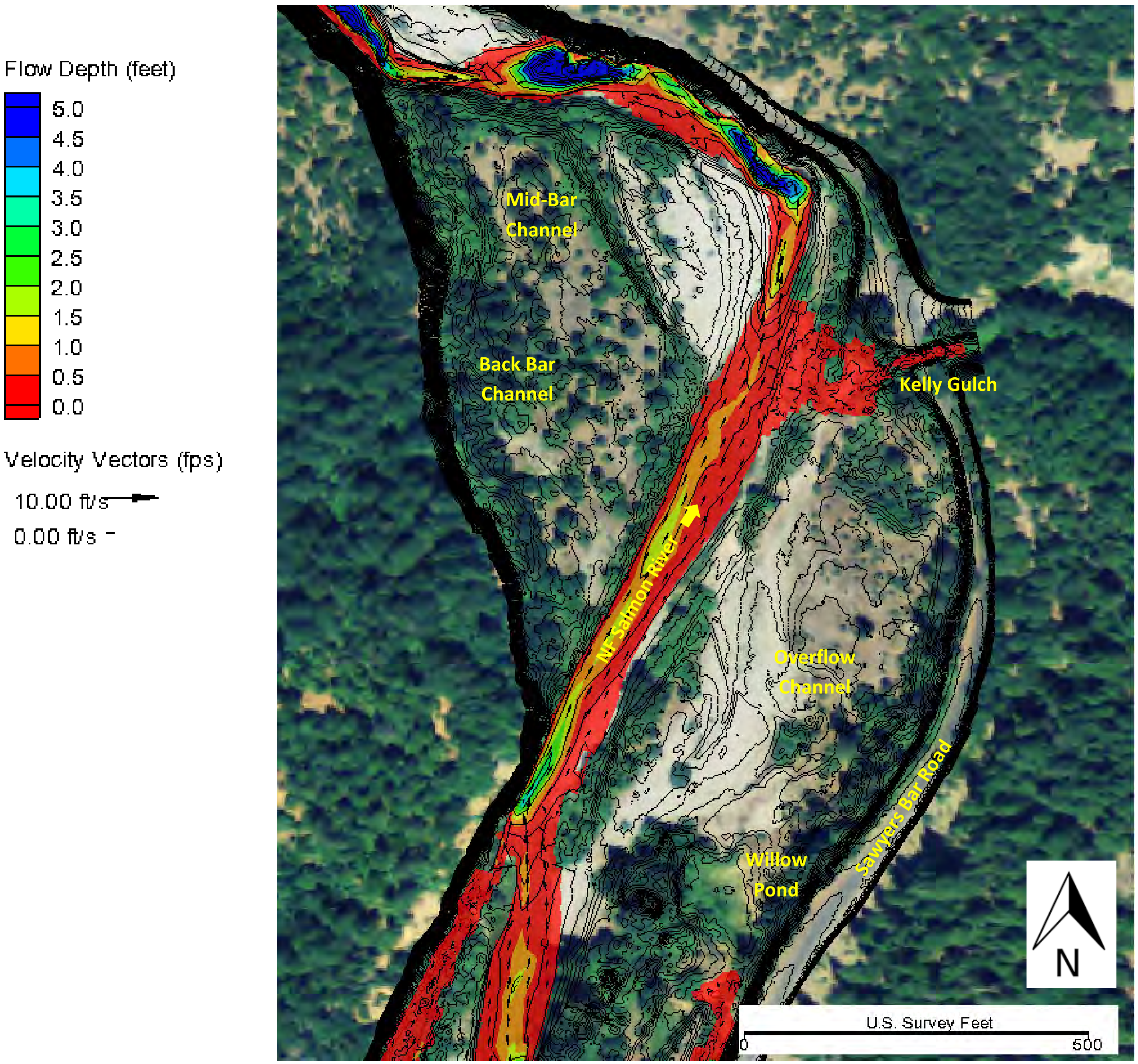
Kelly Bar HEC-RAS Calibration Modeling													
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Obs WS	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
E-CH-ALIGI	4705.16	5/28/15 121 cfs	121	1973.62	1980.262		1974.736	1980.267	0.000178	0.58	207.54	44	0.05
E-CH-ALIGI	4705.16	6/22/15 71 cfs	71	1973.62	1979.886		1974.457	1979.888	0.000079	0.37	191	43.82	0.03
E-CH-ALIGI	4705.16	7/29/15 46 cfs	46	1973.62	1979.633		1974.278	1979.634	0.000039	0.26	180.08	42.4	0.02
E-CH-ALIGI	4625.47	Lidar 296-cfs	296	1971.52	1981.222	1981.24	1974.896	1981.23	0.000351	0.76	389.76	97.24	0.07
E-CH-ALIGI	4625.47	10/9 25-cfs	25	1971.52	1979.354		1972.724	1979.355	0.000007	0.1	240.04	65.2	0.01
E-CH-ALIGI	4625.47	10/24 471-cfs	471	1971.52	1981.96		1975.534	1981.976	0.000561	1.01	465.15	107.28	0.09
E-CH-ALIGI	4625.47	11/22 1437-cfs	1437	1971.52	1984.009		1977.635	1984.075	0.001582	2.06	696.02	119.59	0.15
E-CH-ALIGI	4625.47	12/12 1072 cfs	1072	1971.52	1983.358		1976.977	1983.405	0.001215	1.73	620.08	114.12	0.13
E-CH-ALIGI	4625.47	12/21 2083 cfs	2083	1971.52	1984.815		1978.654	1984.922	0.002239	2.62	794.3	123.4	0.18
E-CH-ALIGI	4625.47	10/21 114 cfs	114	1971.52	1980.207		1973.782	1980.209	0.000092	0.38	301.67	79.14	0.03
E-CH-ALIGI	4625.47	2/6 4300 cfs	4300	1971.52	1986.898		1981.136	1987.155	0.003986	4.06	1058.76	130.61	0.25
E-CH-ALIGI	4625.47	4/1/15 268 cfs	268	1971.52	1981.087		1974.755	1981.094	0.000316	0.71	376.72	95.87	0.06
E-CH-ALIGI	4625.47	4/26/15 173 cfs	173	1971.52	1980.585		1974.242	1980.589	0.000166	0.52	332.41	83.6	0.05
E-CH-ALIGI	4625.47	5/28/15 121 cfs	121	1971.52	1980.253		1973.835	1980.255	0.000101	0.4	305.27	79.67	0.04
E-CH-ALIGI	4625.47	6/22/15 71 cfs	71	1971.52	1979.881		1973.362	1979.882	0.000044	0.26	276.51	75.36	0.02
E-CH-ALIGI	4625.47	7/29/15 46 cfs	46	1971.52	1979.631		1973.058	1979.631	0.000021	0.18	258.53	68.68	0.02
E-CH-ALIGI	4589.12	Lidar 296-cfs	296	1978.32	1981.085	1981.11	1979.957	1981.161	0.008579	2.22	133.6	74.86	0.29
E-CH-ALIGI	4589.12	10/9 25-cfs	25	1978.32	1979.318		1978.955	1979.342	0.016543	1.23	20.29	45.82	0.33
E-CH-ALIGI	4589.12	10/24 471-cfs	471	1978.32	1981.797		1980.299	1981.887	0.008267	2.41	195.26	92.96	0.29
E-CH-ALIGI	4589.12	11/22 1437-cfs	1437	1978.32	1983.678		1981.64	1983.885	0.010705	3.65	393.96	121.27	0.36
E-CH-ALIGI	4589.12	12/12 1072 cfs	1072	1978.32	1983.076		1981.149	1983.246	0.010061	3.31	324.29	110.5	0.34
E-CH-ALIGI	4589.12	12/21 2083 cfs	2083	1978.32	1984.381		1982.232	1984.671	0.012356	4.32	482.56	128.35	0.39
E-CH-ALIGI	4589.12	10/21 114 cfs	114	1978.32	1980.13		1979.466	1980.176	0.010555	1.72	66.2	64.47	0.3
E-CH-ALIGI	4589.12	2/6 4300 cfs	4300	1978.32	1986.212		1983.854	1986.758	0.014823	5.93	724.91	136.54	0.45
E-CH-ALIGI	4589.12	4/1/15 268 cfs	268	1978.32	1980.957		1979.894	1981.03	0.008811	2.16	124.08	73.88	0.29
E-CH-ALIGI	4589.12	4/26/15 173 cfs	173	1978.32	1980.486		1979.647	1980.544	0.009806	1.92	90.14	70.17	0.3
E-CH-ALIGI	4589.12	5/28/15 121 cfs	121	1978.32	1980.172		1979.479	1980.22	0.010526	1.76	68.92	65.05	0.3
E-CH-ALIGI	4589.12	6/22/15 71 cfs	71	1978.32	1979.824		1979.296	1979.86	0.011541	1.51	47.13	60.1	0.3
E-CH-ALIGI	4589.12	7/29/15 46 cfs	46	1978.32	1979.585		1979.141	1979.614	0.01288	1.37	33.53	53.44	0.31
E-CH-ALIGI	4536.1	Lidar 296-cfs	296	1977.13	1979.823	1980.26	1979.546	1980.266	0.023735	5.34	55.42	36.94	0.77
E-CH-ALIGI	4536.1	10/9 25-cfs	25	1977.13	1978.18		1977.984	1978.305	0.021298	2.83	8.82	14.3	0.64
E-CH-ALIGI	4536.1	10/24 471-cfs	471	1977.13	1980.459		1980.067	1980.979	0.023559	5.78	81.43	47.7	0.78
E-CH-ALIGI	4536.1	11/22 1437-cfs	1437	1977.13	1983.132		1981.851	1983.399	0.007049	4.14	346.82	135.24	0.46
E-CH-ALIGI	4536.1	12/12 1072 cfs	1072	1977.13	1982.334		1981.468	1982.633	0.010603	4.39	244.04	119.1	0.54
E-CH-ALIGI	4536.1	12/21 2083 cfs	2083	1977.13	1983.811		1982.39	1984.16	0.006951	4.74	439.65	138.42	0.47
E-CH-ALIGI	4536.1	10/21 114 cfs	114	1977.13	1979.018		1978.819	1979.266	0.024146	4	28.51	30.1	0.72
E-CH-ALIGI	4536.1	2/6 4300 cfs	4300	1977.13	1985.64		1983.741	1986.225	0.006798	6.14	700.86	146.52	0.49
E-CH-ALIGI	4536.1	4/1/15 268 cfs	268	1977.13	1979.73		1979.454	1980.142	0.023252	5.15	52.05	36.11	0.76
E-CH-ALIGI	4536.1	4/26/15 173 cfs	173	1977.13	1979.324		1979.086	1979.644	0.023743	4.54	38.1	32.59	0.74
E-CH-ALIGI	4536.1	5/28/15 121 cfs	121	1977.13	1979.068		1978.854	1979.32	0.023349	4.03	30.02	30.51	0.72
E-CH-ALIGI	4536.1	6/22/15 71 cfs	71	1977.13	1978.754		1978.535	1978.934	0.023858	3.41	20.84	27.96	0.7
E-CH-ALIGI	4536.1	7/29/15 46 cfs	46	1977.13	1978.521		1978.27	1978.668	0.022318	3.08	14.95	22.26	0.66
E-CH-ALIGI	4470.01	Lidar 296-cfs	296	1974.95	1977.426	1977.91	1977.397	1978.175	0.03755	6.95	42.61	26.73	0.97
E-CH-ALIGI	4470.01	10/9 25-cfs	25	1974.95	1975.851		1975.851	1976.074	0.057486	3.79	6.6	14.61	0.99
E-CH-ALIGI	4470.01	10/24 471-cfs	471	1974.95	1978.134		1977.995	1979.018	0.031044	7.55	62.42	29.4	0.91
E-CH-ALIGI	4470.01	11/22 1437-cfs	1437	1974.95	1980.721		1980.539	1982.034	0.029498	9.2	156.27	53.02	0.94
E-CH-ALIGI	4470.01	12/12 1072 cfs	1072	1974.95	1979.841		1979.535	1981.113	0.025371	9.05	118.46	36.13	0.88
E-CH-ALIGI	4470.01	12/21 2083 cfs	2083	1974.95	1982.135		1981.651	1983.12	0.019616	7.97	264.12	98.1	0.79
E-CH-ALIGI	4470.01	10/21 114 cfs	114	1974.95	1976.611		1976.611	1977.041	0.045793	5.26	21.67	24.67	0.99
E-CH-ALIGI	4470.01	2/6 4300 cfs	4300	1974.95	1984.609		1983.503	1985.526	0.009729	8.12	658.64	162.51	0.61
E-CH-ALIGI	4470.01	4/1/15 268 cfs	268	1974.95	1977.293		1977.271	1978.022	0.039629	6.85	39.11	26.12	0.99
E-CH-ALIGI	4470.01	4/26/15 173 cfs	173	1974.95	1976.896		1976.896	1977.453	0.043052	5.99	28.87	25.57	0.99
E-CH-ALIGI	4470.01	5/28/15 121 cfs	121	1974.95	1976.637		1976.637	1977.093	0.047052	5.42	22.33	24.8	1.01
E-CH-ALIGI	4470.01	6/22/15 71 cfs	71	1974.95	1976.321		1976.321	1976.669	0.048919	4.73	15	21.07	0.99
E-CH-ALIGI	4470.01	7/29/15 46 cfs	46	1974.95	1976.088		1976.088	1976.388	0.054917	4.4	10.46	17.9	1.01
E-CH-ALIGI	4390.29	Lidar 296-cfs	296	1971.11	1977.247	1977.36	1974.606	1977.328	0.001761	2.28	129.56	42	0.23
E-CH-ALIGI	4390.29	10/9 25-cfs	25	1971.11	1975.594		1972.366	1975.596	0.000075	0.39	63.76	28.01	0.05
E-CH-ALIGI	4390.29	10/24 471-cfs	471	1971.11	1977.868		1975.332	1978.01	0.00253	3.02	155.98	43.05	0.28
E-CH-ALIGI	4390.29	11/22 1437-cfs	1437	1971.11	1980.146		1977.481	1980.623	0.005239	5.54	259.28	47.66	0.42
E-CH-ALIGI	4390.29	12/12 1072 cfs	1072	1971.11	1979.417		1976.883	1979.769	0.004407	4.76	225.1	46.19	0.38
E-CH-ALIGI	4390.29	12/21 2083 cfs	2083	1971.11	1981.288		1978.458	1981.932	0.007987	6.44	323.49	67.93	0.51
E-CH-ALIGI	4390.29	10/21 114 cfs	114	1971.11	1976.382		1973.468	1976.405	0.000711	1.21	93.84	40.61	0.14
E-CH-ALIGI	4390.29	2/6 4300 cfs	4300	1971.11	1984.02		1981.531	1984.836	0.006343	7.62	728.12	166.34	0.49
E-CH-ALIGI	4390.29	4/1/15 268 cfs	268	1971.11	1977.133		1974.48	1977.204	0.001621	2.15	124.79	41.82	0.22

