TECHNICAL MEMORANDUM 3-12

New Colgate Powerhouse Ramping

Yuba River Development Project
FERC Project No. 2246

December 2012

TECHNICAL MEMORANDUM 3-12

EXECUTIVE SUMMARY

In 2012, Yuba County Water Agency (YCWA) investigated ramping of New Colgate Powerhouse in the 1.79-mile long section of the Yuba River between the New Colgate Powerhouse and the normal maximum water surface elevation of the United States Army Corps of Engineers' Englebright Reservoir.

The goal of the study was to determine the occurrence of and potential for fish stranding in the Yuba River downstream of New Colgate Powerhouse due to Project ramping operations.

Study methods and analyses included field measurement and modeling of flow, depth, velocity, wetted perimeter, areas of inundation at seven collaboratively selected transects and, visual observations for fish stranding at each cobble bar. The target species for analysis and observation was resident rainbow trout (*Oncorhynchus mykiss*), though all observed species were documented.

Six visual observation surveys were performed, one each on June 12 and 13; July 27 and 28; and August 25 and 30, 2012. Each survey began approximately 1 hour before a New Colgate Powerhouse down-ramp event was scheduled to begin, continued throughout the down-ramp event, and terminated no less than 1 hour after down-ramp event ended. Down ramps ranged from a rapid reduction in flow of 1,000 to 1,662 cfs, with starting flows ranging from 1,509 to 3,261 cfs.

Visual observation surveys were conducted to document fish presence in the varial littoral zone by walking or snorkeling before and after down-ramp events. Fish stranding surveys were conducted via walking along the littoral zones at both locations during each of the six down-ramp events.

All stranding observations were made in three specific locations labeled that appeared to possess high-stranding potential. Stranding Zone A was located at the head of Condemned Bar, near the confluence of Dobbins Creek. Stranding Zone B was located downstream on the opposite side of the river from Condemned Bar. Stranding Zone C was located at the end of French Bar on river left. Each zone was characterized by boulder and cobble substrate, though they also contained sand in the interstitial spaces between boulders.

Of the 16 stranding observations made during the study, only one observation was of rainbow trout (i.e., 40 mm in length). All stranded fish of any species were less than 50 mm long, and 75 percent were less than 15 mm long. No fish species listed as threatened or endangered under the federal Endangered Species Act or the California Endangered Species Act, or otherwise considered special-status, were observed stranded.

The observation of adult rainbow trout in pre- and post-ramp surveys as well as in fish surveys conducted in support of Study 3.8, *Stream Fish Populations Upstream of Englebright Reservoir*, indicate a persistent population that is not forced downstream by daily pulsed flows.

In the reach downstream of New Colgate Powerhouse, isolated pools and potholes along the stream margins created during dewatering events appear to influence stranding potential more than the surveyed low gradient gravel or cobble bars. Of the seven transect locations selected for intensive topographical survey, only one transect - R3 - had a potential stranding zone gradient of 4.9 percent, though no stranding was documented at that location. Stranding was only observed on the right bank of R1, the furthest downstream transect in the study.

Rate of stage change, defined as the change in water surface elevation over the time between the initial response time to the point of stabilization, was calculated for each transect in the study area. Overall, the rates of stage change ranged from 0.115 ft per minute (ft/min) to 0.026 ft/min or 6.9 ft per hour (ft/hr) to 1.56 ft/hr. The results show a linear relationship with increasing distance from the powerhouse. Channel shape and gradient also influenced the attenuation of the ramping rates observed at each transect.

The study was conducted according to the Federal Energy Regulatory Commission (FERC)-approved Study 3.12, *New Colgate Powerhouse Ramping*, with one variance. The FERC-approved study specified the study be completed by the end of September 2012. Due to a series of powerhouse maintenance outages in August 2012, flow scheduling for purposes of visual observation stranding surveys was limited thereby resulting in a delay of study completion.

The study is complete.

Table of Contents

Table of Contents (continued)

List of Figures

List of Figures (continued)

List of Figures (continued)

List of Tables

List of Attachments

Page Left Blank

TECHNICAL MEMORANDUM 3-12

NEW COLGATE POWERHOUSE RAMPING[1]

Yuba County Water Agency's (YCWA) continued operation and maintenance (O&M) of the Yuba River Development Project, Federal Energy Regulatory Commission (FERC or Commission) Project Number 2246 (Project) may potentially have an adverse effect on fish populations in the Yuba River due to fish stranding between the Project's New Colgate Powerhouse and the United States Army Corps of Engineers (USACE) Englebright Reservoir.[2]

1.0 Study Goals and Objectives

The goal of the study was to determine the occurrence of and potential for fish stranding in the Yuba River downstream of New Colgate Powerhouse due to Project ramping operations. The objectives of the study were to: 1) analyze the effects of New Colgate Powerhouse peaking operations on changes in flow, depth, velocity, wetted perimeter, and areas of inundation using time-steps typical of New Colgate Powerhouse peaking operations; and 2) perform visual observations of fish standing during Project ramping events.

2.0 Methods

The methods used in the study are described below.

2.1 Study Area

The study area includes approximately 1.7 miles of the Yuba River from New Colgate Powerhouse at RM 34.2 to the normal water surface elevation (NMWSE) of Englebright Reservoir at approximately RM 32.7 (Figure 2.1-1).

[1] This technical memorandum provides the results for Study 3.12, *New Colgate Powerhouse Ramping*. In its September 30, 2011 Study Plan Determination, FERC directed YCWA to develop and perform Study 3.12, and FERC approved YCWA's study in its May 14, 2012, Modified Study Determination. There were no modifications to Study 3.12 subsequent to FERC's May 14, 2012 Study Determination.

[2] Englebright Dam, which is about 260 feet high and forms Englebright Reservoir, was constructed by the California Debris Commission in 1941. The dam is owned by the United States. When the California Debris Commission was decommissioned in 1986, administration of Englebright Dam and Reservoir passed to the USACE. The primary purpose of the dam is to trap and contain sediment derived from extensive historic hydraulic mining operations in the Yuba River watershed. Englebright Reservoir is about 9 miles long with a surface area of 815 acres. Englebright Reservoir when first constructed had a gross storage capacity of 70,000 ac-ft; however, due to sediment capture, the gross storage capacity today is approximately 50,000 ac-ft (USGS 2003).