Kelly Bar HEC-RAS Calibration Modeling												
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Obs WS	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
E-CH-ALIGI	4390.29	4/26/15 173 cfs	173	1971.11	1976.705		1973.915	1976.745	0.001086	1.62	107.04	41.13	0.18
E-CH-ALIGI	4390.29	5/28/15 121 cfs	121	1971.11	1976.423		1973.511	1976.448	0.000758	1.27	95.53	40.68	0.15
E-CH-ALIGI	4390.29	6/22/15 71 cfs	71	1971.11	1976.097		1973.055	1976.109	0.000416	0.86	82.35	40.16	0.11
E-CH-ALIGI	4390.29	7/29/15 46 cfs	46	1971.11	1975.894		1972.718	1975.9	0.00024	0.62	74.21	39.47	0.08
E-CH-ALIGI	4251.07	Lidar 296-cfs	296	1969.85	1977.2	1977.51	1972.686	1977.216	0.000217	1.02	289.01	65.04	0.09
E-CH-ALIGI	4251.07	10/9 25-cfs	25	1969.85	1975.593		1970.908	1975.593	0.000005	0.13	186.83	55.63	0.01
E-CH-ALIGI	4251.07	10/24 471-cfs	471	1969.85	1977.793		1973.114	1977.825	0.000371	1.44	327.79	65.75	0.11
E-CH-ALIGI	4251.07	11/22 1437-cfs	1437	1969.85	1979.953		1974.866	1980.096	0.001127	3.04	472.58	68.33	0.2
E-CH-ALIGI	4251.07	12/12 1072 cfs	1072	1969.85	1979.263		1974.285	1979.361	0.000862	2.52	425.71	67.51	0.18
E-CH-ALIGI	4251.07	12/21 2083 cfs	2083	1969.85	1980.99		1975.877	1981.217	0.001588	3.82	545.05	71.82	0.24
E-CH-ALIGI	4251.07	10/21 114 cfs	114	1969.85	1976.367		1971.751	1976.371	0.000061	0.48	235.28	64.04	0.04
E-CH-ALIGI	4251.07	2/6 4300 cfs	4300	1969.85	1983.565		1977.903	1984.087	0.002641	5.81	771.29	120.22	0.33
E-CH-ALIGI	4251.07	4/1/15 268 cfs	268	1969.85	1977.091		1972.478	1977.105	0.000192	0.95	281.92	64.91	0.08
E-CH-ALIGI	4251.07	4/26/15 173 cfs	173	1969.85	1976.68		1972.078	1976.687	0.000109	0.68	255.36	64.41	0.06
E-CH-ALIGI	4251.07	5/28/15 121 cfs	121	1969.85	1976.407		1971.794	1976.411	0.000067	0.51	237.85	64.09	0.05
E-CH-ALIGI	4251.07	6/22/15 71 cfs	71	1969.85	1976.09		1971.448	1976.092	0.00003	0.33	217.55	63.71	0.03
E-CH-ALIGI	4251.07	7/29/15 46 cfs	46	1969.85	1975.89		1971.203	1975.891	0.000015	0.22	204.84	63.47	0.02
E-CH-ALIGI	4152.67	Lidar 296-cfs	296	1974.68	1977.044	1977.11	1976.018	1977.128	0.003505	2.33	127.27	70.93	0.31
E-CH-ALIGI	4152.67	10/9 25-cfs	25	1974.68	1975.573		1975.13	1975.585	0.00271	0.9	27.84	54.21	0.22
E-CH-ALIGI	4152.67	10/24 471-cfs	471	1974.68	1977.566		1976.331	1977.692	0.004001	2.85	165.47	75.04	0.34
E-CH-ALIGI	4152.67	11/22 1437-cfs	1437	1974.68	1979.485		1977.599	1979.806	0.004875	4.54	316.48	81.72	0.41
E-CH-ALIGI	4152.67	12/12 1072 cfs	1072	1974.68	1978.868		1977.161	1979.119	0.00464	4.02	266.58	79.92	0.39
E-CH-ALIGI	4152.67	12/21 2083 cfs	2083	1974.68	1980.421		1978.255	1980.855	0.005187	5.28	394.22	84.44	0.43
E-CH-ALIGI	4152.67	10/21 114 cfs	114	1974.68	1976.302		1975.57	1976.337	0.002811	1.51	75.46	68.65	0.25
E-CH-ALIGI	4152.67	2/6 4300 cfs	4300	1974.68	1982.783		1980.049	1983.576	0.006001	7.15	604.89	98.99	0.49
E-CH-ALIGI	4152.67	4/1/15 268 cfs	268	1974.68	1976.947		1975.964	1977.024	0.00343	2.23	120.43	70.64	0.3
E-CH-ALIGI	4152.67	4/26/15 173 cfs	173	1974.68	1976.583		1975.761	1976.634	0.003081	1.82	94.9	69.54	0.27
E-CH-ALIGI	4152.67	5/28/15 121 cfs	121	1974.68	1976.338		1975.595	1976.375	0.002854	1.55	77.94	68.8	0.26
E-CH-ALIGI	4152.67	6/22/15 71 cfs	71	1974.68	1976.048		1975.4	1976.071	0.002526	1.22	58.23	67.54	0.23
E-CH-ALIGI	4152.67	7/29/15 46 cfs	46	1974.68	1975.862		1975.265	1975.878	0.002341	1.01	45.72	66.99	0.21
E-CH-ALIGI	4035.8	Lidar 296-cfs	296	1974.23	1976.479	1976.42	1975.773	1976.588	0.006001	2.65	111.53	77.58	0.39
E-CH-ALIGI	4035.8	10/9 25-cfs	25	1974.23	1975.095		1974.74	1975.124	0.006001	1.37	18.29	34.59	0.33
E-CH-ALIGI	4035.8	10/24 471-cfs	471	1974.23	1976.955		1976.066	1977.11	0.00601	3.16	148.85	79.14	0.41
E-CH-ALIGI	4035.8	11/22 1437-cfs	1437	1974.23	1978.813		1977.266	1979.161	0.006007	4.73	303.56	86.93	0.45
E-CH-ALIGI	4035.8	12/12 1072 cfs	1072	1974.23	1978.208		1976.844	1978.49	0.006001	4.26	251.61	84.61	0.44
E-CH-ALIGI	4035.8	12/21 2083 cfs	2083	1974.23	1979.74		1977.891	1980.194	0.006006	5.4	385.76	91.25	0.46
E-CH-ALIGI	4035.8	10/21 114 cfs	114	1974.23	1975.812		1975.355	1975.866	0.006003	1.86	61.23	72.76	0.36
E-CH-ALIGI	4035.8	2/6 4300 cfs	4300	1974.23	1982.09		1979.601	1982.853	0.006006	7.05	647	135.8	0.49
E-CH-ALIGI	4035.8	4/1/15 268 cfs	268	1974.23	1976.392		1975.716	1976.494	0.006003	2.56	104.87	77.3	0.39
E-CH-ALIGI	4035.8	4/26/15 173 cfs	173	1974.23	1976.061		1975.519	1976.134	0.006003	2.17	79.57	74.86	0.37
E-CH-ALIGI	4035.8	5/28/15 121 cfs	121	1974.23	1975.844		1975.381	1975.9	0.006001	1.9	63.57	73.03	0.36
E-CH-ALIGI	4035.8	6/22/15 71 cfs	71	1974.23	1975.594		1975.069	1975.632	0.006008	1.56	45.6	70.92	0.34
E-CH-ALIGI	4035.8	7/29/15 46 cfs	46	1974.23	1975.433		1974.918	1975.461	0.006008	1.34	34.31	66.81	0.33

Appendix G

Existing Condition 2-D Modeling Results

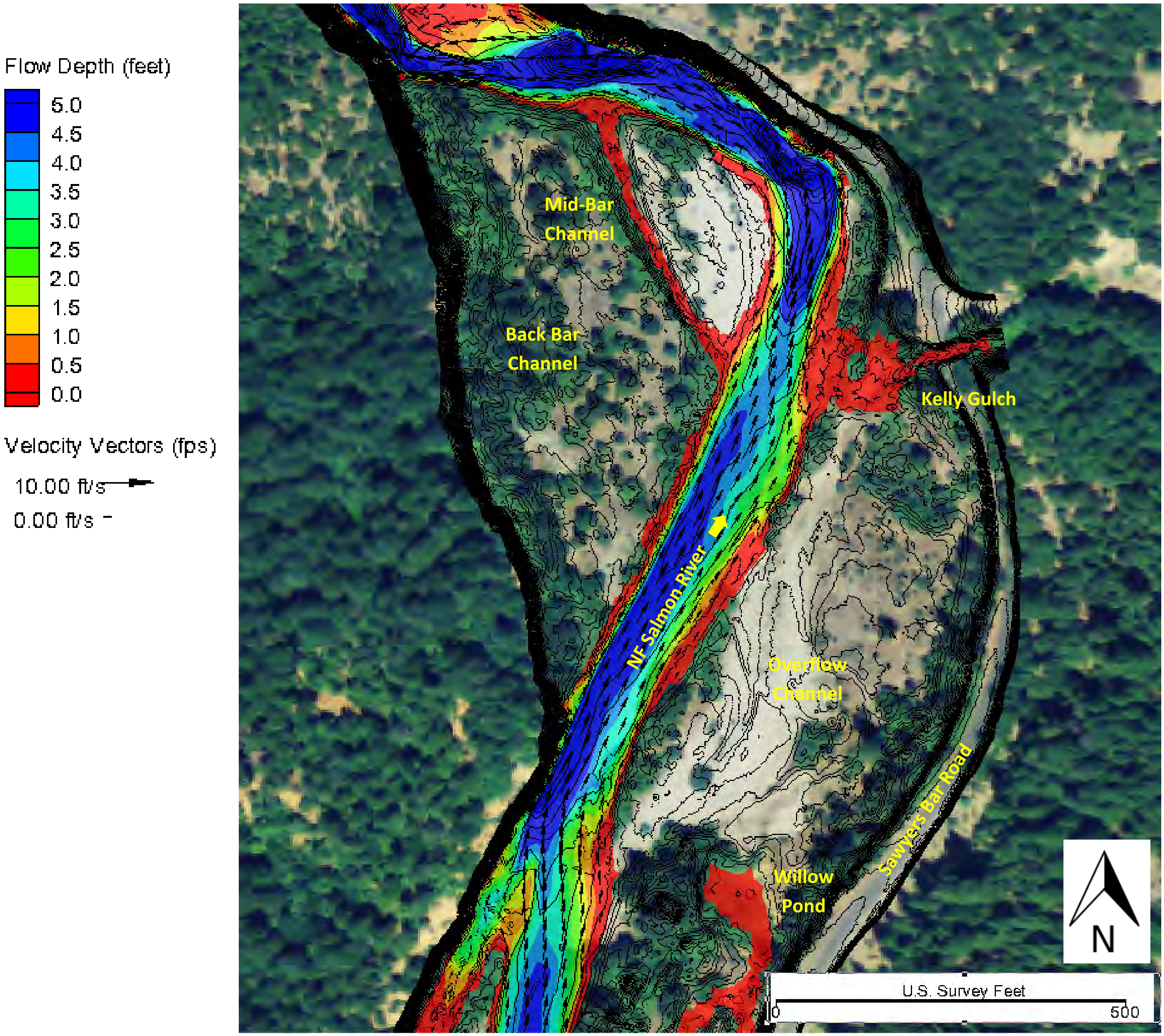
Existing Condition
2-D Model-Predicted Flow Depths and Velocities for the NF Salmon River at Kelly Bar for a 50% Exceedance Flow Event
(197 cfs)



Existing Condition

2-D Model-Predicted Flow Depths and Velocities for the NF Salmon River at Kelly Bar for a 1.2-Year Flow Event

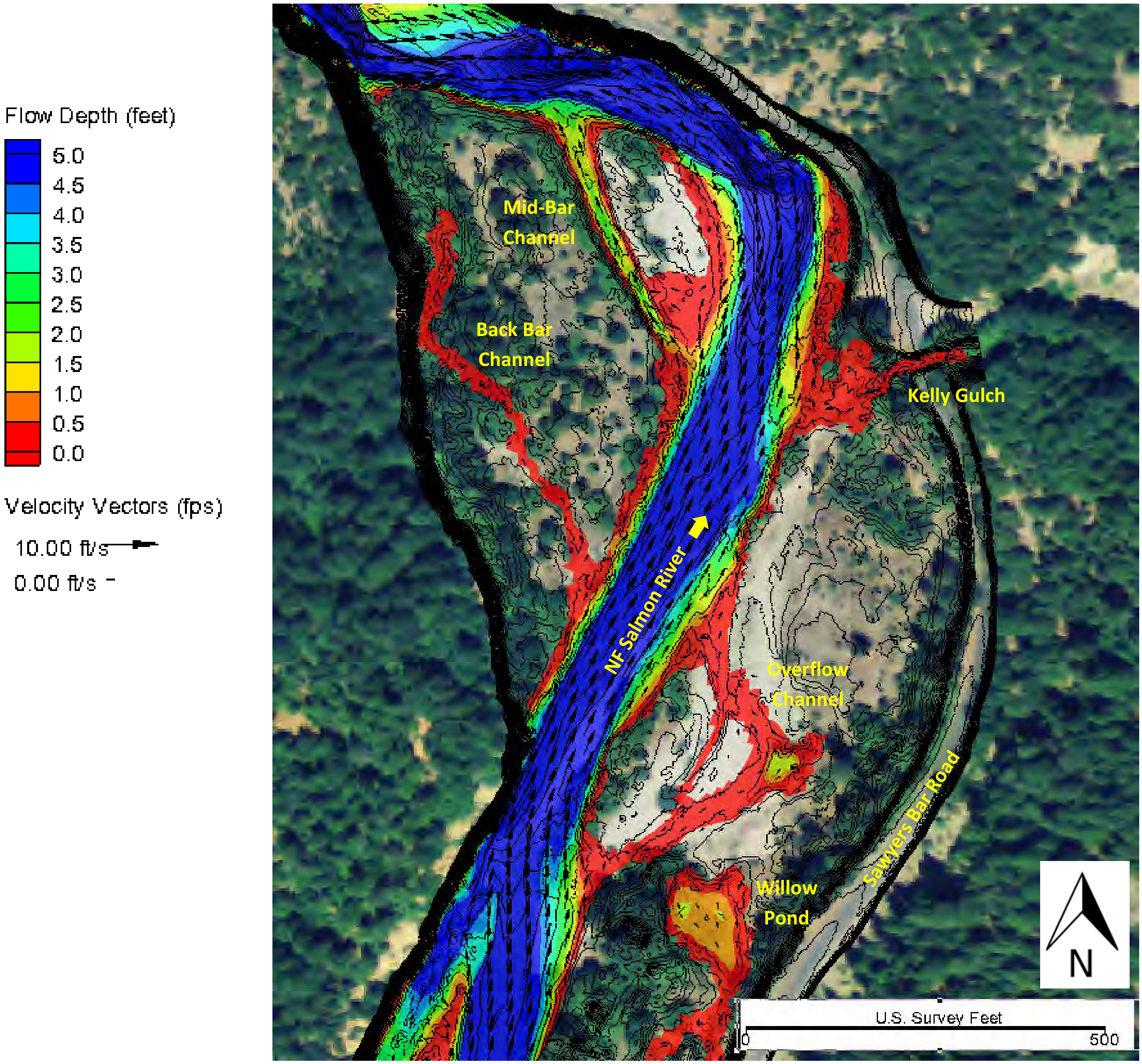
(2,083 cfs)



Existing Condition

2-D Model-Predicted Flow Depths and Velocities for the NF Salmon River at Kelly Bar for a 2.2-Year Flow Event

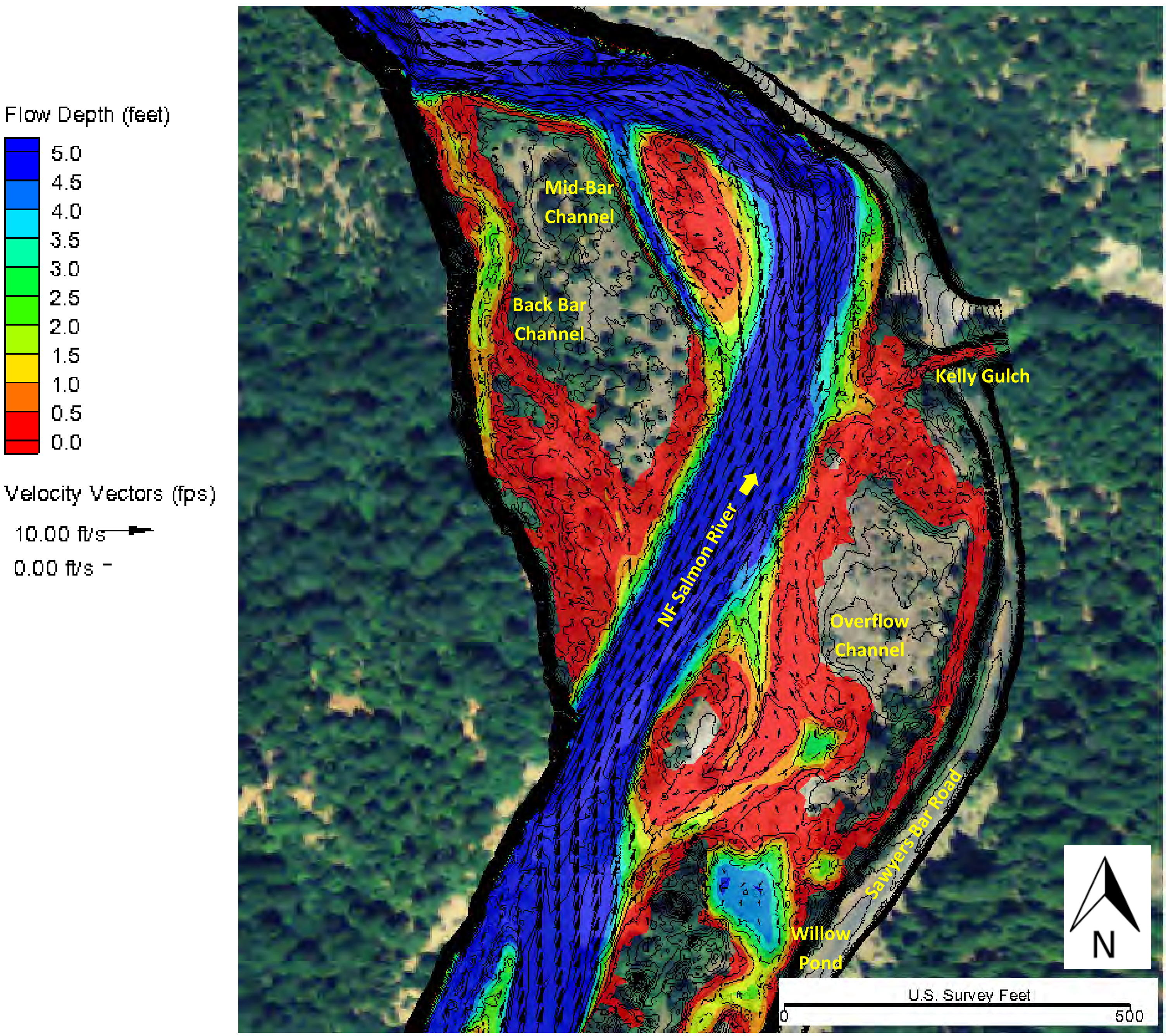
(4,300 cfs)



Existing Condition

2-D Model-Predicted Flow Depths and Velocities for the NF Salmon River at Kelly Bar for a 5-Year Flow Event

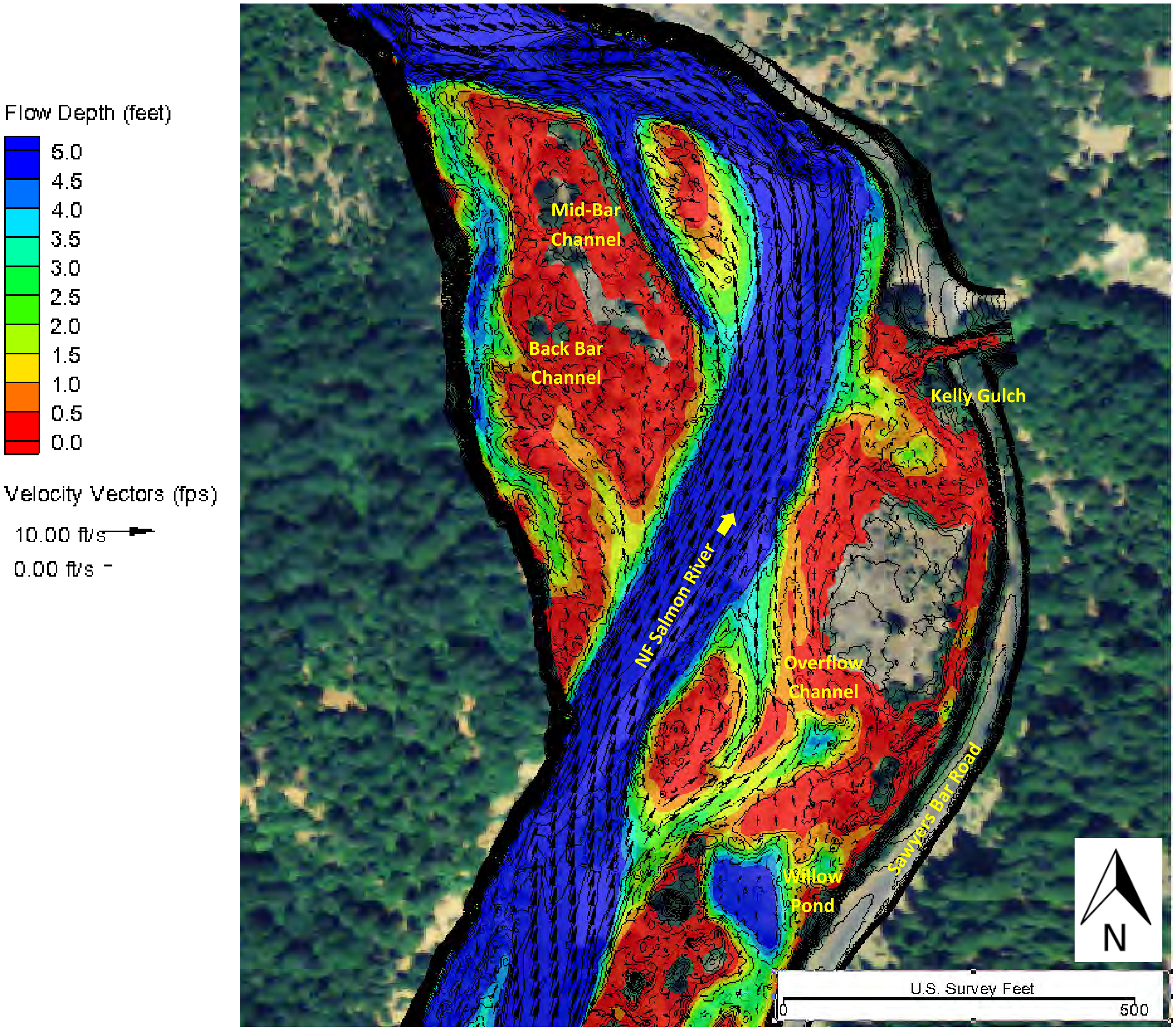
(7,056 cfs)



Existing Condition

2-D Model-Predicted Flow Depths and Velocities for the NF Salmon River at Kelly Bar for a 10-Year Flow Event

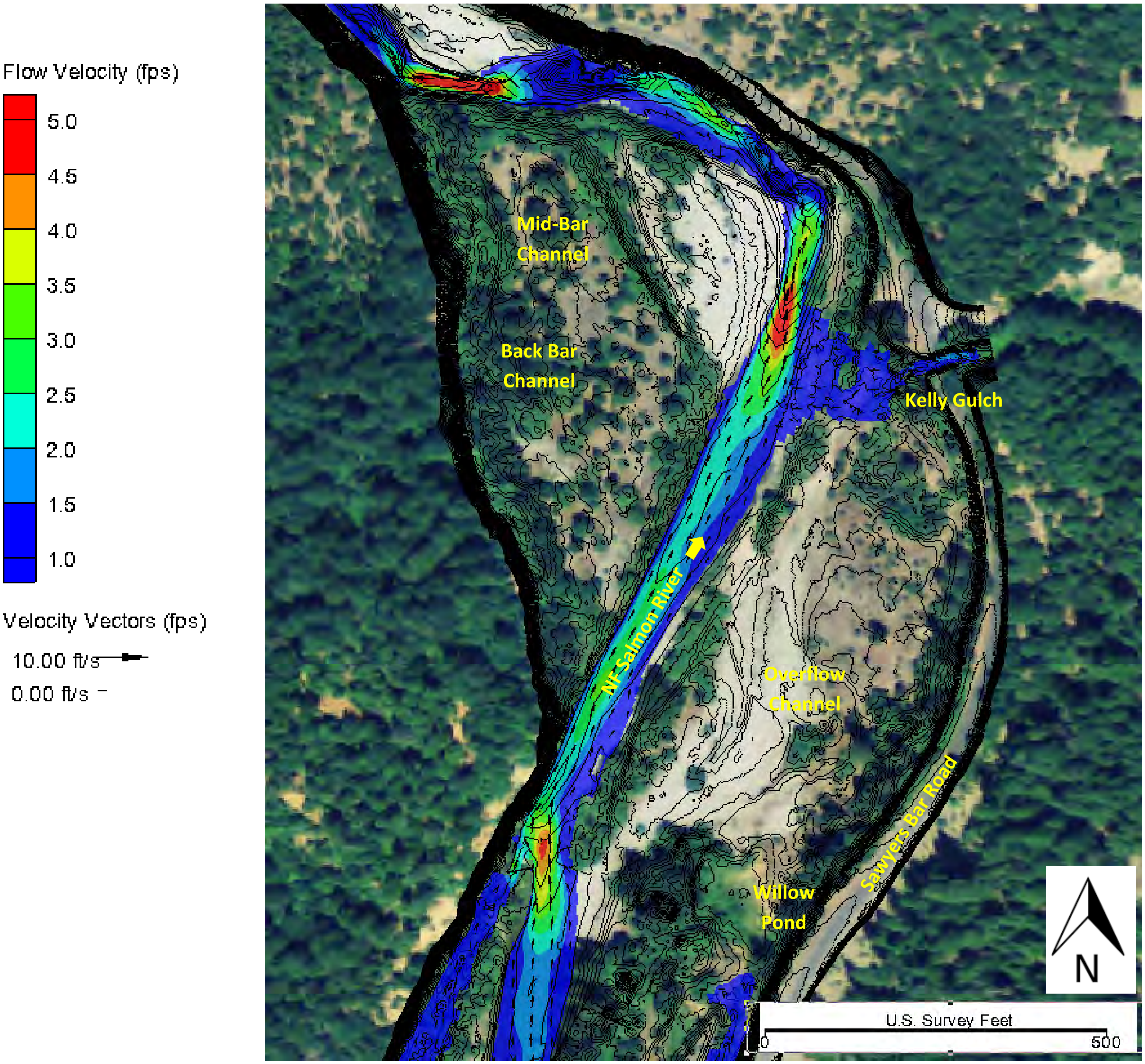
(9,514 cfs)



Existing Condition

2-D Model-Predicted Flow Velocities for the NF Salmon River at Kelly Bar for a 50% Exceedance Flow Event

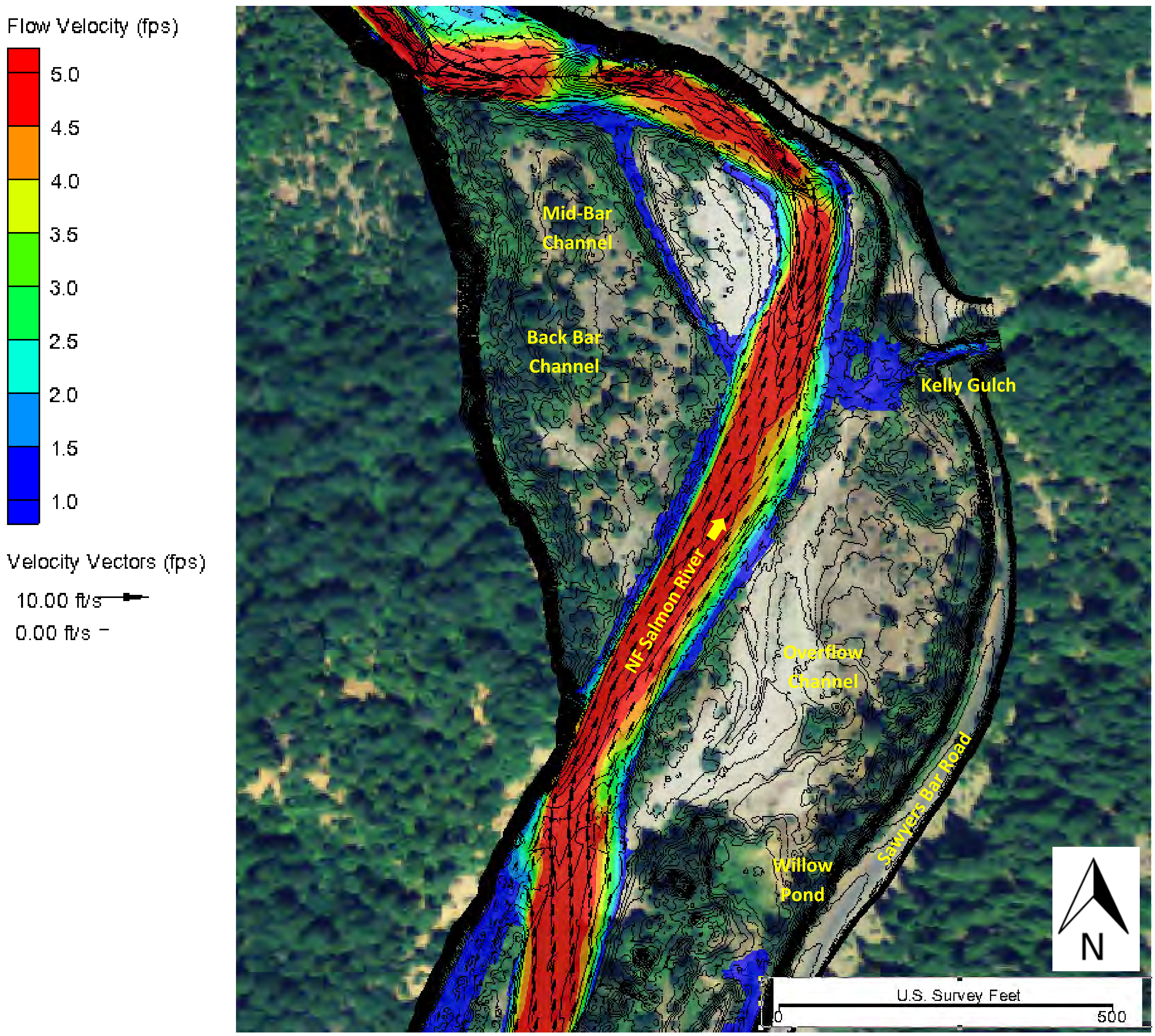
(197 cfs)



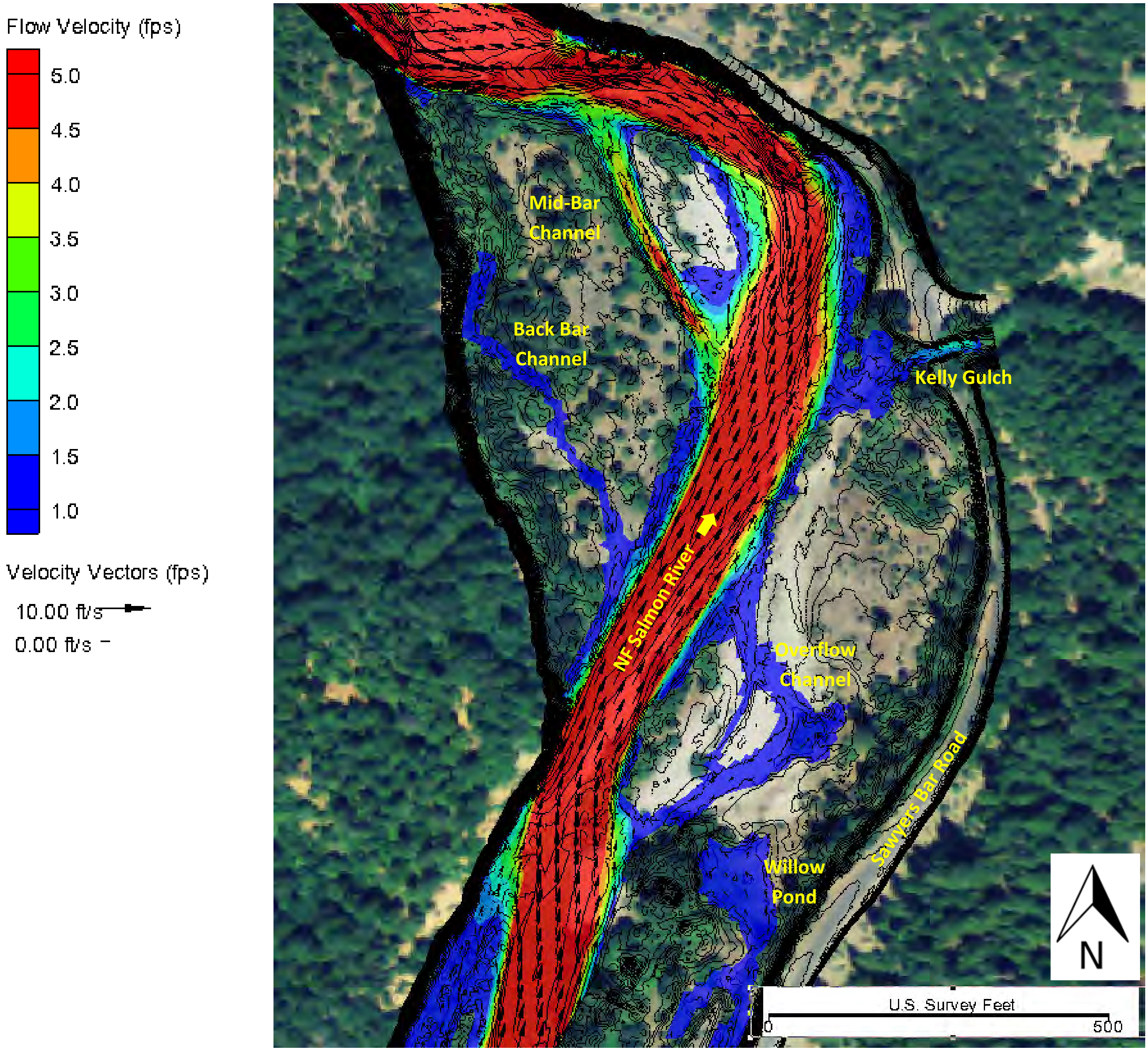
Existing Condition

2-D Model-Predicted Flow Velocities for the NF Salmon River at Kelly Bar for a 1.2-Year Flow Event

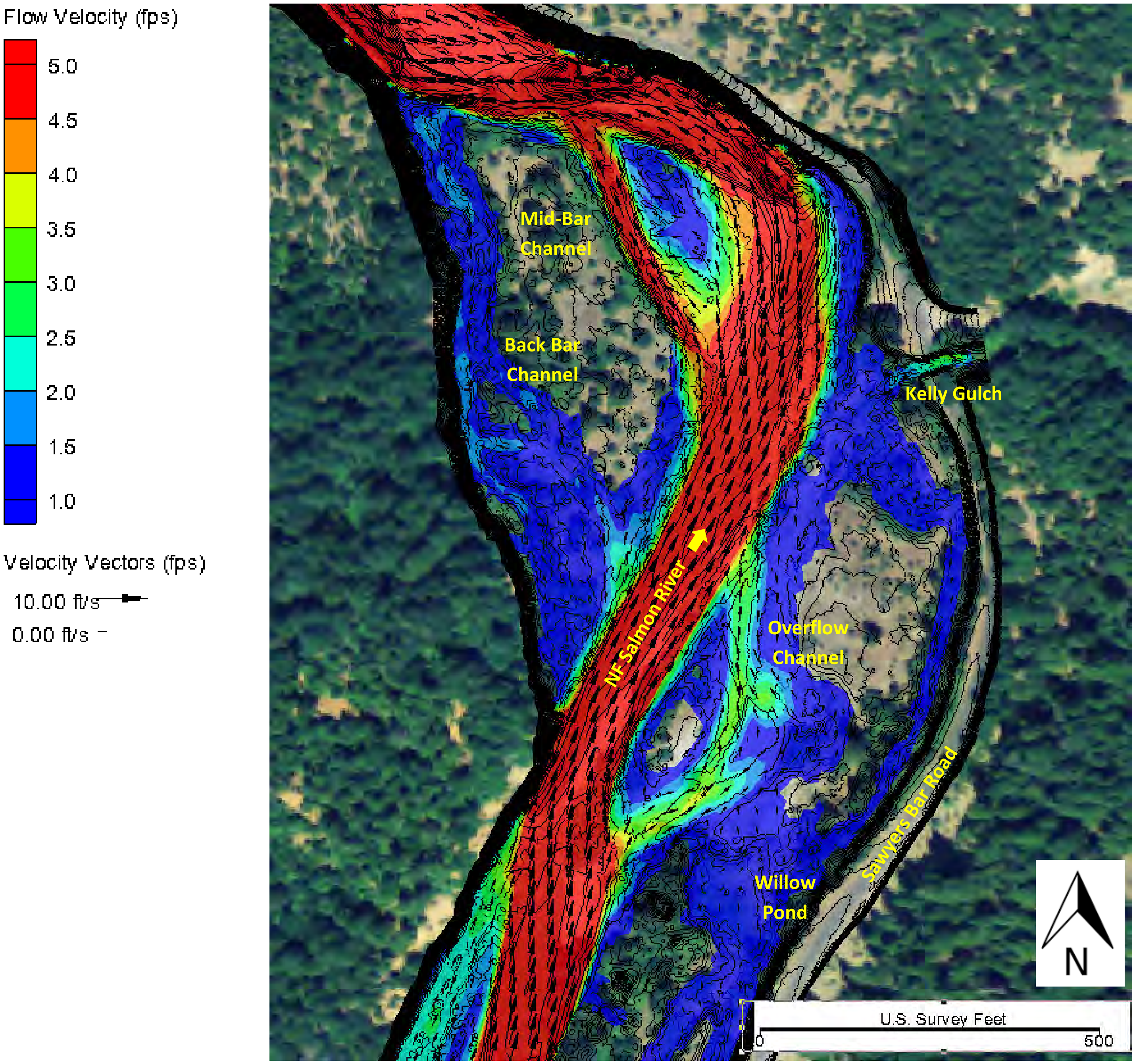
(2,083 cfs)