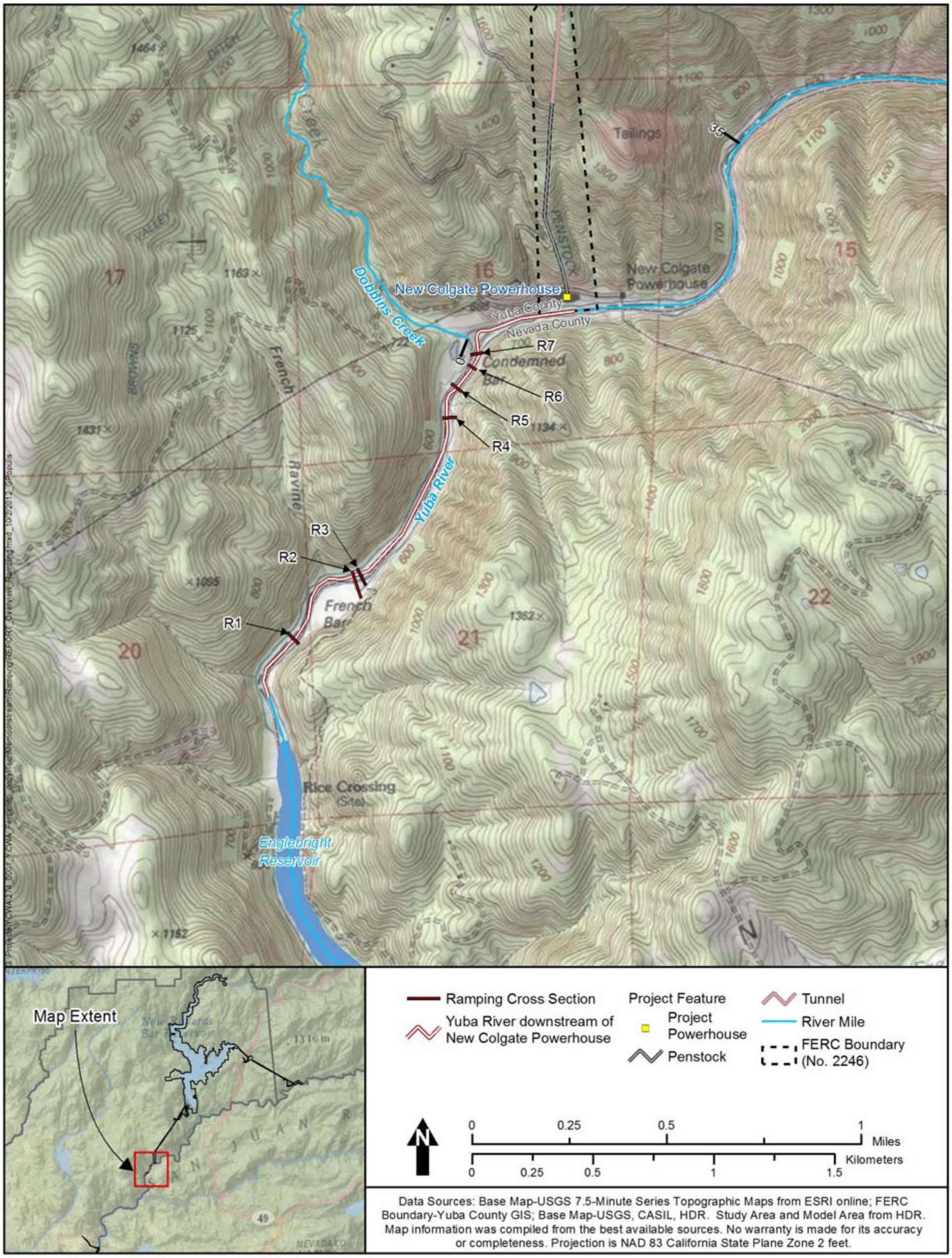

Figure 2.1-1. Study area for Study 3.12, *New Colgate Powerhouse Ramping*, including locations of ramping transects.

2.2 Observation Site Locations

Two very large cobble bars were the primary investigation areas. They are known as "Condemned Bar" (Figure 2.2-1), which is approximately 0.3 mile downstream of New Colgate Powerhouse, and "French Bar" (Figure 2.2-2), which is located approximately 1.2 miles downstream of the powerhouse. Neither bar is affected by Englebright Reservoir water surface elevations (WSE). The two bars comprised approximately 20 percent of the total study area.