Existing Condition
2-D Model-Predicted Flow Velocities for the NF Salmon River at Kelly Bar for a 2.2-Year Flow Event
(4,300 cfs)



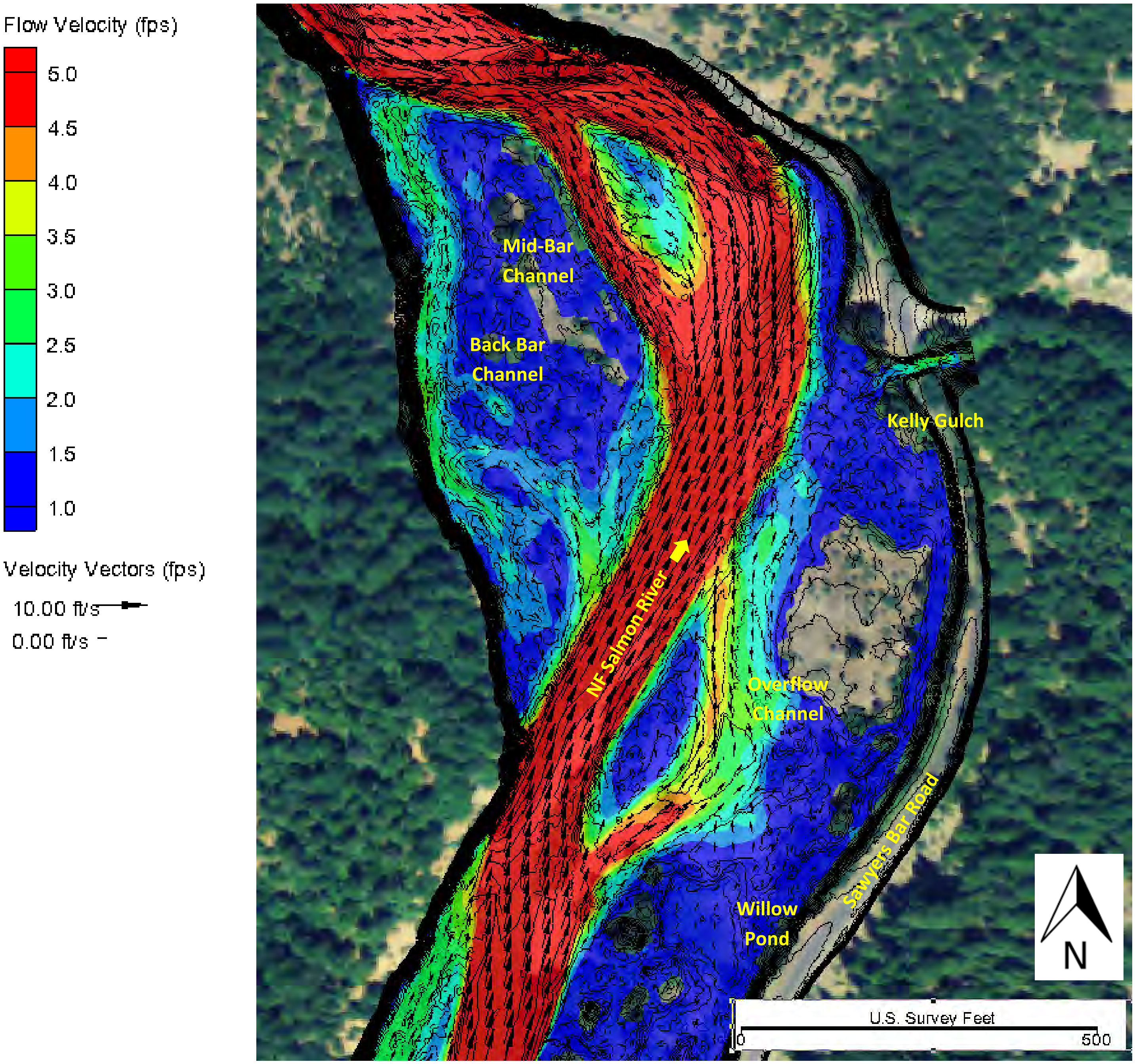
Existing Condition
2-D Model-Predicted Flow Velocities for the NF Salmon River at Kelly Bar for a 5-Year Flow Event
(7,056 cfs)



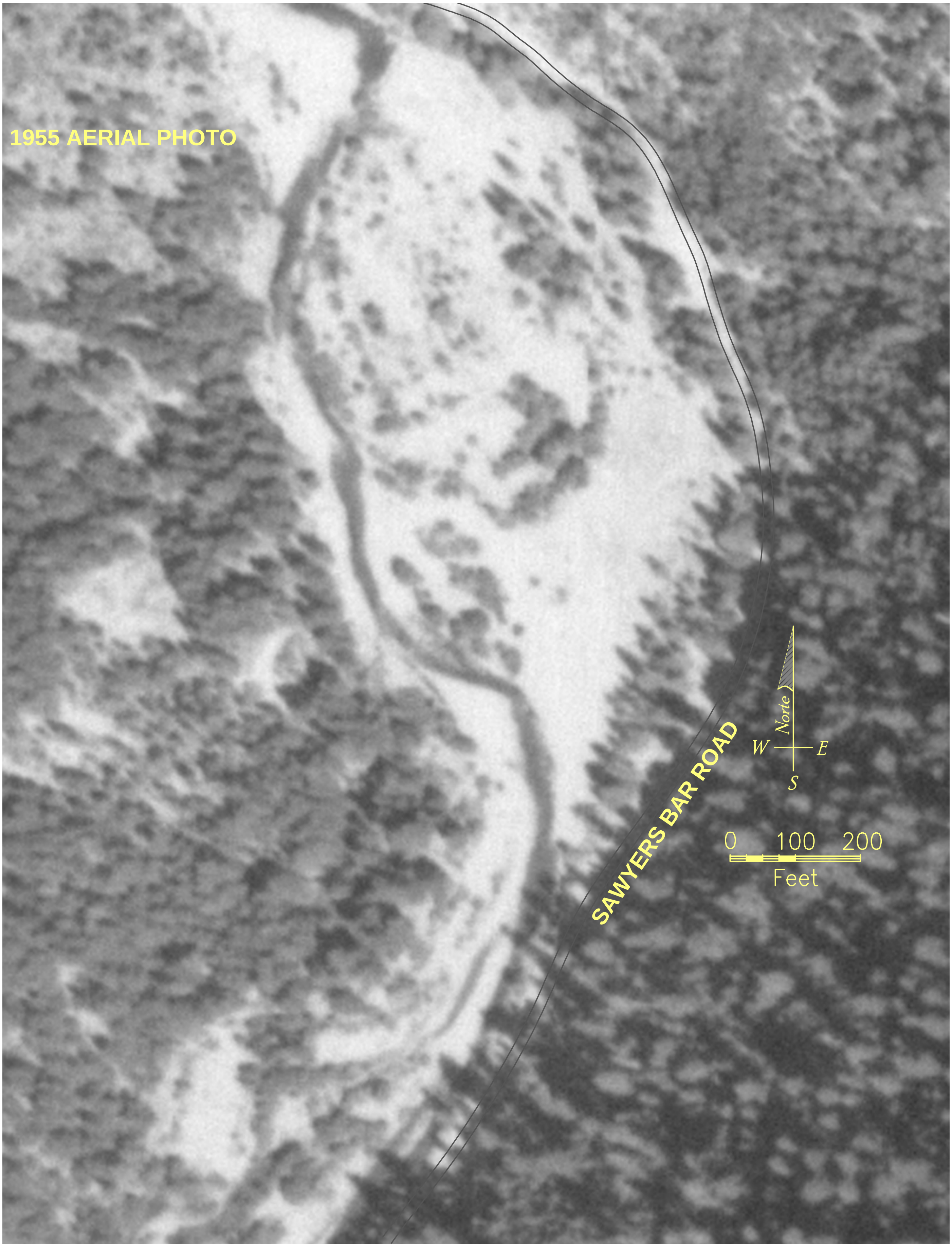
Existing Condition

2-D Model-Predicted Flow Velocities for the NF Salmon River at Kelly Bar for a 10-Year Flow Event

(9,514 cfs)



Appendix H
Historical Aerial Photographs


1955 AERIAL PHOTO
SAWYERS BAR ROAD
Norte
W
E
S
0 100 200
Feet


1965 AERIAL PHOTO
SAWYERS BAR ROAD
Norte
W
E
S
0
100
200
Feet

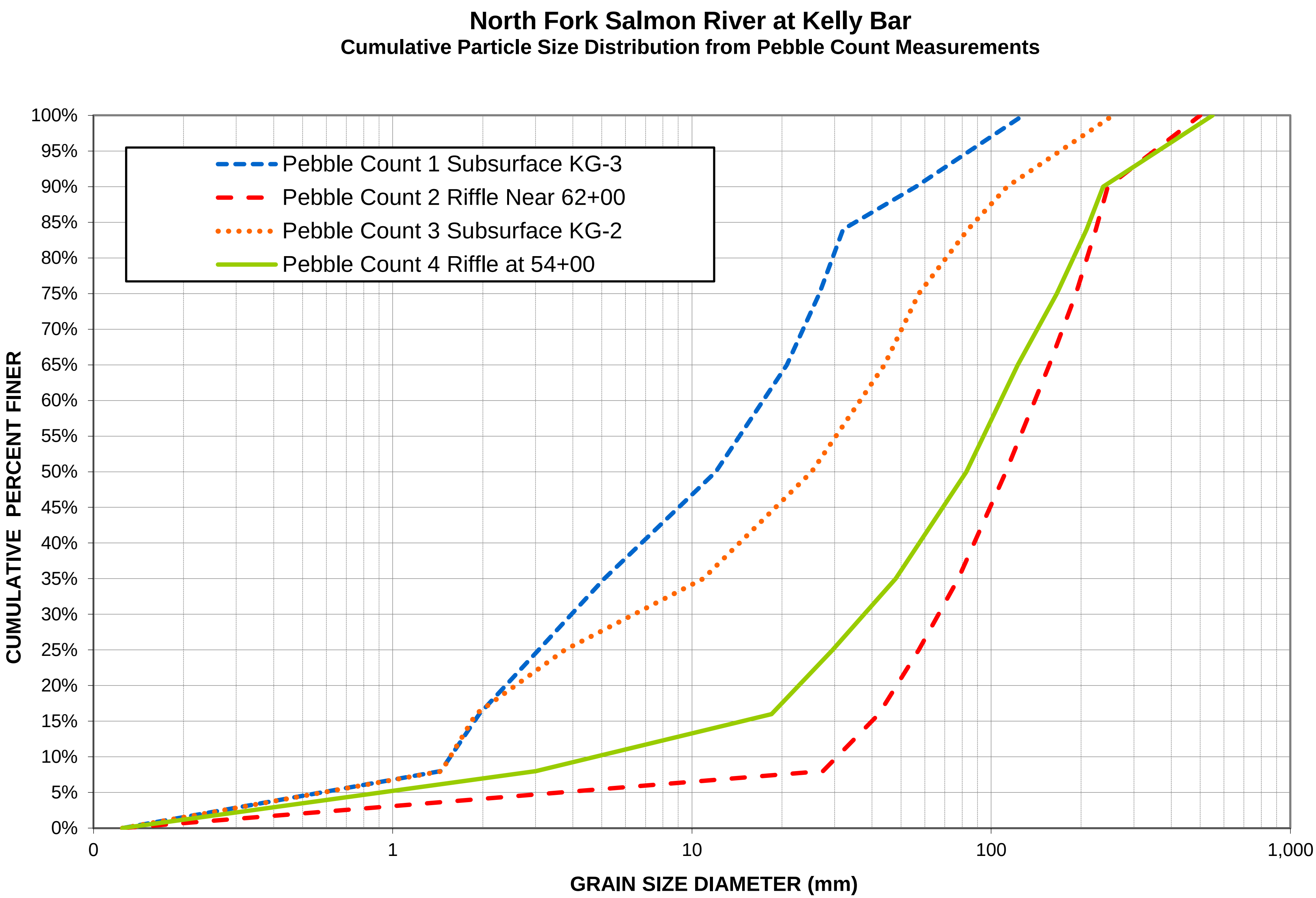

1975 AERIAL PHOTO
SAWYERS BAR ROAD
Norte
W
E
S
0 100 200
Feet


1980 AERIAL PHOTO
SAWYERS BAR ROAD
Norte
W
E
S
0
100
200
Feet


2012 AERIAL PHOTO
SAWYERS BAR ROAD
Norte
W
E
S
0
100
200
Feet

Appendix I

Pebble Counts


North Fork Salmon River at Kelly Bar
Cumulative Particle Size Distribution from Pebble Count Measurements
Pebble Count 1 Subsurface KG-3
Pebble Count 2 Riffle Near 62+00
Pebble Count 3 Subsurface KG-2
Pebble Count 4 Riffle at 54+00
CUMULATIVE PERCENT FINER
100%
95%
90%
85%
80%
75%
70%
65%
60%
55%
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
0
1
10
100
1,000
GRAIN SIZE DIAMETER (mm)

Appendix J

Mining Claim Deeds

Siskiyou County Recorder
Leanna Dancer, Recorder

DOC - 08-0009101
Monday, AUG 18, 2008 10:04:39
Ttl Pd $11.00 Nbr-0000148900
JES/C1/1-2

Recording requested by and return to:

Name: April Halsten
Address: P.O. Box 263
Firestone, CO 80520

Send tax information to same as above

Placer Mining Claim Location Notice

To whom it may concern, please take notice that:

1.) Name of this placer mining claim is: The Lost Jewel
2.) This mining claim is located in: Siskiyou County, California
3.) Date of location (Date the proper location monument was erected and location notice posted in or on it): July 25, 2008

4.) Description of discovery monument is: Federal Mining Claim Sign

5.) Natural object is: North Fork of the Salmon River
6.) Discovery monuments location in relationship to the natural object: Approximately 200 ft. east of the North Fork of the Salmon River

7.) Claim consists of approximately: 120 acres

8.) This placer mining claim IS IN an area where there is a U.S Public Land Survey and the description of the claim by legal subdivision including aliquot part (A.P.) of section is as follows;

Aliquot Part (AP)	Sec.	T.	R.	Meridian
N1/2 SE1/4, N1/2 SW1/4 SE1/4, N1/2 SE1/4 SE1/4	24	40N	12W	Mt. Diablo

9.) Excluding from this Claim any Private land infringed upon and any portion isolated by any easement or right of way.

10.) Locator(s) of said claim are:

Locator(s) of said claim are:	Address:
April Halsten	P.O. Box 263, Firestone, CO 80520
Michael Jeffs	Same
Victoria Halsten	Same
Jack Jeffs	Same
Mark Halsten	Same
Sarah Prickett	Same

11.) April Halsten as Agent for all; April Halsten

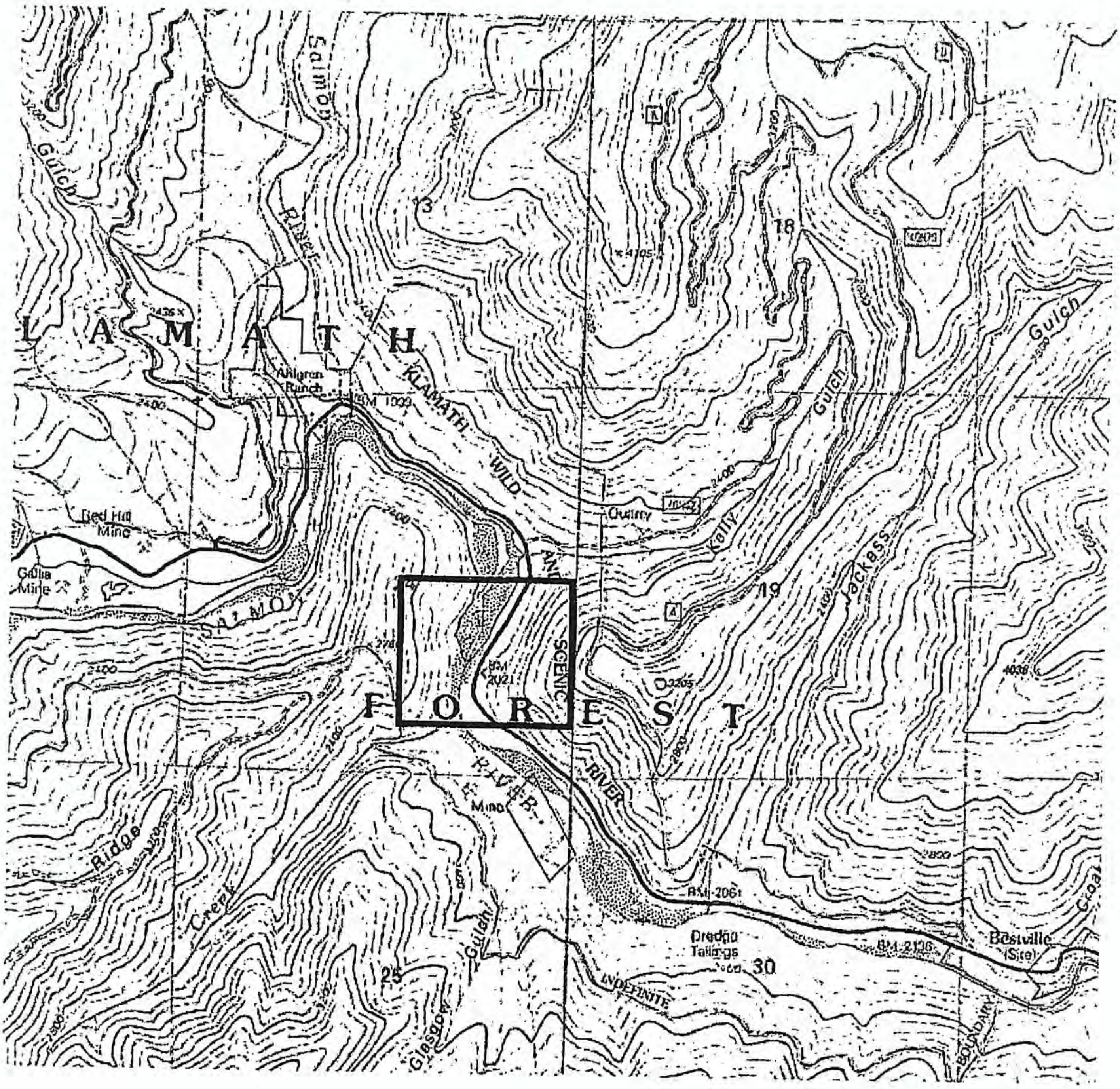
Agent signature

12.) See reverse for Map

PAGE 2
PLACER MINING CLAIM LOCATION NOTICE

The Lost Jewel, USGS SAWYERS BAR (CA) Topo Map

Map



Recording requested by and return to
The New 49ers
PO Box 47
Happy Camp, CA. 96039

Siskiyou, County Recorder
Mike Mallory, Assessor-Recorder
DOC – 2015 – 0002963 – 00
Check Number 20749
Thursday, APR 09, 2015 09:02:43
Ttl Pd $14.00 Nbr-0000260567
EVH / C2 / 1-1

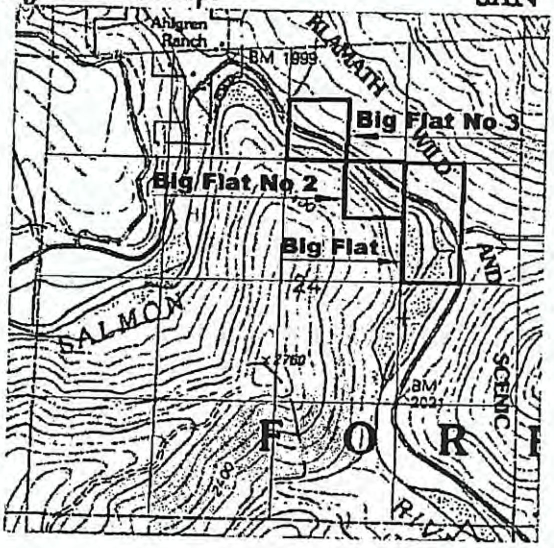
__SPACE ABOVE FOR RECORDERS USE ONLY__

Placer Mining Location Notice

Whom it may concern; Please note that...

Located to comply with PL-359 regulations, IF APLICABLE

1. The name of this Placer Mining Claim is; **Big Flat**
2. Located in the NE ¼ of Section 24. See Cadastral description for T. R. Mer.
3. Located in the Elk Creek Mining District, County of Siskiyou, State of California
4. The date of this location, as posted on said claim is January 15, 2015
5. Acreage claimed is 20 acres and shall be located by legal subdivision
6. Cadastral Description; E½-SE¼-NE¼ of Section 24, T40N, R12W Mt Diablo Mer. Excluding from this claim any Private Land, Easements, Right of Way, or any portion isolated by any Easement or Right of Way that would make it noncontiguous with the creek bottom claimed as drawn on the following location map.



7. Location Map of Section 24:
8. Locator (s) of said Claim;

Derek Eimer
Derek D Eimer

PO Box 47, Happy Camp CA. 96039

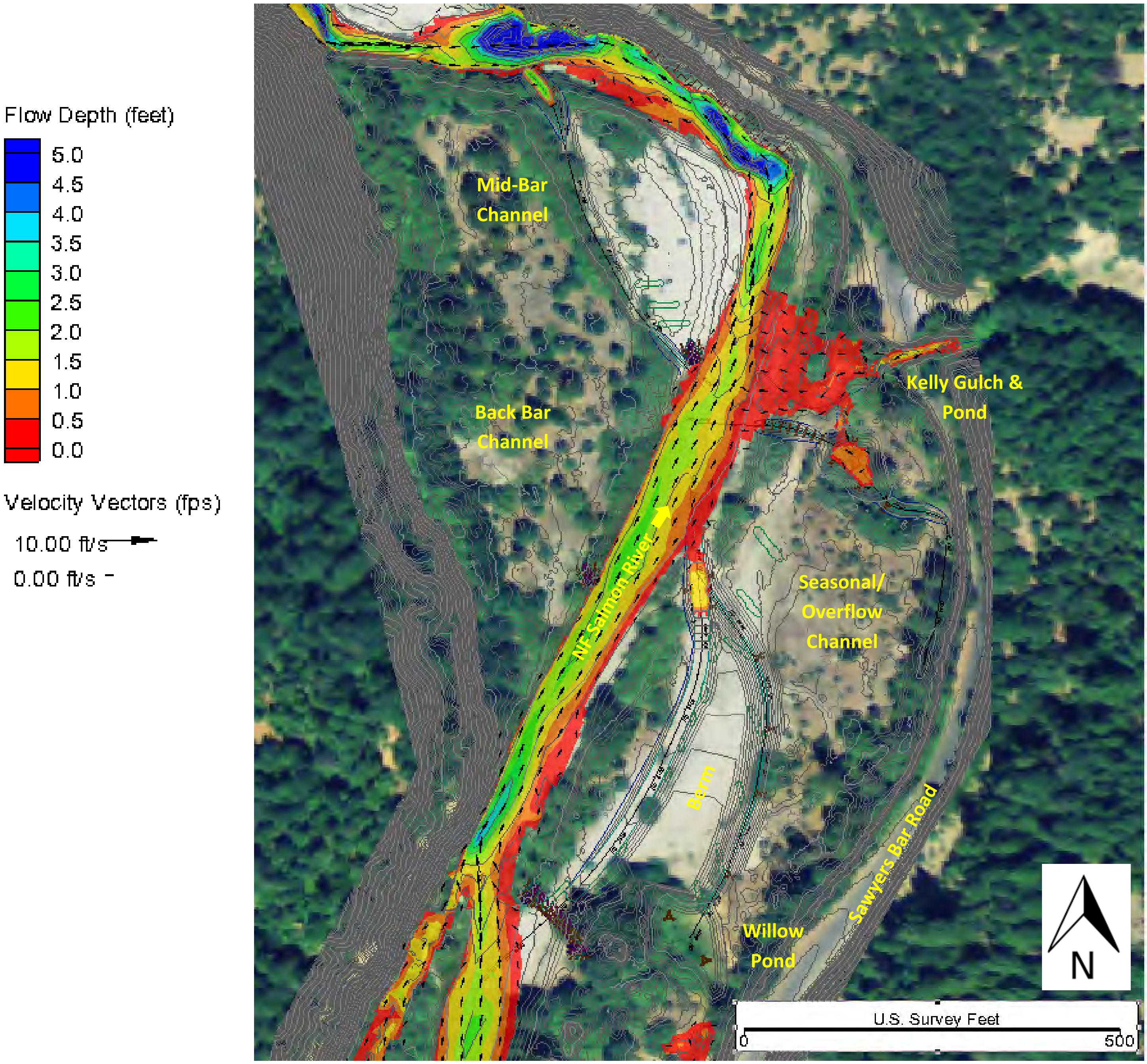
Appendix K

Design Condition 2-D Modeling Results

Design Condition

2-D Model-Predicted Flow Depths and Velocities for the NF Salmon River at Kelly Bar for a 50% Exceedance Flow Event

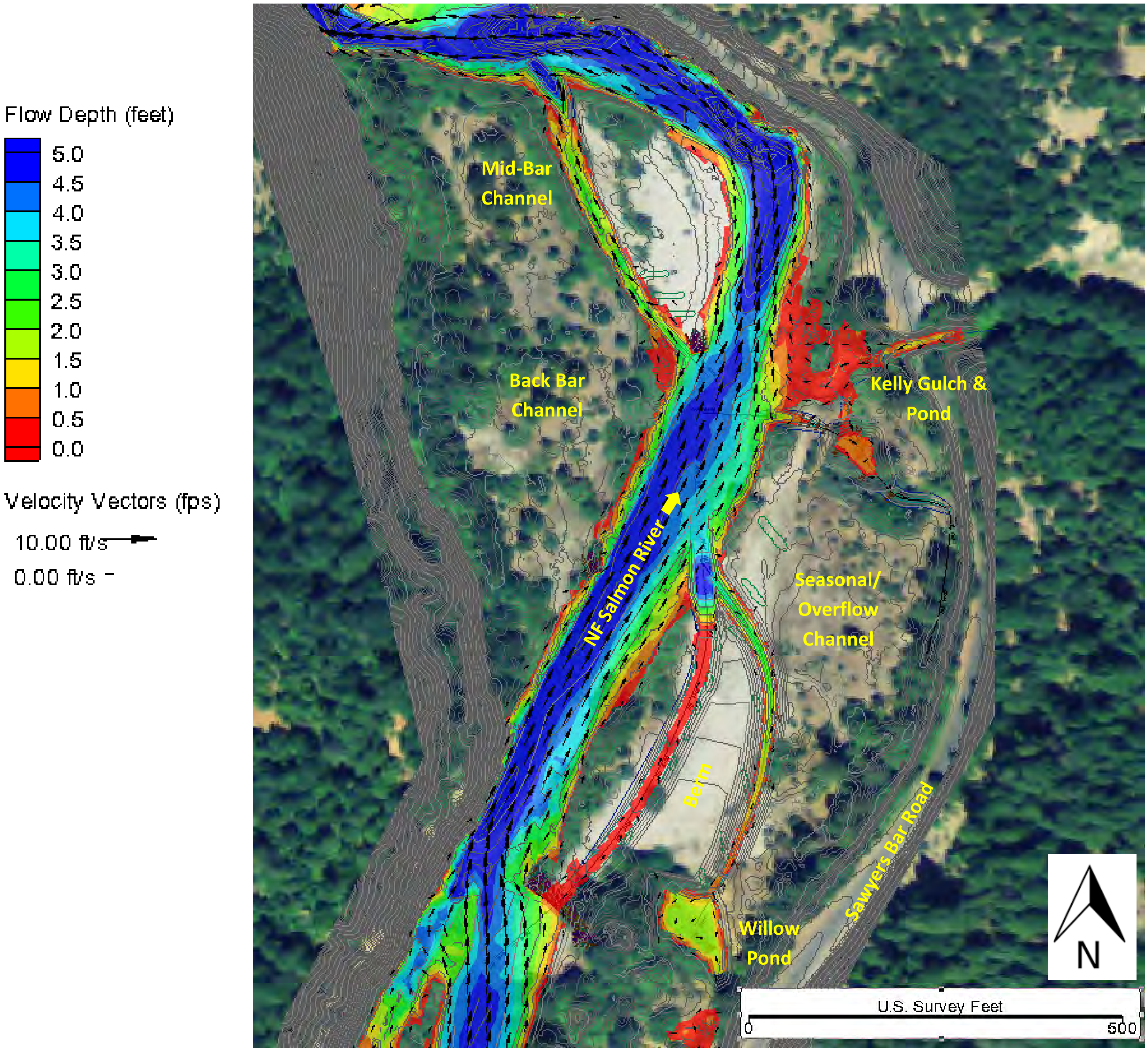
(197 cfs)



Design Condition

2-D Model-Predicted Flow Depths and Velocities for the NF Salmon River at Kelly Bar for a 1.2-Year Flow Event

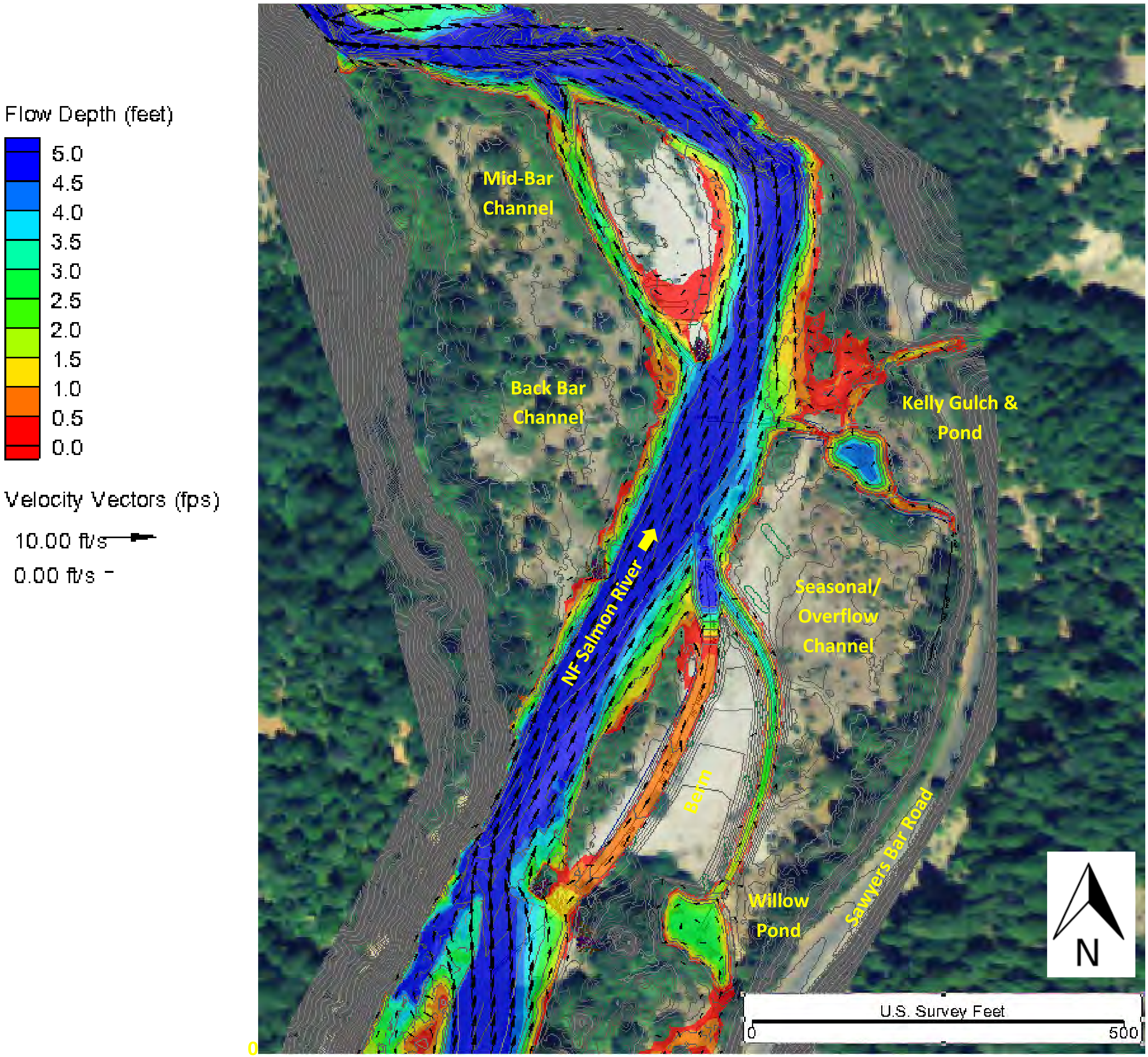
(2,083 cfs)



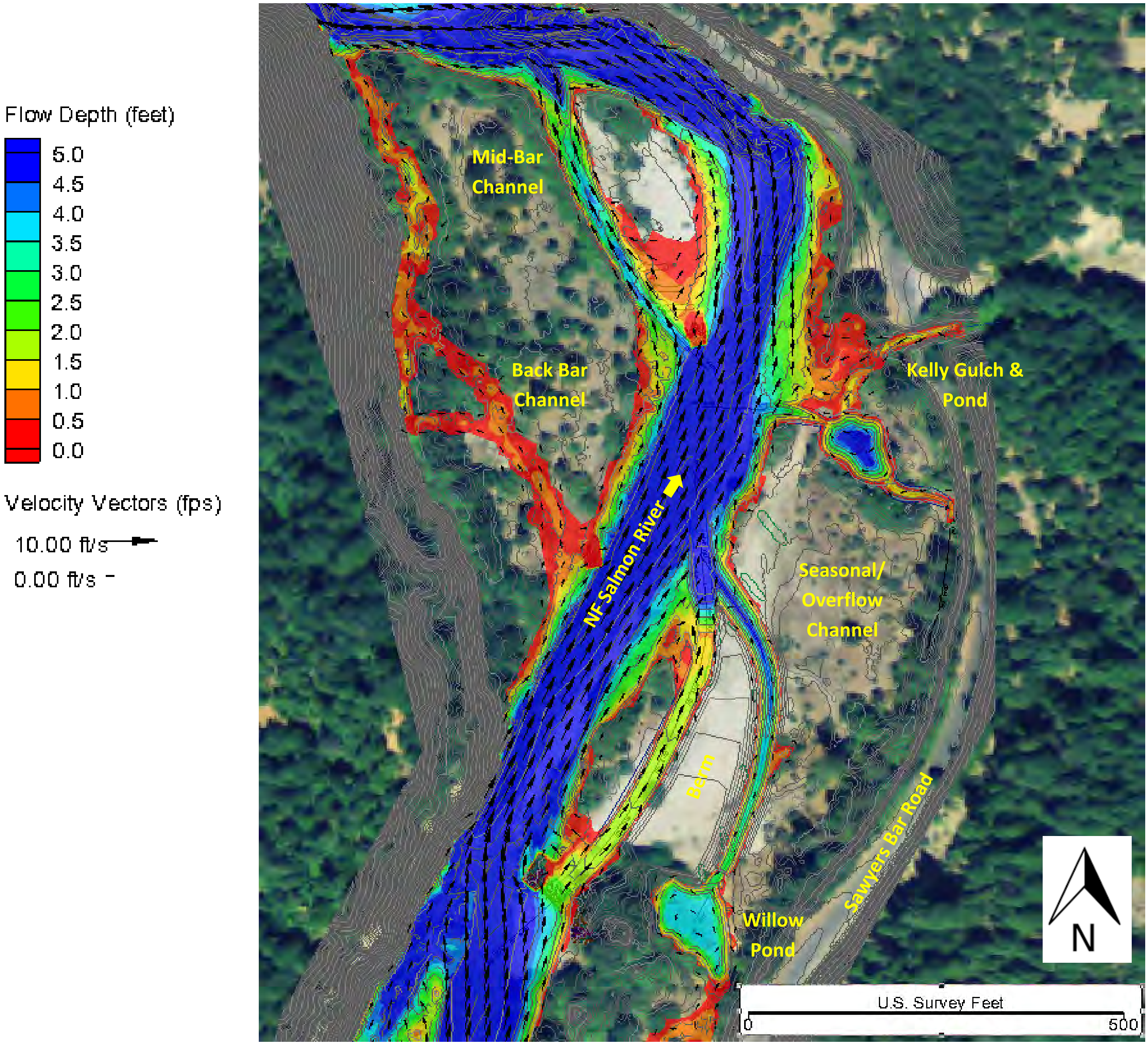
Design Condition

2-D Model-Predicted Flow Depths and Velocities for the NF Salmon River at Kelly Bar for a 1.5-Year Flow Event