Page Left Blank

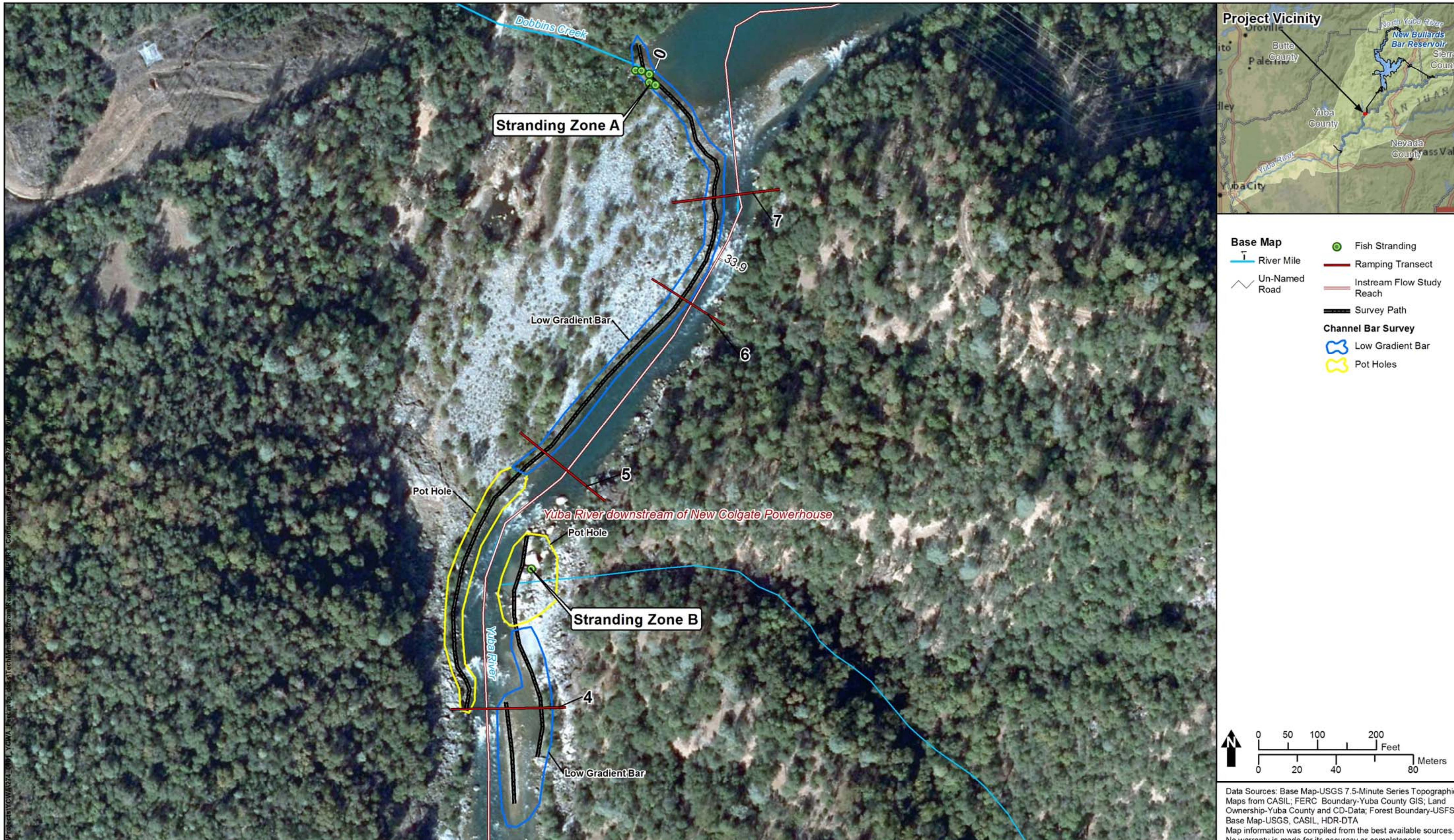

Figure 2.2-1. Location of Condemned Bar downstream of the New Colgate Powerhouse. Hydraulic transects, bar habitat mapping, fish stranding survey routes and fish stranding observations are shown.

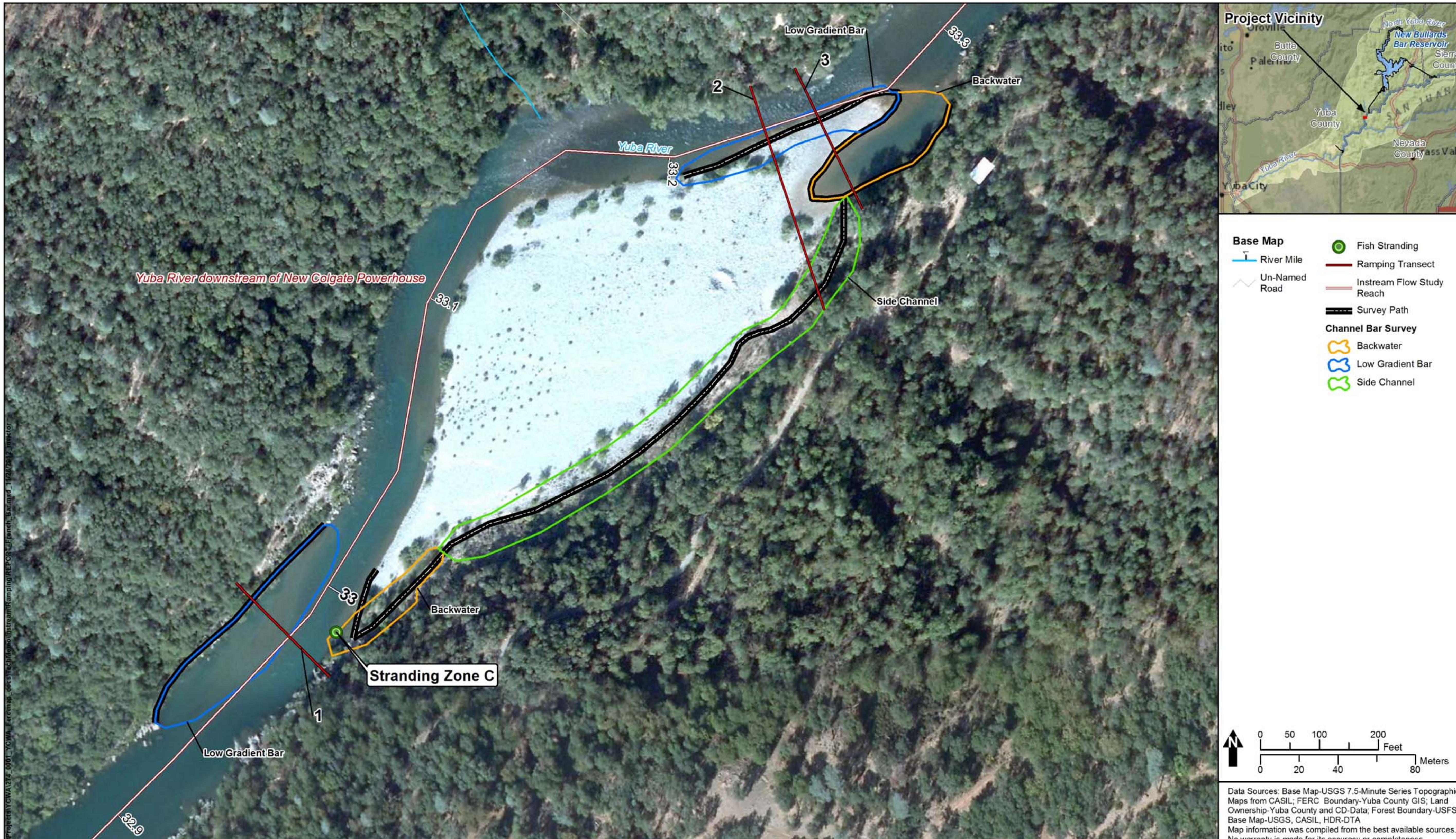

Figure 2.2-2. Location of French Bar downstream of New Colgate Powerhouse Reach. Hydraulic transects, bar habitat mapping, fish stranding survey routes and fish stranding observations are shown.