(2,966 cfs)



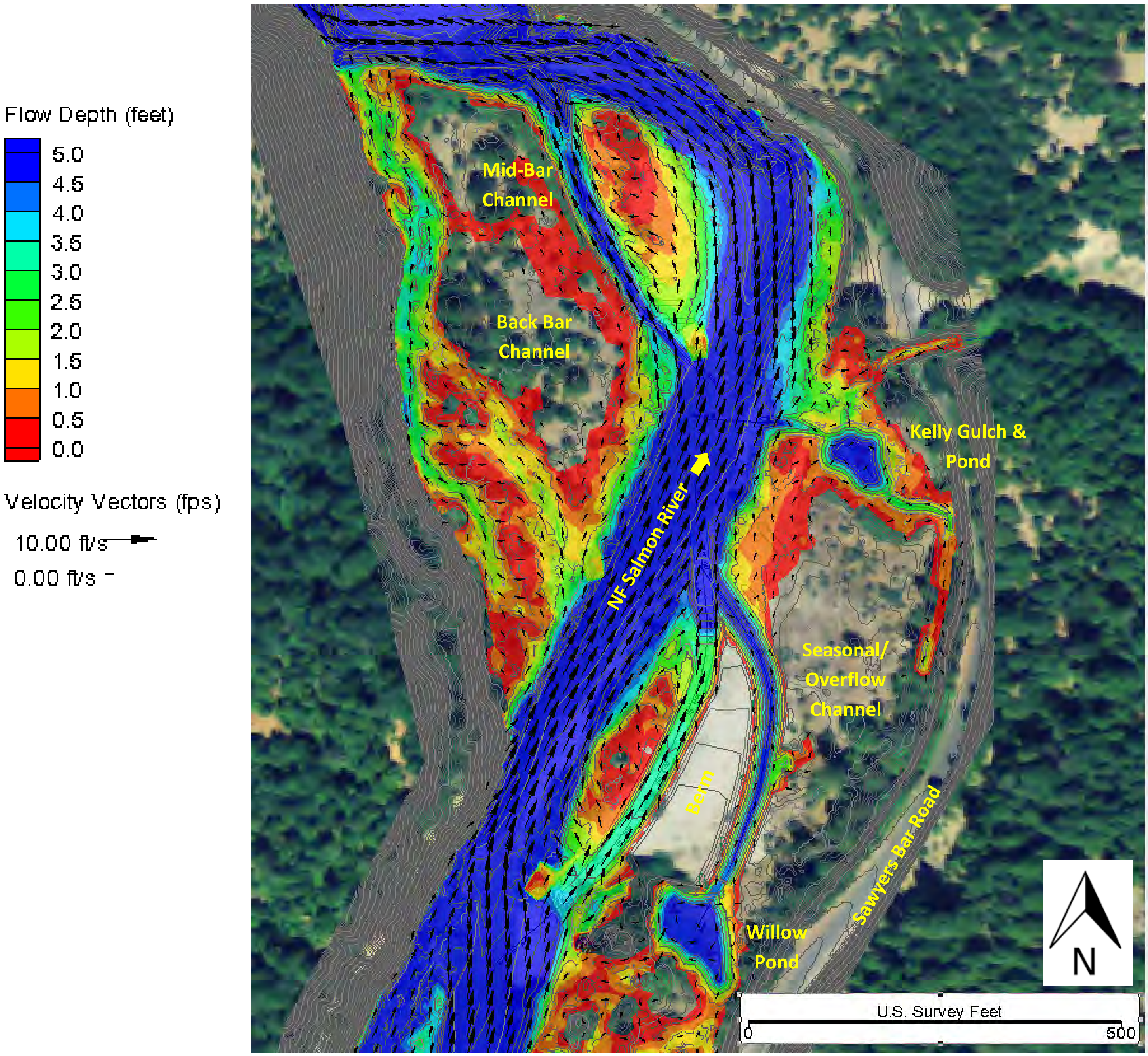
Design Condition
2-D Model-Predicted Flow Depths and Velocities for the NF Salmon River at Kelly Bar for a 2.2-Year Flow Event
(4,300 cfs)



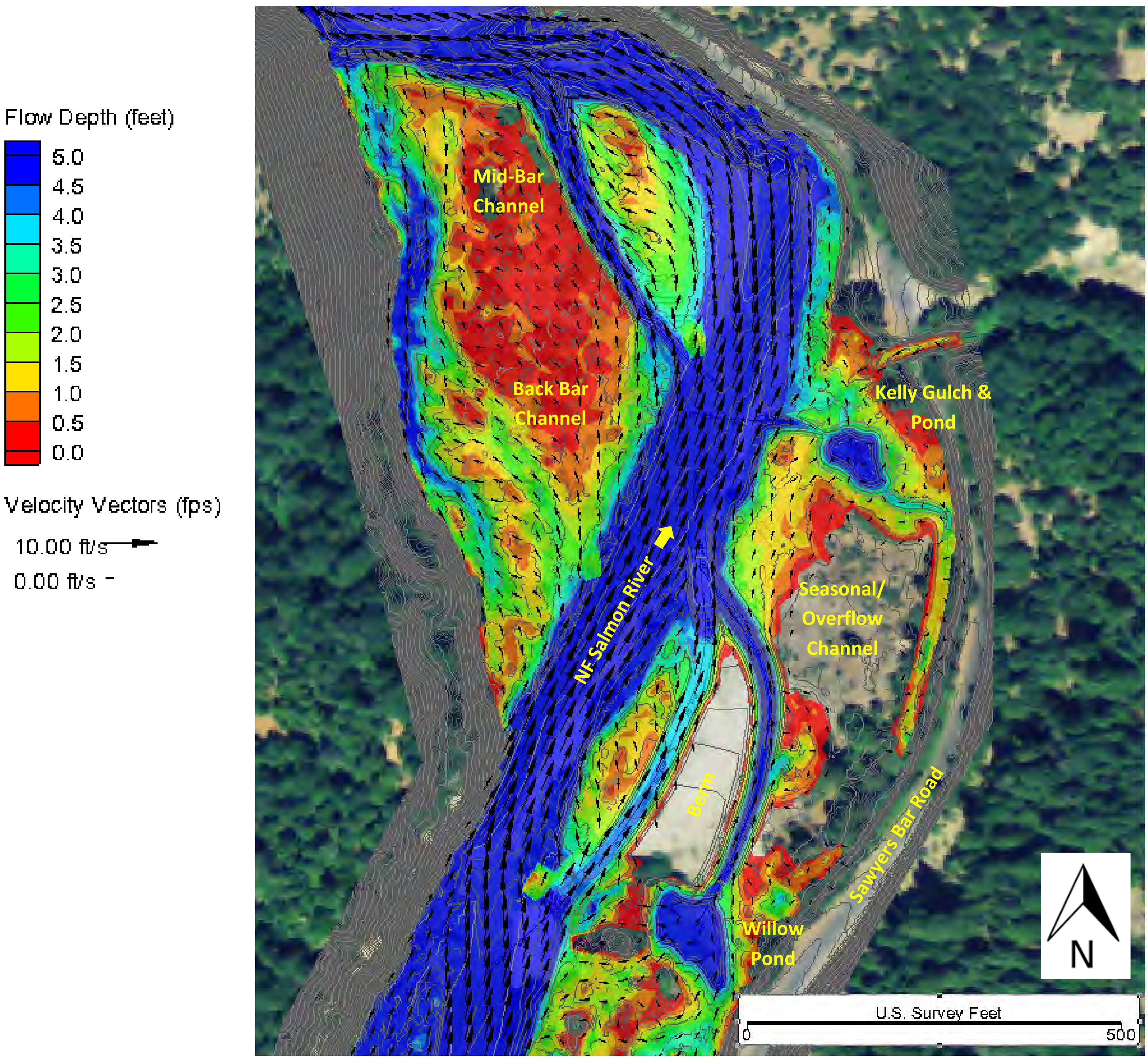
Design Condition

2-D Model-Predicted Flow Depths and Velocities for the NF Salmon River at Kelly Bar for a 5-Year Flow Event

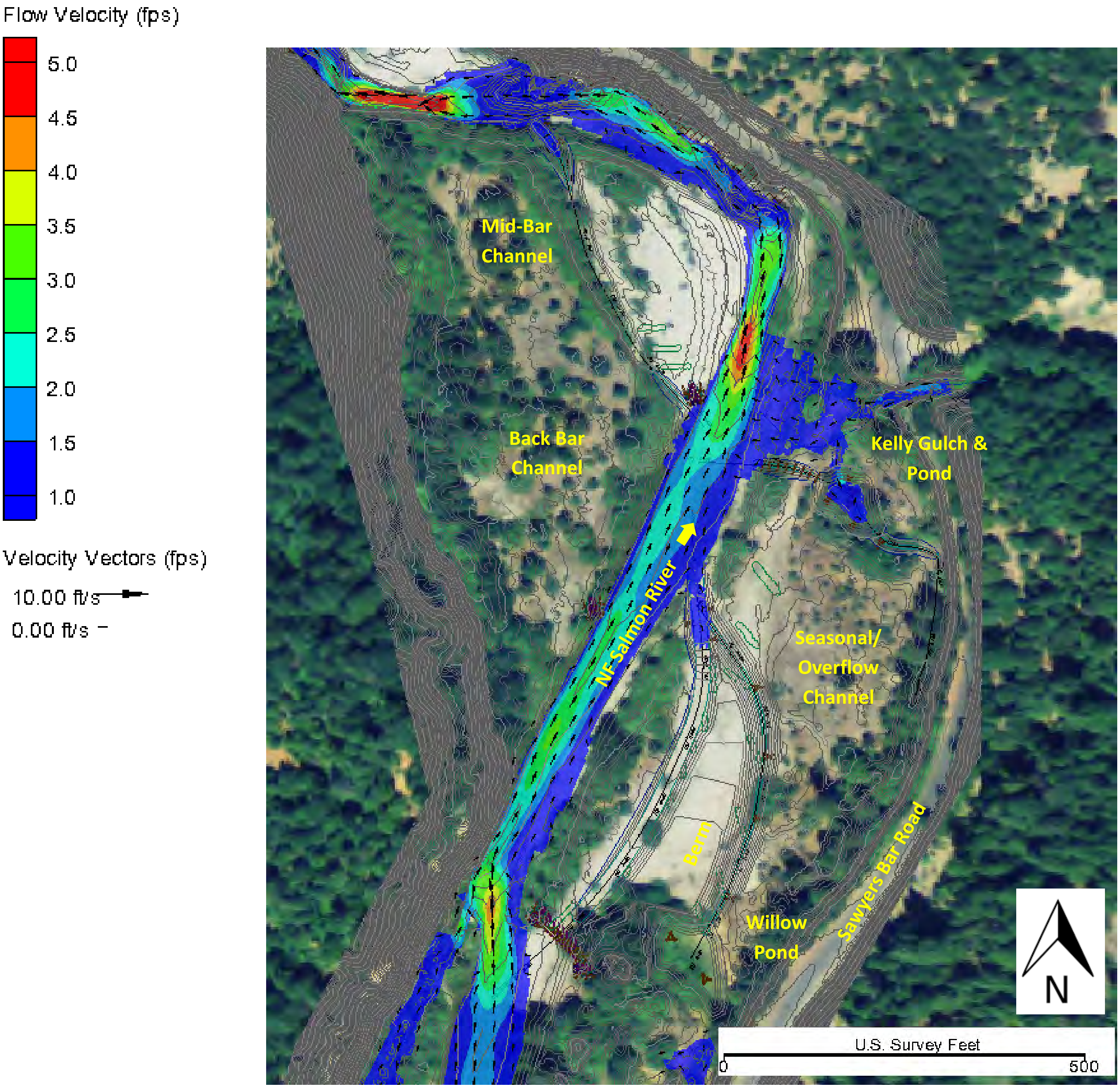
(7,056 cfs)



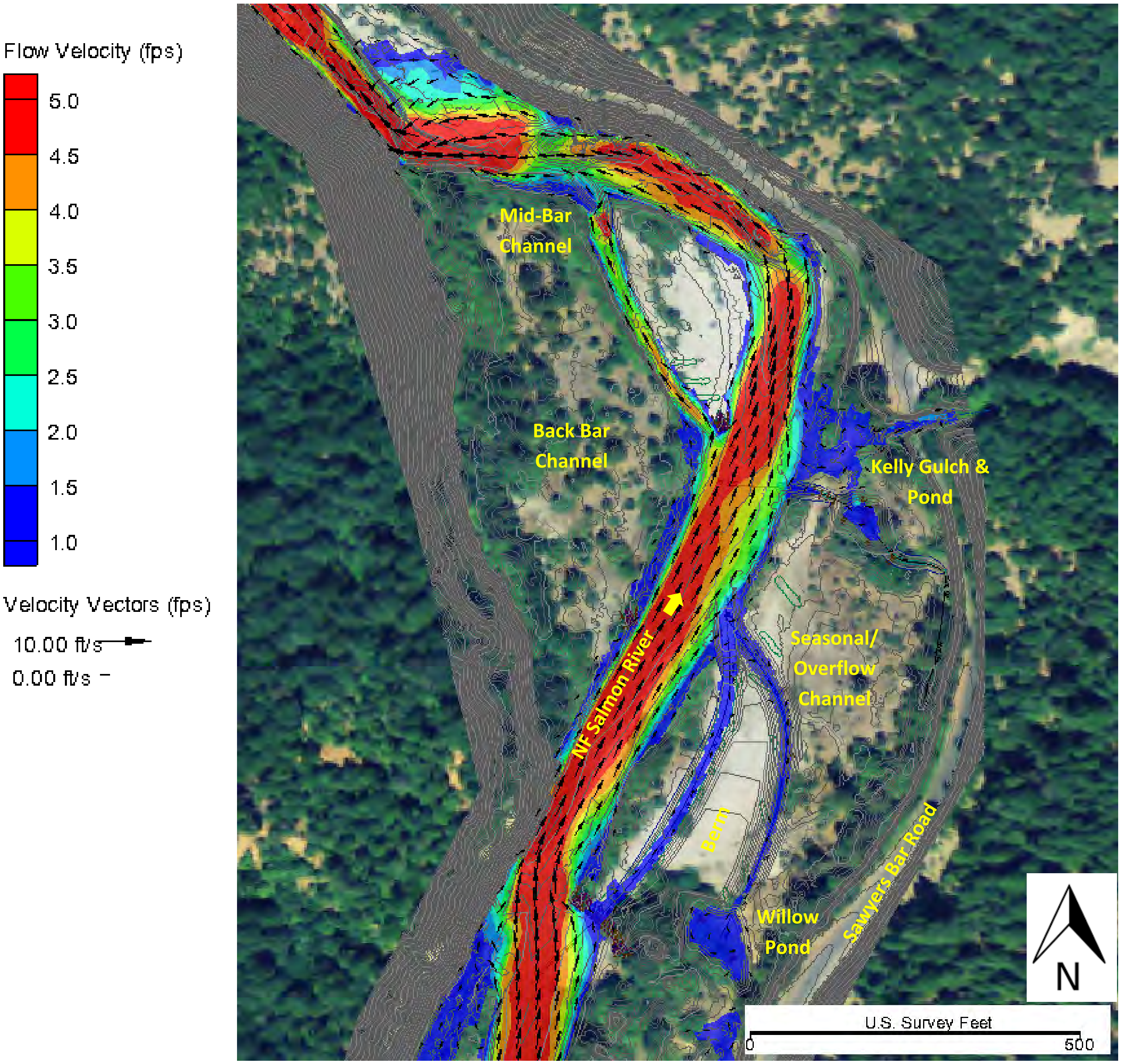
Design Condition
2-D Model-Predicted Flow Depths and Velocities for the NF Salmon River at Kelly Bar for a 10-Year Flow Event
(9,514 cfs)



Design Condition
2-D Model-Predicted Flow Velocities for the NF Salmon River at Kelly Bar for a 50% Exceedance Flow Event
(197 cfs)