2.3 Select Transects to Measure and Model

YCWA and Relicensing Participants identified seven sites on Condemned Bar and French Bar where ramping specific transects were to be placed. The seven sites were specifically identified as potential stranding locations based on the following criteria: 1) low-gradient channel with slopes ranging from 0 to 5 percent; or 2) topographic features, such as potholes or backwater areas where fish could be potentially stranded; or 3) both 1 and 2. Ramping transect locations are shown in Figures 3.1-1, 3.2-4 and 3.2-5 and the location of each transect downstream of the New Colgate Powerhouse is presented in Table 3.3-2.

Table 2.3-1. Distances downstream of the New Colgate Powerhouse for each transect.

Transect		Distance Downstream from New Colgate Powerhouse (RM 34.2)	
Ramping #	**PHABSIM #[1]**	**Feet**	**RM**
R7	T-18	1,474	33.92
R6	T-17	1,674	33.88
R5	T-16	2,030	33.82
R4	T-13	2,501	33.73
R3	--	5,016	33.25
R2	T-6	5,112	33.23
R1	T-3	6,445	32.98

[1] YCWA and Relicensing Participants co-located the transects with Physical Habitat Simulation (PHABSIM) transects placed for YCWA's Study 3.10, *Instream Flow Upstream of Englebright Reservoir.* This column provides the number of the PHABSIM transect in Study 3.10.

The four transects associated with Condemned Bar are shown in representative photos in Figures 2.3-1 through 2.3-4. The three transects associated with French Bar are shown in representative photos in Figures 2.3-5 through 2.3-7.

Figure 2.3-1. Transect R7 – Right bank water's edge looking upstream at 130 cfs.

Figure 2.3-2. Transect R6 – Right bank looking upstream to right bank at 176 cfs.

Figure 2.3-3. Transect R5 – Right bank looking upstream at 176 cfs.

Figure 2.3-4. Transect R4 – Looking downstream at mid channel cobble bar at 541 cfs.

Figure 2.3-5. Transect R3 – Looking upstream from transect at point bar at 176 cfs

Figure 2.3-6. Transect R2 – looking upstream toward R3 and backwater/perched pool at 176 cfs.

Figure 2.3-7. Transect R1 – Left bank looking downstream at the gravel/cobble bar at 541 cfs

2.4 Mapping of Observation Site Locations

Potential fish stranding site characteristics of Condemned Bar and French Bar were mapped in Geographic Information System (GIS) according to the following definitions:

- Side Channel. Secondary channels formed along the lateral margins of bars that are typically separated from the main channel at low flow.
- Backwater. Relatively large pools formed along the lateral margins of bars by sediment deposition, beaver dams, and other obstructions.
- Pothole. Small, isolated depressions typically caused by local scouring around obstructions (e.g., woody vegetation) on bar surfaces.
- Low-Gradient Bar. Bars with less than 5 percent slopes.

Figures 2.1-1 and 2.1-2 show the mapped site characteristics.

2.5 Visual Observation for Fish Stranding

Because channel morphology and hydraulic analyses only indicate the potential for stranding, ramping studies often include visual empirical observation surveys in addition to hydraulic modeling (YCWA 2003, PacifiCorp 2004, Hunter 1992). Visual observation also allows investigators to focus on specific areas where, by professional judgment and empirical indicators, stranding would be most likely to occur. The specific locations of these areas in the reach downstream of the New Colgate Powerhouse are described below.

All fish species identifications and length estimates were made without handling fish. Individual fish that could not be identified without handling (e.g., usually fish les than approximately 20 mm in length) were considered “unidentified.”

2.5.1 Number of Observations and Seasonal and Daily Timing

Six visual observation surveys were performed, one each on June 12 and 13; July 27 and 28; and August 25 and 30, 2012. Each survey began approximately 1 hour before a New Colgate Powerhouse down-ramp event was scheduled to begin, continued throughout the down-ramp event, and terminated no less than 1 hour after each down-ramp event ended.

2.5.2 Flow Range

Target ramp down flows were established to replicate typical operational changes made at the New Colgate Powerhouse. For example, at full generation and full pool, the powerhouse discharges 3,400 cfs.

Each down-ramp event was coordinated with daily powerhouse operations. Initial starting flows were held for a minimum of 4 hours before down-ramp began. This allowed for fish to move into near-shore littoral habitat prior to the down-ramp. After the down-ramp, target flows were subsequently held for 4 hours to allow for the completion of the stranding observations. Table 2.5-1 shows the dates and flow range during each of the seven observation events. To establish base flows (i.e., the flow upstream of the powerhouse), discharge measurements were made upstream of the New Colgate Powerhouse before each ramping event.

Table 2.5-1. Date and flow range during each observation event.

Date	Base Flow Yuba River Above Colgate Powerhouse (cfs)	Flow Ramp Down Start		Flow Ramp Down End		Total River Flow Range (cfs)	Observation Time Start (PDST)	Observation Time End (PDST)
		Time (PDST)[1]	Powerhouse Discharge (cfs)	Time (PDST)	Powerhouse Discharge (cfs)			
RECONNAISSANCE SURVEYS								
6/11/2012	85.8	New Colgate Powerhouse Release was approximately 536 cfs						
RAMPING EVENTS								
6/12/2012	85.8	4:00 PM	2,973	8:00 PM	1,475	3,059 - 1561	3:49 PM	5:08 PM
6/13/2012		10:09 AM	1,455	2:00 PM	455	1541 - 541	9:42 AM	11:05 AM
7/27/2012	50.0	2:00 PM	3,211	6:00 PM	1,549	3,261 – 1,599	2:10 PM	3:00 PM
7/28/2012		12:00 PM	1,559	2:30 PM	126	1,609 – 176	10:23 AM	1:36 PM
8/25/2012	33.7	7:00 AM	3,075	11:00 AM	1,468	3,109 – 1502	6:40 AM	8:06 AM
8/30/2012		9:00 AM	1,475	1:00 PM	96	1,509 - 130	8:30 AM	10:22 AM

[1] PDST means Pacific Daylight Savings Time.

Fish stranding surveys in June and July 2012 were conducted on two consecutive days while surveys in August 2012 spanned a 6-day period. Fifteen-minute New Colgate Powerhouse flow records for each survey period in which sampling occurred are shown in Figures 2.5-1 through 2.5-3. Normal daily operations between survey days in August are included. Scheduled ramping test flows are shown overlaid in the figures.

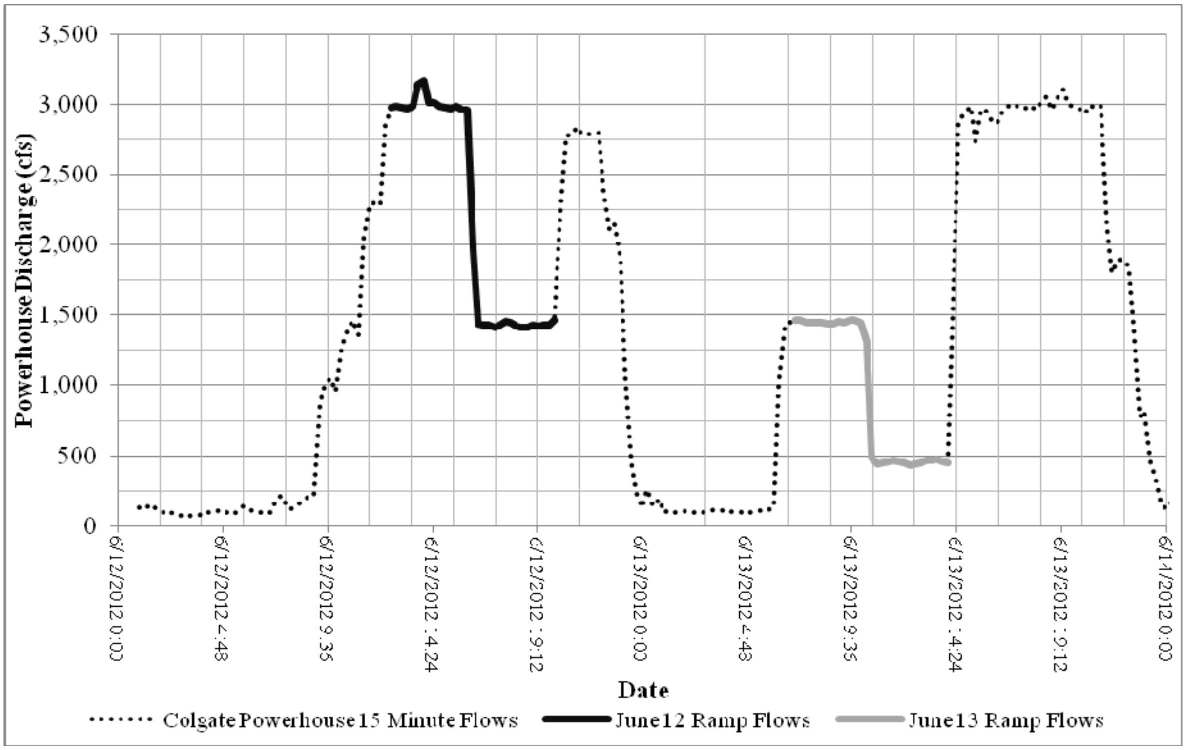

Figure 2.5-1. New Colgate Powerhouse operations for June 12 and June 13, 2012. Data shown are in 15 minute intervals. Scheduled ramping test flows are overlaid in solid black and solid grey.

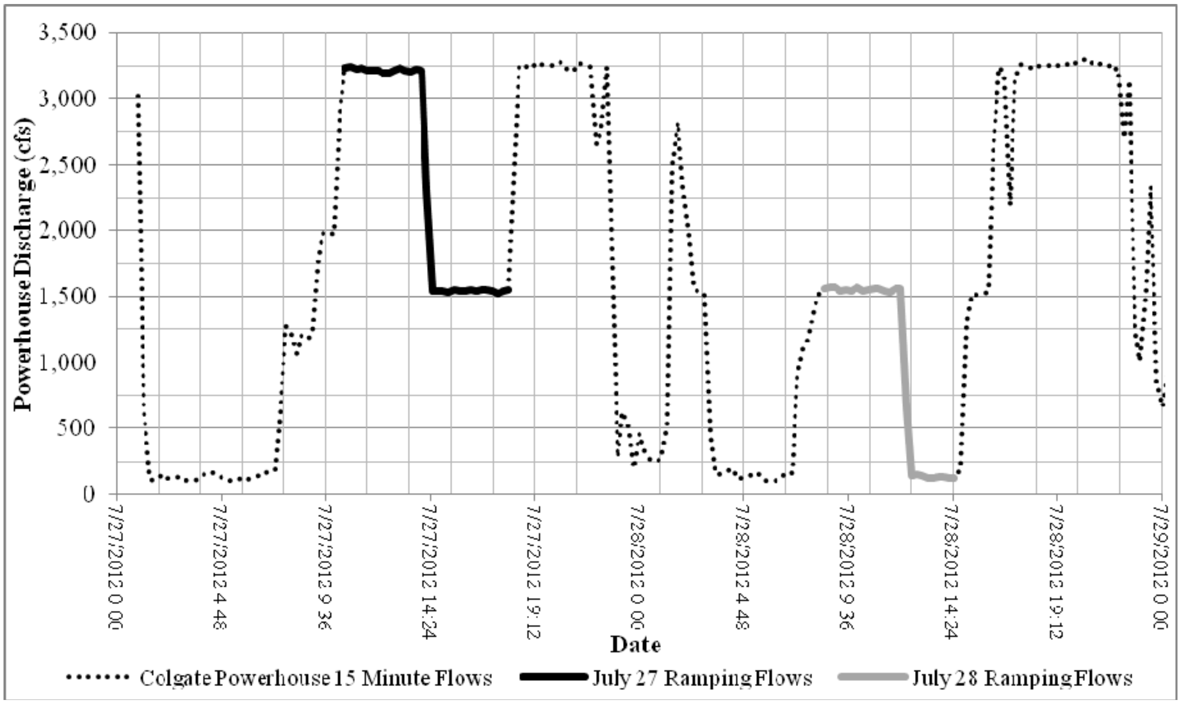

Figure 2.5-2. New Colgate Powerhouse operations for July 27 and July 28, 2012. Data shown are in 15 minute intervals. Scheduled ramping study flows are overlaid in solid black and solid grey.