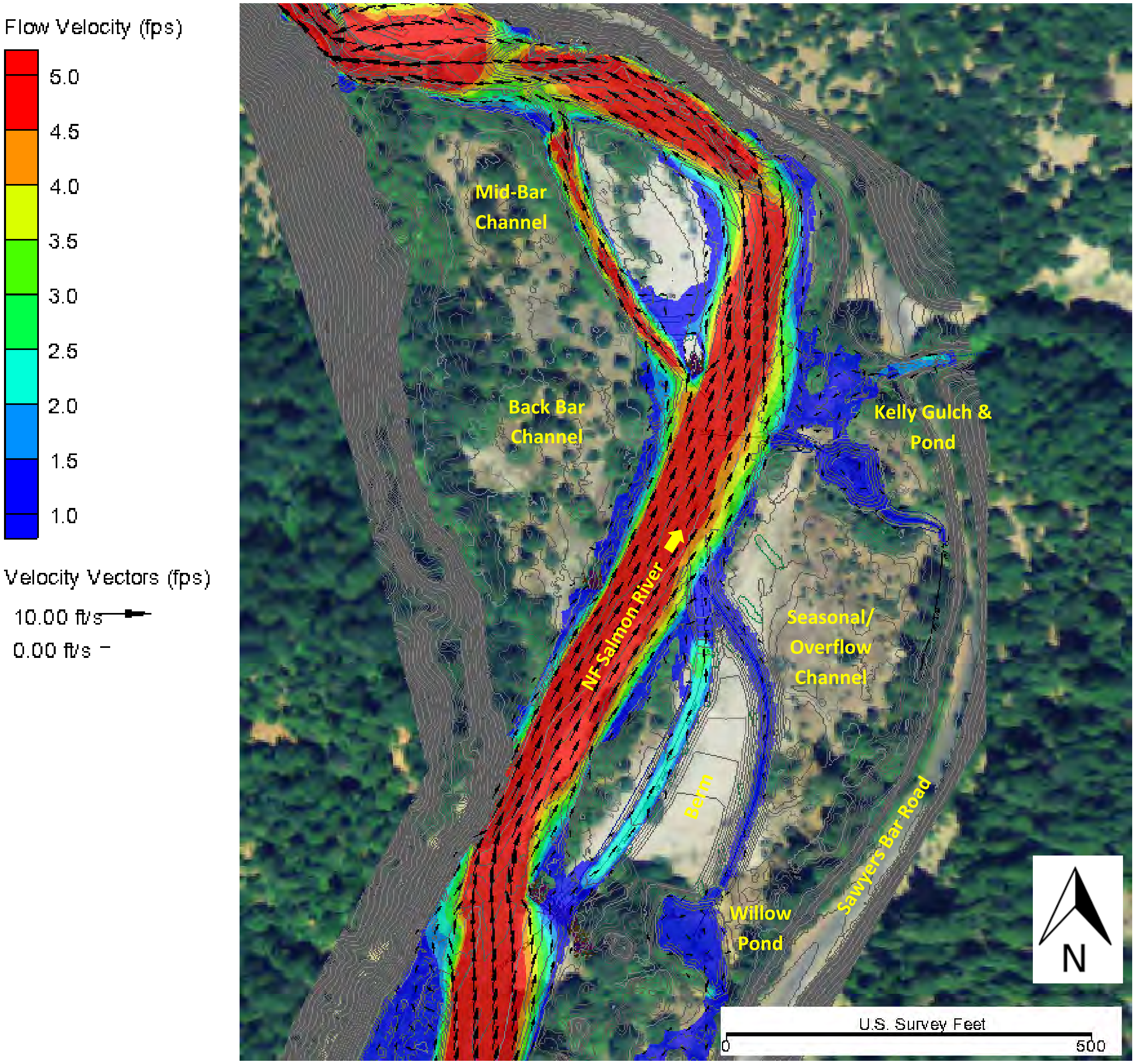
Design Condition
2-D Model-Predicted Flow Velocities for the NF Salmon River at Kelly Bar for a 1.2-Year Flow Event
(2,083 cfs)



Design Condition

2-D Model-Predicted Flow Velocities for the NF Salmon River at Kelly Bar for a 1.5-Year Flow Event

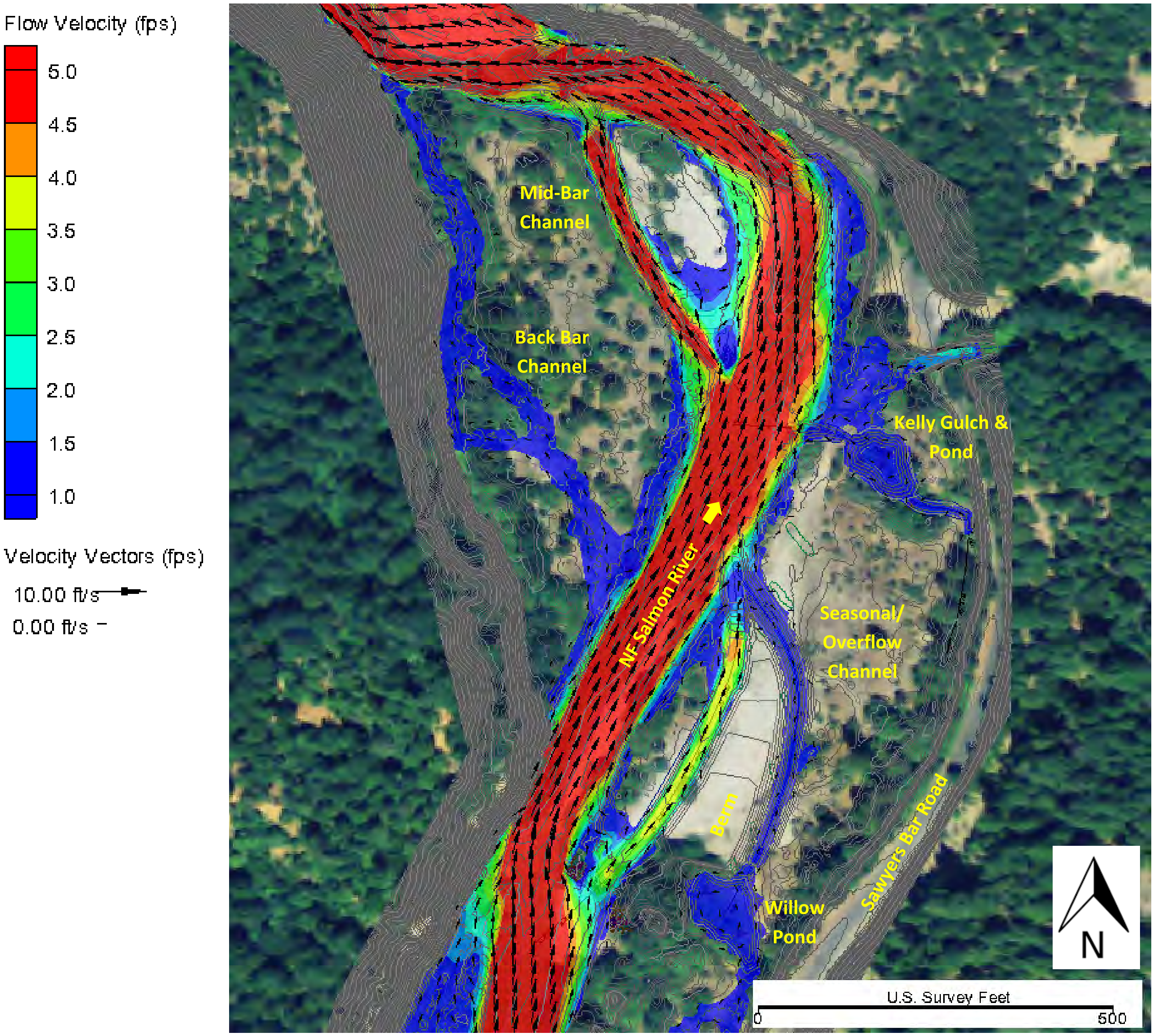
(2,966 cfs)



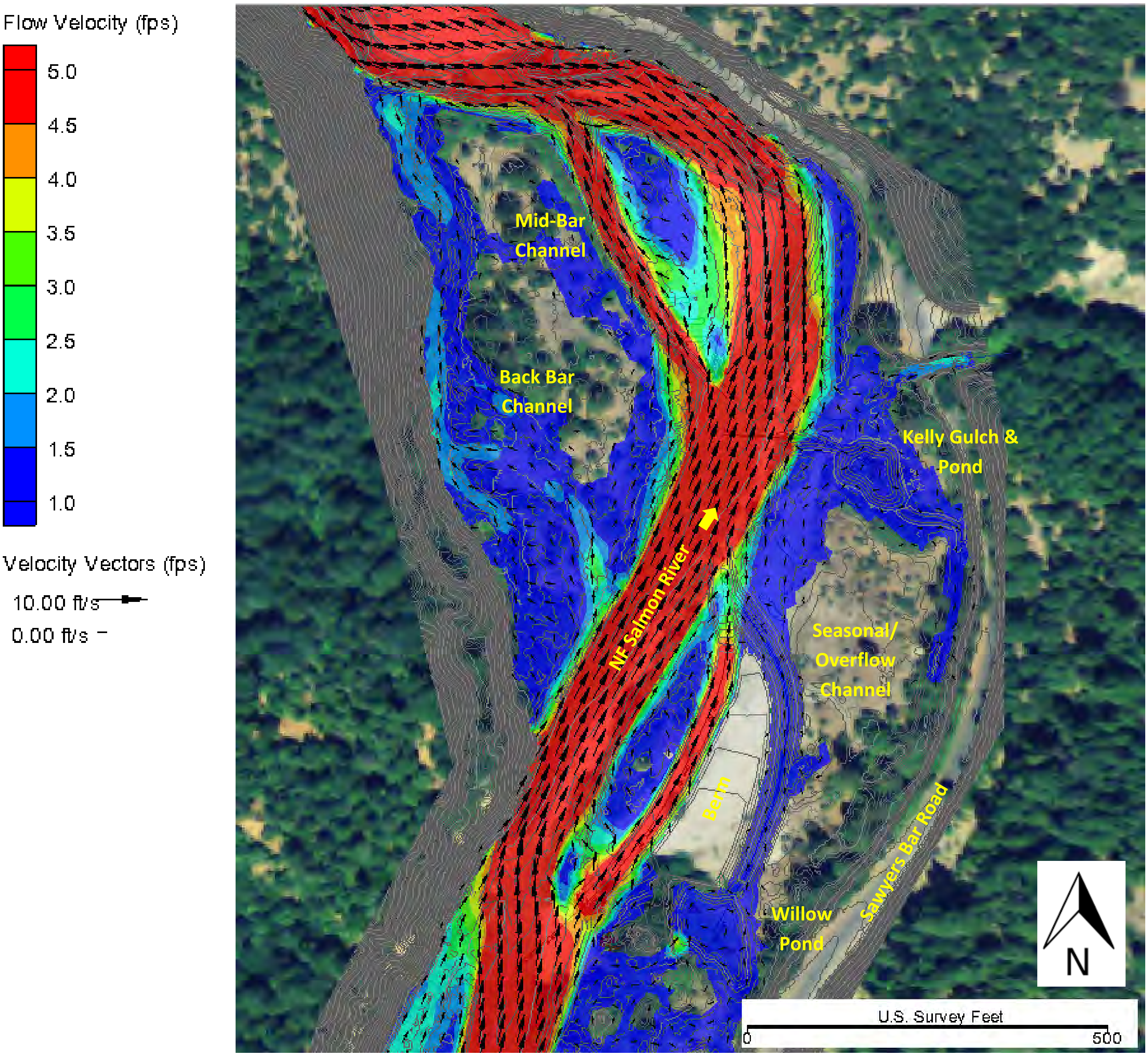
Design Condition

2-D Model-Predicted Flow Velocities for the NF Salmon River at Kelly Bar for a 2.2-Year Flow Event

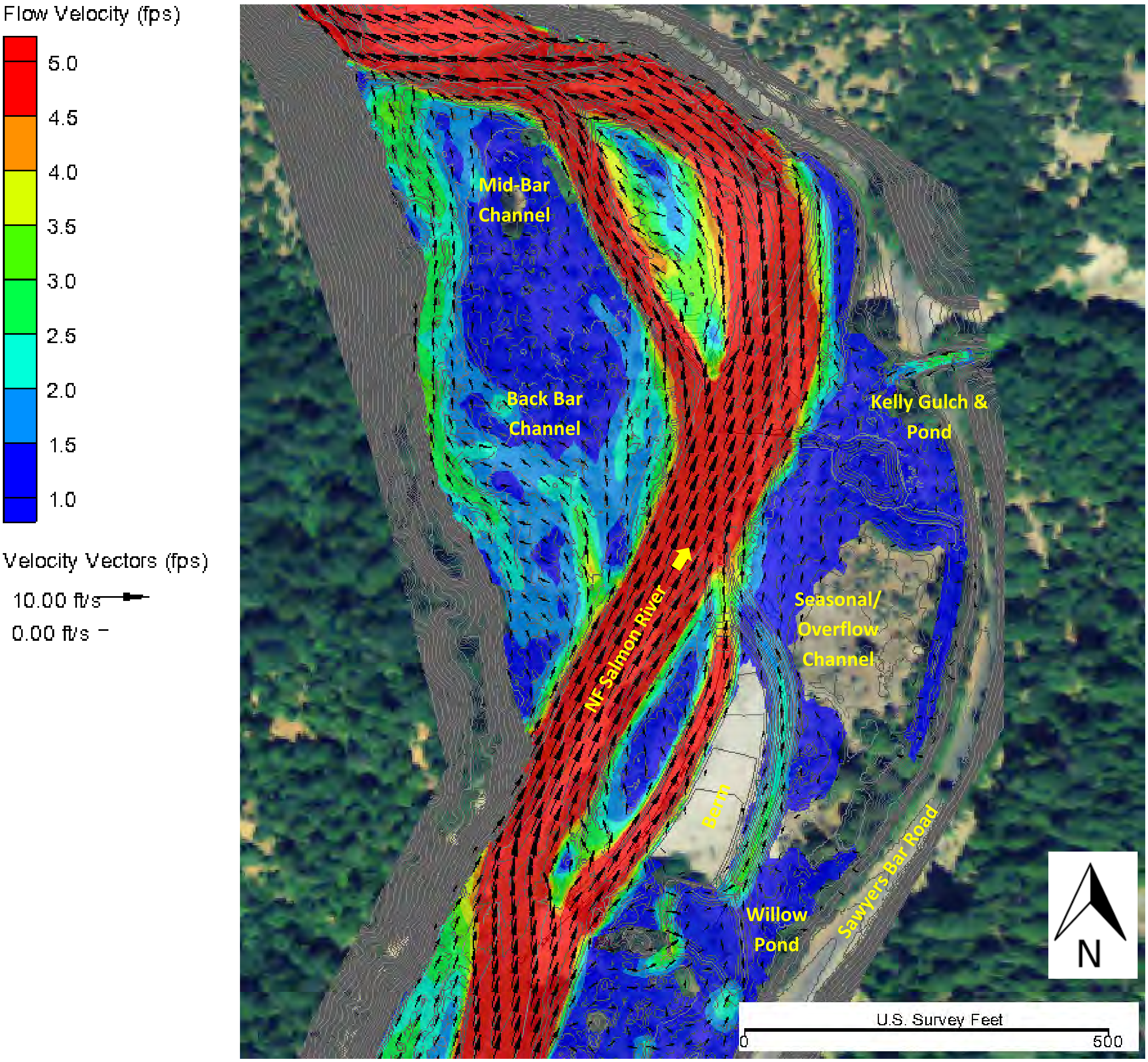
(4,300 cfs)



Design Condition
2-D Model-Predicted Flow Velocities for the NF Salmon River at Kelly Bar for a 5-Year Flow Event
(7,056 cfs)



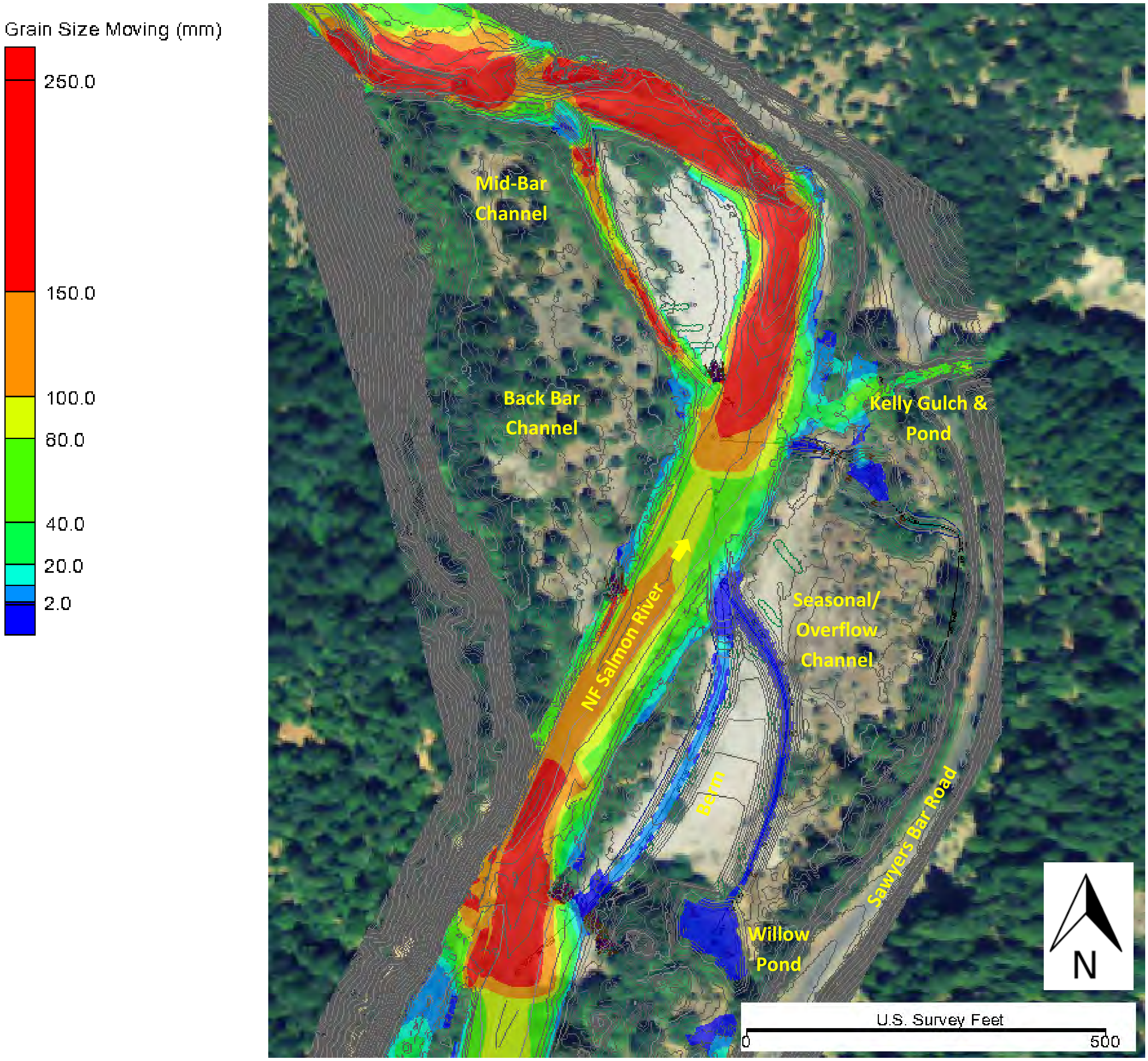
Design Condition
2-D Model-Predicted Flow Velocities for the NF Salmon River at Kelly Bar for a 10-Year Flow Event
(9,514 cfs)