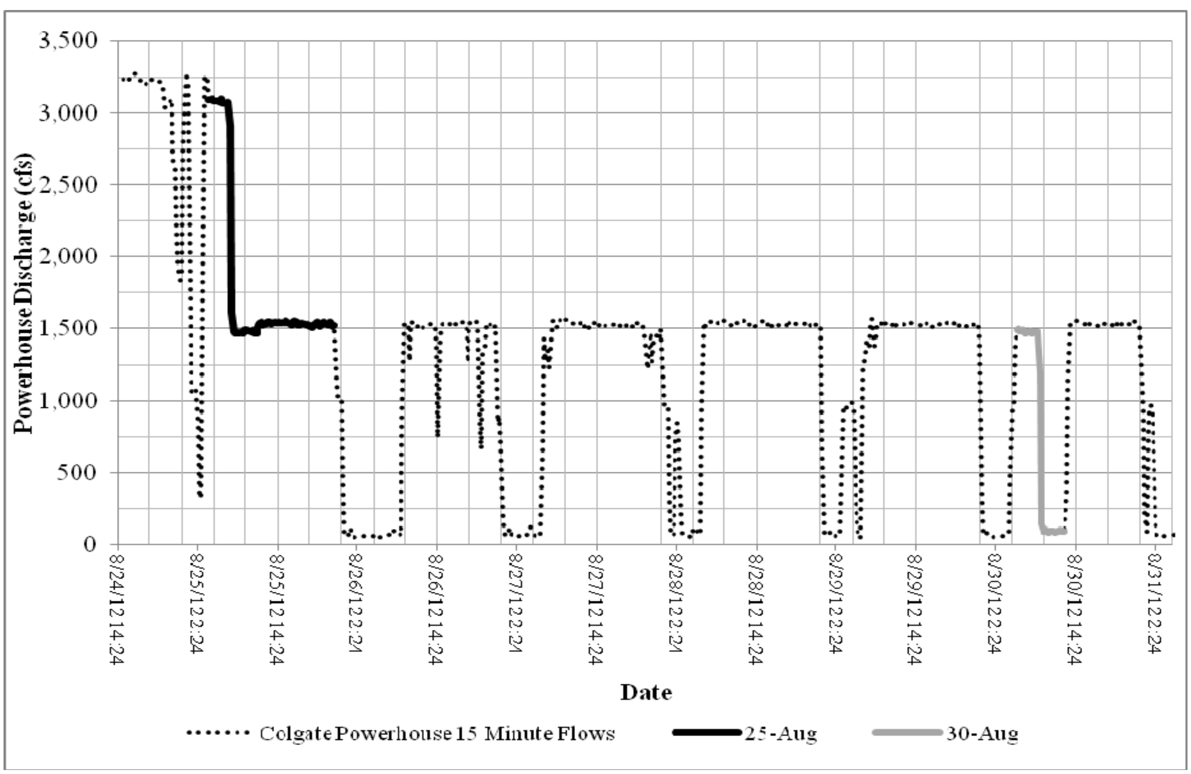

Figure 2.5-3. New Colgate Powerhouse operations for Aug 25 and Aug 30, 2012. Data shown are in 15 minute intervals. Scheduled ramping study flows are overlaid in solid black and solid grey.

2.5.3 Visual Stranding Surveys

Visual stranding surveys were performed in two parts: 1) pre- and post-ramp down surveys, and 2) down ramp stranding surveys. The primary objectives of this task were to visually determine the presence or absence of fish in the vicinity of each cobble bar and to visually survey for stranded fish in edgewater, backwater, perched habitats, potholes and on exposed bars during scheduled down-ramp events at Condemned Bar and French Bar.

YCWA conducted one reconnaissance survey on June 11 with a steady flow release of approximately 536 cfs and conducted six formal stranding surveys on the following dates: June 12 and 13, July 27 and 28, and August 25 and 30, 2012. Each of these surveys is described below.

2.5.3.1 Reconnaissance Survey

YCWA performed a reconnaissance fish survey, in particular for rainbow trout (*Oncorhynchus mykiss*) fry, prior to the first fish stranding observation survey. This survey was conducted on June 11, 2012. The reconnaissance survey was conducted not only to document rainbow trout fry, but to establish the exact protocol to be used during the ramping events. Biologists determined the length and location of each survey route for both walking surveys and snorkel surveys. Once established, the time to complete each route was determined.

2.5.3.2 Pre-ramp and Post-ramp Down Surveys

The primary objective of the pre-ramp and post-ramp surveys was to document fish presence in the vicinity of the Condemned Bar and French Bar. The survey method for the pre-ramp and post-ramp down flows included dry land walking, wading and snorkeling observation techniques. Deep (i.e., >2 feet) cobble bar edgewater, perched and backwater habitats were snorkeled in a downstream, rather than upstream, direction due to very swift flows. Potential stranding areas less than 1 to 2 feet (ft) deep were surveyed with a dry-land walking or wading survey observing the pools at an oblique angle to the sun, avoiding shadows, and using polarized sun glasses.

For one hour before and one hour after each of the seven down ramp events, the occurrence and relative abundance of fish in edgewater, backwater, and perched habitats was determined by surveying the observation sites. Field crews consisted of two persons experienced in snorkeling and fish identification. The species, number, and size class of fish were recorded on plastic slates or data forms.

2.5.3.3 Down-ramp Stranding Surveys

In total, over 1,900 ft of shoreline on Condemned Bar and over 2,700 ft of shoreline on French Bar were surveyed. During the down-ramp event, exposed shorelines also called the varial zone,[3] were surveyed multiple times as flows receded. Each field crew member was positioned at one of the survey routes established during the reconnaissance survey at the beginning of the ramping event. As flows receded and new substrate was exposed, the crew searched the exposed portion of the transects and recorded the number, size, and species of any stranded fish observed. Searches included turning over random cobbles to document the presence of fish in suspected stranding areas, such as small residual interstitial pocket pools. On large bar areas that could not be completely searched in one pass, multiple passes were made measuring approximately 5 ft in width along the newly exposed shoreline. Each site was surveyed at least once after temporary staff gage readings were stable.

Photographs were taken at each transect to document the stage change from the starting flow to ending flow. Surveyors also documented the dimensions of residual pools, the general habitat, and degree of isolation associated with fish stranding observations.

To monitor flow changes and water elevation stability, temporary staff gages were placed at both Condemned Bar and French Bar before scheduled flow changes were made. Staff gages were read and recorded at approximately 10 to 20 minute intervals during each pass to determine when water levels stabilized between ramping changes.

2.6 Operations and Hydrologic Information

As part of YCWA's relicensing Study 2.1, *Hydrologic Alteration*, and Study 2.2, *Water Balance/Operations Model*, YCWA evaluated historical flow data to characterize flow and ramping rates for the New Colgate Powerhouse. Historical data for New Colgate Powerhouse releases are available in Attachment 2-1A in YCWA's Technical Memorandum 2-1, *Hydrologic Alteration*, and as part of Attachment 2-2F in YCWA's Technical Memorandum 2-2, *Water Balance/Operations Model*.

For most of the year, New Colgate Powerhouse is operated as a peaking facility or to provide ancillary services for spinning reserves or regulation. Under peaking operations, releases through the powerhouse occur in hours of the day when power is most valuable or when power is needed most (e.g., weekdays from mid-morning through early evening, largely corresponding to warmer times of the day and/or peak workday and early evening hours). Under ancillary services operations, the generating station may be ramped upwards or downwards quickly to respond to power system load changes on a near-real-time basis, and generating station output and flows may vary substantially minute-to-minute.

In general, New Colgate Powerhouse ramps up and down at least once a day from a few cfs to close to full flow for peaking operations in spring and summer months. In fall and winter months, peaking flows for New Colgate Powerhouse are generally at a reduced range of flows, depending on inflow hydrology - in relatively dry years, fall and winter flows may ramp up and down from approximately half capacity or less. In addition, the powerhouse can ramp up and down as much as 1,000 cfs or more several times each day for ancillary services. To

[3] The varial zone is defined as the height between the minimum and maximum water surface elevations at each transect or survey location.

characterize the daily operations of New Colgate Powerhouse during the summer study period, Figure 2.6-1 shows 15-minute powerhouse flow records[4] for July 2012.

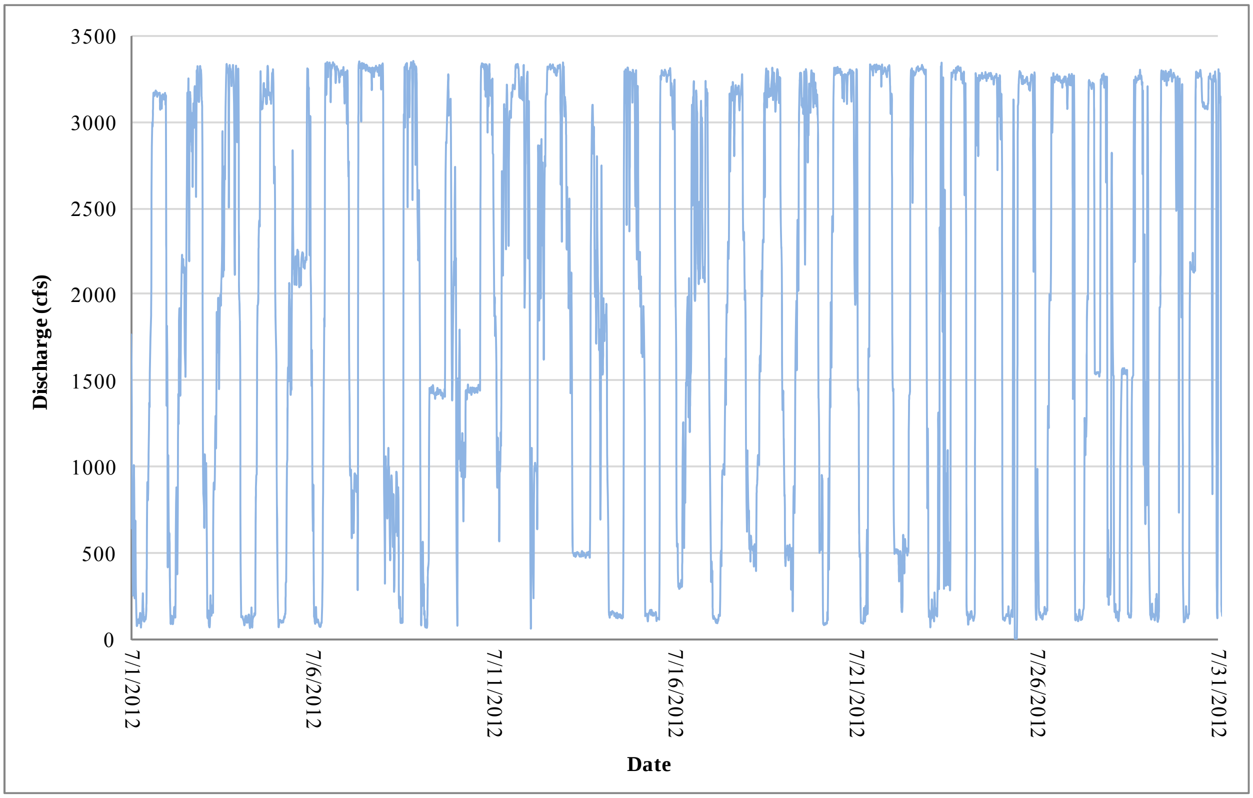

Figure 2.6.1. New Colgate Powerhouse discharge from July 1 through July 31, 2012.

For greater detail, Figure 2.6-2 shows New Colgate Powerhouse 15-minute discharge for the 5-day period from July 7 to July 12, 2012.