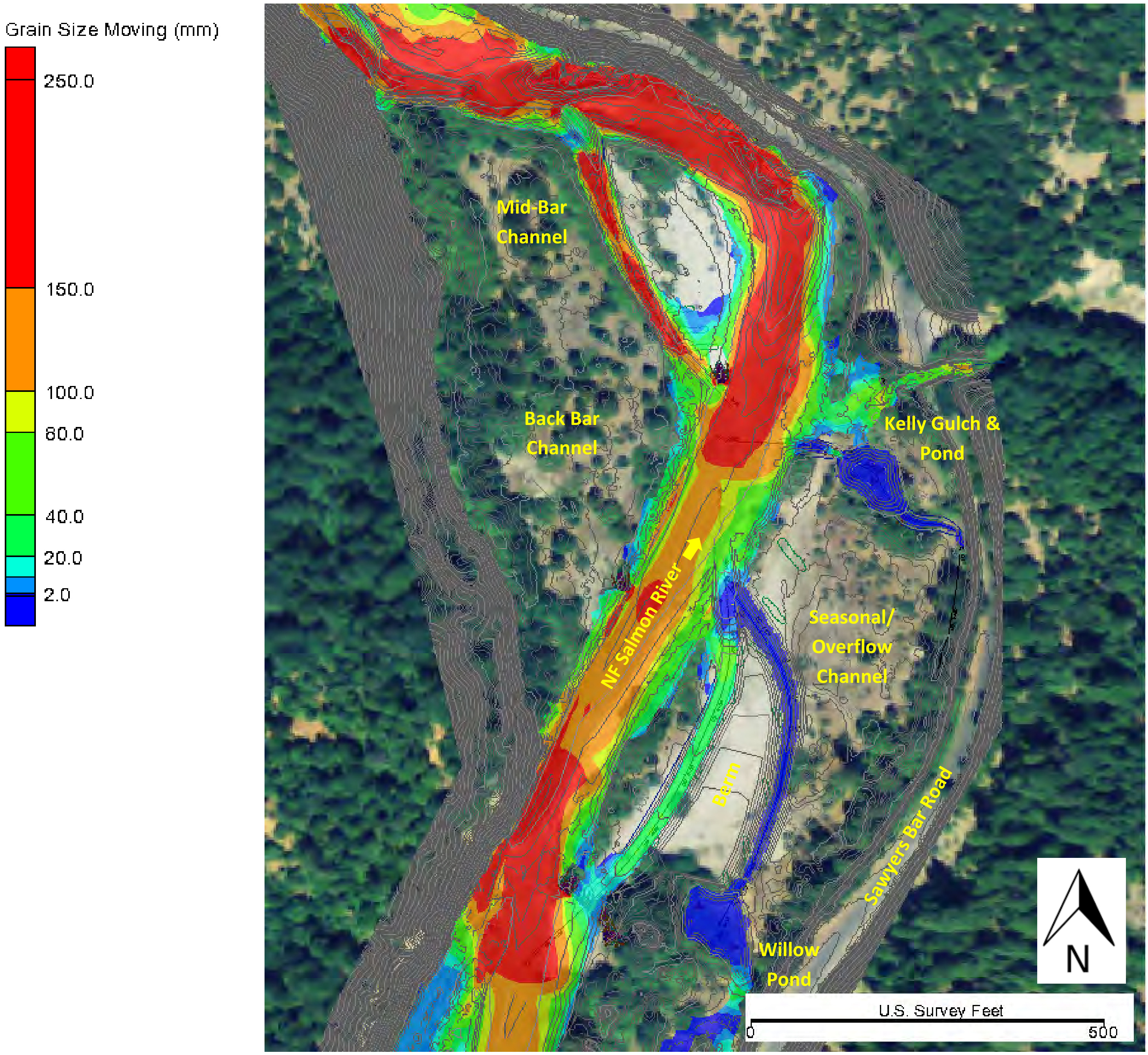
Design Condition

2-D Model-Predicted Sediment Size Mobilized for the NF Salmon River at Kelly Bar for a 1.2-Year Flow Event

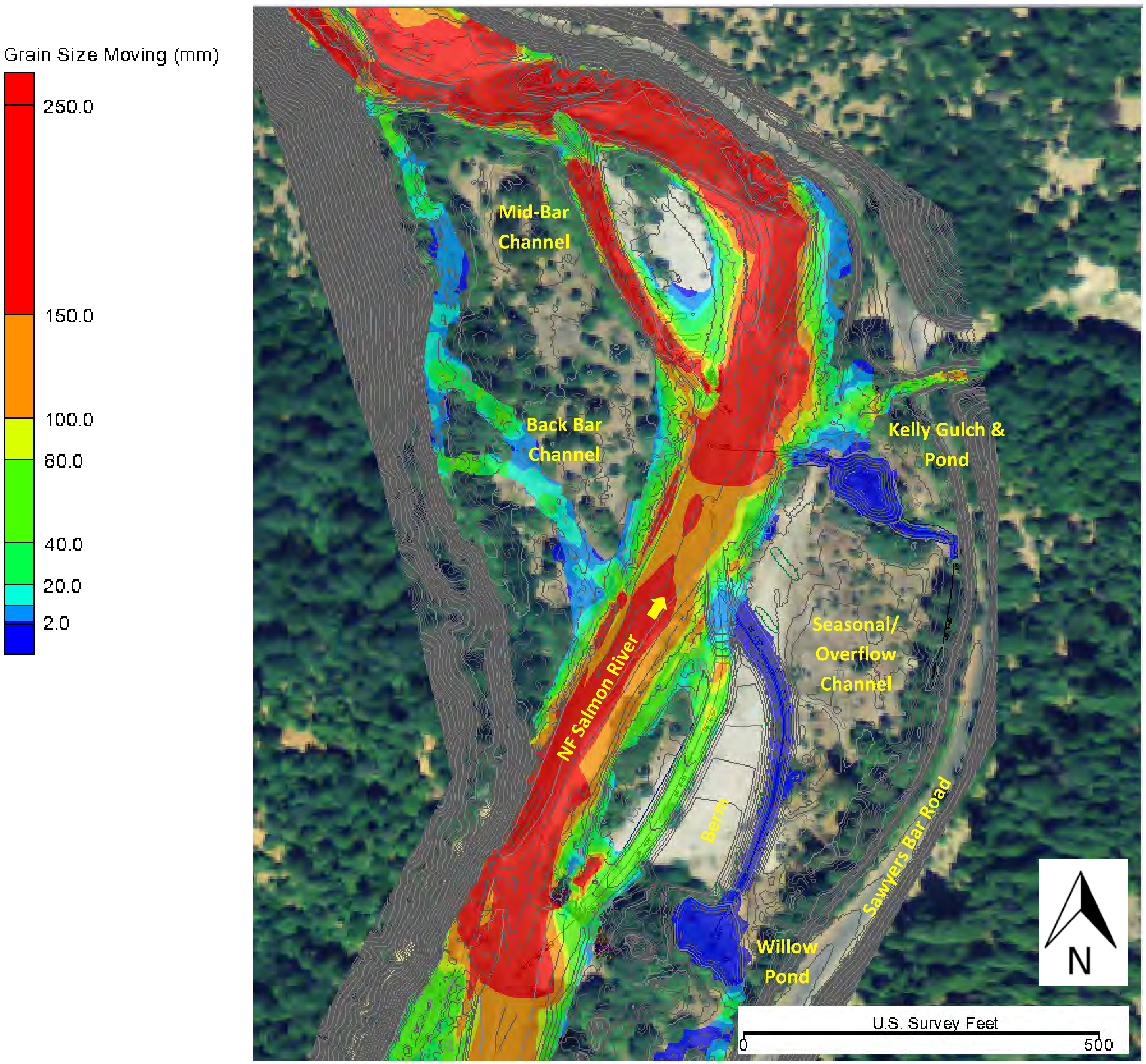
(2,083 cfs)



Design Condition
2-D Model-Predicted Sediment Size Mobilized for the NF Salmon River at Kelly Bar for a 1.5-Year Flow Event
(2,966 cfs)



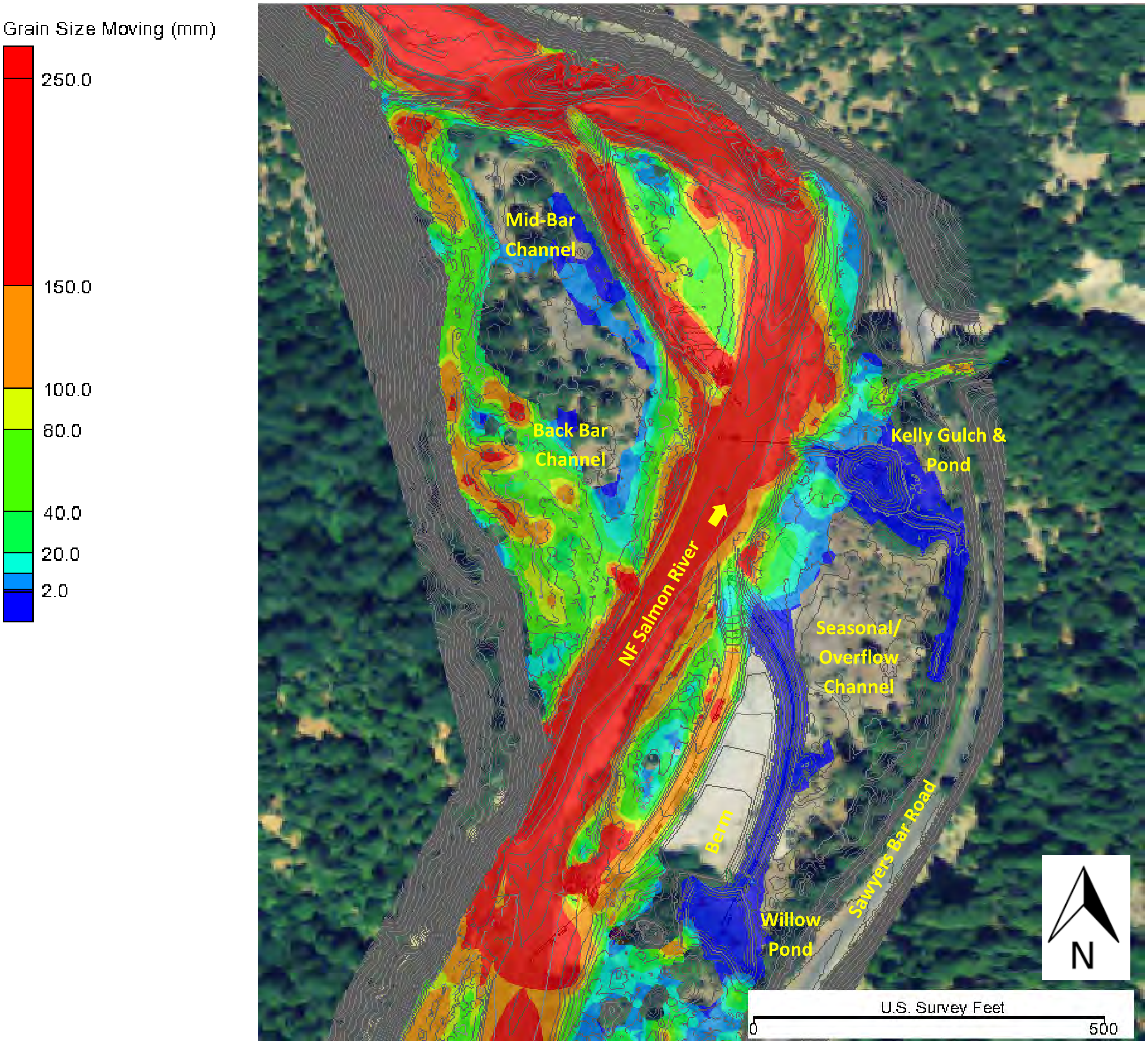
Design Condition
2-D Model-Predicted Sediment Size Mobilized for the NF Salmon River at Kelly Bar for a 2.2-Year Flow Event
(4,300 cfs)



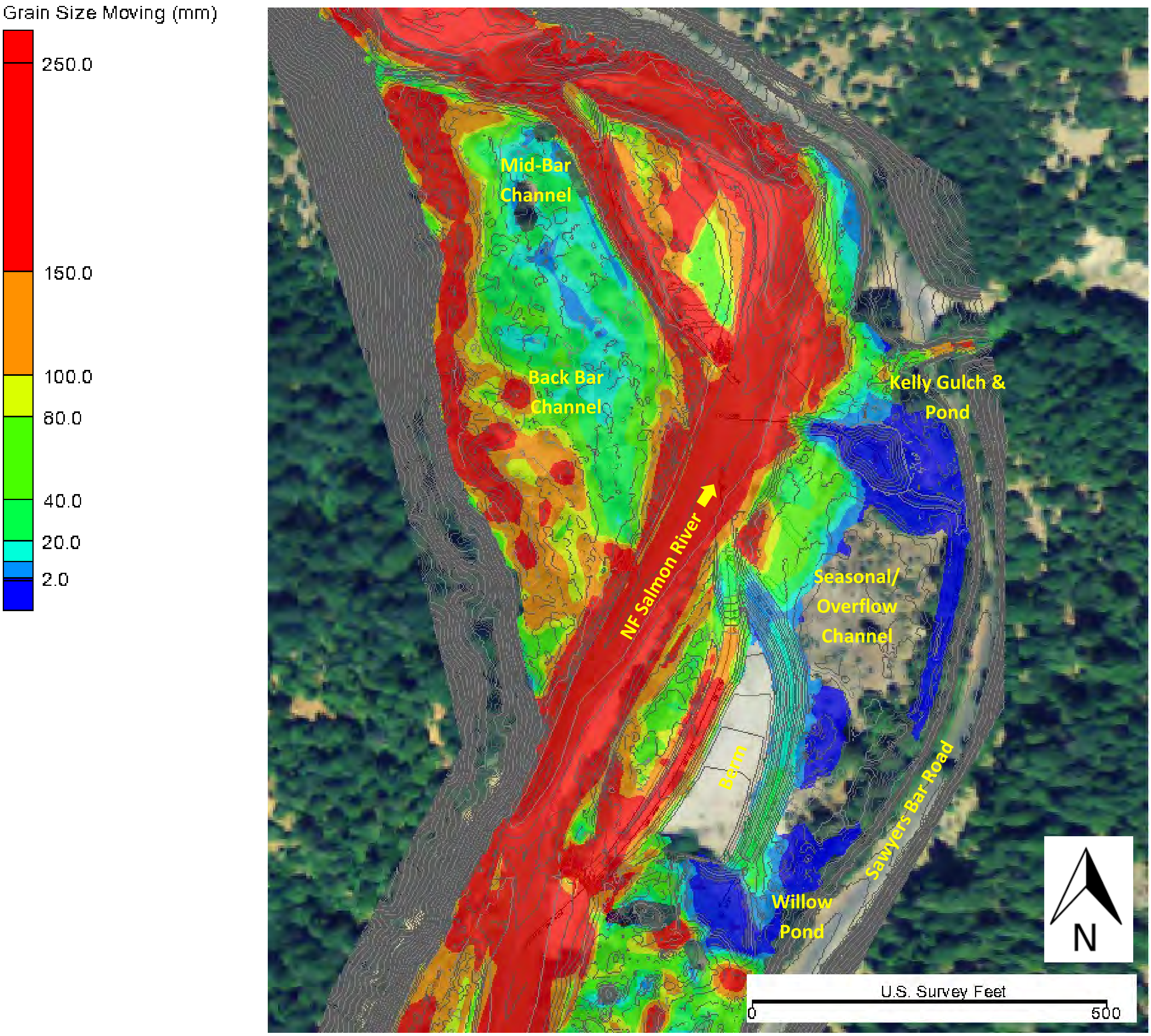
Design Condition

2-D Model-Predicted Sediment Size Mobilized for the NF Salmon River at Kelly Bar for a 5-Year Flow Event

(7,056 cfs)



Design Condition
2-D Model-Predicted Sediment Size Mobilized for the NF Salmon River at Kelly Bar for a 10-Year Flow Event
(9,514 cfs)



Appendix L

Opinion of Probable Construction Cost

Opinion of Probable Construction Cost for 30% Design Submittal

Kelly Gulch Off-Chanel Fisheries and Riparian Habitat Design

9/30/2015

Michael Love & Associates
Hydrologic Solutions
PO Box 4477 • Arcata, CA 95518 • (707) 822 -2411

Line Item	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Mobilization/Demobilization	LS	2	$28,500	$57,000
2	Clearing, Grubbing, and Construction Access	LS	1.0	$5,000	$5,000
3	Temporary River Crossing	LS	1.0	$8,000	$8,000
4	Dewatering	Day	40	$250	$10,000
5	Temporary Site Stabilization (Seed and Mulch)	AC	2	$1,200	$2,400
6	Fish Relocation	Day	3	$1,200	$3,600
7	Excavation/Spoil Placement	CY	5,700	$25	$142,500
8	Apex Bar Jam/Abutment Jam	EA	4	$36,000	$144,000
9	Large Wood Habitat Structures	EA	15	$5,000	$75,000
10	Large Wood Pond Cover Structures	EA	5	$5,000	$25,000
11	Log Steps	EA	8	$6,000	$48,000
12	Large Wood Inlet Weir	EA	1	$41,000	$41,000
13	Live Willow Stakes	EA	2,000	$5	$10,000
14	Live Brush Baffles	LF	650	$60	$39,000
15	Cattle Exclusion Fencing	FT	1,600	$7	$11,200
16	12-foot 6-Bar Galvanized Steel Gate	EA	1	$500	$500
				Subtotal Construction	**$622,200**
			Contingency	25%	$155,550
TOTAL CONSTRUCTION COSTS					**$777,750**