[4] The flow measuring device is an acoustical velocity meter (AVM) on the New Colgate Powerhouse Penstock. The AVM has an accuracy of approximately 3 percent.

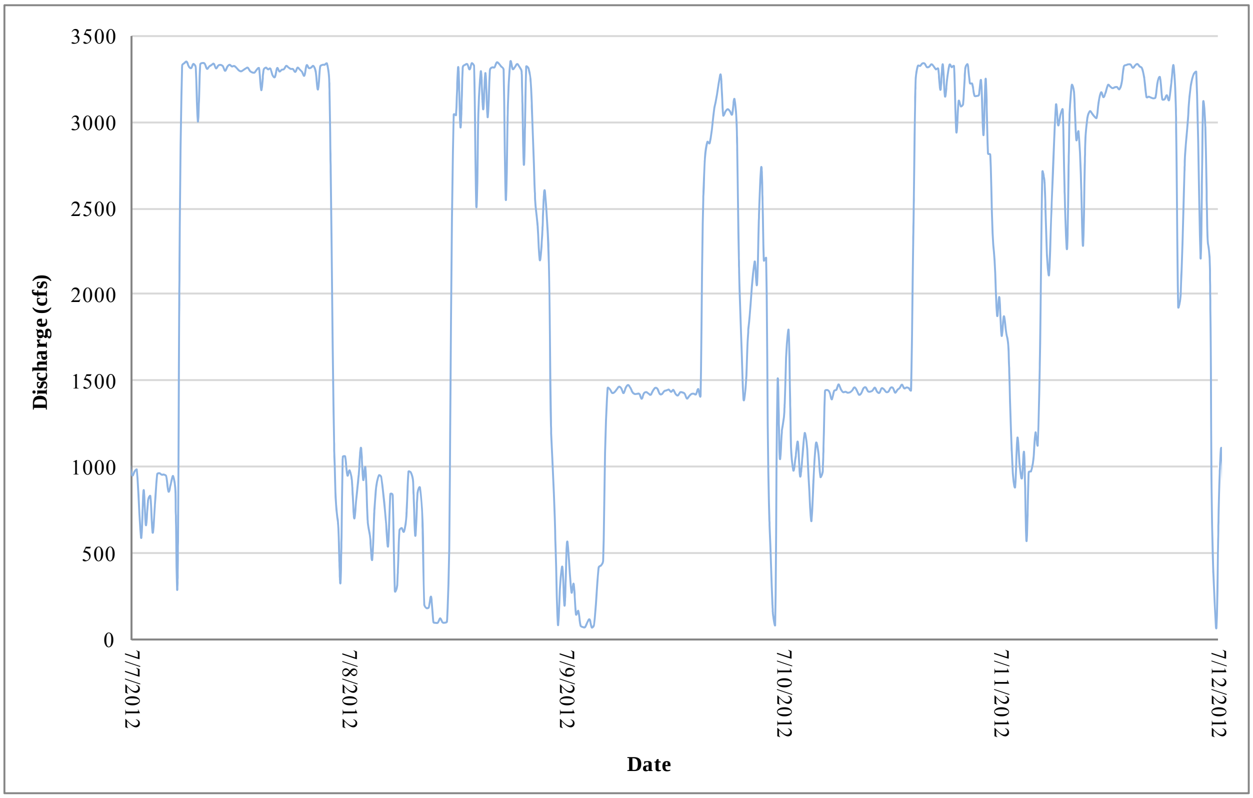

Figure 2.6.2. New Colgate Powerhouse flow records from July 7 through July 12, 2012.

Total river flow at Condemned Bar and French Bar results from a combination of releases from New Colgate Powerhouse, New Bullards Bar Dam on the North Yuba, Log Cabin Diversion Dam on Oregon Creek, and Our House Diversion Dam on the Middle Yuba River in combination with watershed accretion.

To better understand the range of base flows in the Yuba River in the vicinity of New Colgate Powerhouse, mean monthly flows were calculated for all years and by the Yuba River Index Water Year Type.[5] The results are shown in Table 2.6-1. Flow values were determined by summation of the following data: 1) New Colgate Powerhouse releases (USGS 11413510); 2) flow below New Bullards Bar Reservoir (USGS Gage 11413517 and 11413520 as well as historical data from YCWA included in Attachment 2-2F as a part of Technical Memorandum 2-2, *Water Balance/Operations Model*); 3) flows on Oregon Creek below Log Cabin Diversion Dam (USGS Gage 11409400); 4) flows on the Middle Yuba River below Our House Diversion Dam (USGS Gage 11408880); and 5) synthesized accretions for the watershed below these gages, developed based on a comparison of the respective watershed's size and annual precipitation to that of Oregon Creek above Log Cabin Dam, where a historical record of unimpaired flow was available (described in Attachment 2-2D in YCWA's relicensing Technical Memorandum 2-2, *Water Balance/Operations Model*).

[5] Refer to YCWA's relicensing Technical Memorandum 2-1, *Hydrologic Alteration,* for a detailed description of water year type development.

Table 2.6-1. Mean monthly flows (cfs) upstream of the New Colgate Powerhouse for the Yuba River Index water year types from Water Year 1970 through Water Year 2010.

Month	WYs 1970 through 2010	Yuba River Index Water Year Type Mean Monthly Flow (cfs) for WYs 1970 through 2010				
		Wet	Above Normal	Below Normal	Dry	Critical
October	53	59	45	49	52	51
November	135	244	70	98	66	57
December	545	1,306	162	96	111	76
January	1,131	2,691	589	154	145	92
February	836	1,851	442	248	210	147
March	954	1,894	538	669	262	191
April	506	990	293	306	172	146
May	622	1,264	568	220	131	119
June	341	746	164	111	91	73
July	63	79	59	57	54	46
August	49	56	54	50	45	37
September	47	54	53	47	42	35

2.7 Hydraulic and Topographic Measurements at Transects

As part of Study 3.10, hydraulic parameters were measured using a combination of standard techniques of the United States Department of Interior, Fish and Wildlife Service (USFWS) methodology (Trihey and Wegner 1981; Bovee 1982) and the United States Geological Survey (USGS) (Bovee 1997, Bovee *et al.* 1998, and Rantz 1982). Hydraulic modeling utilized USFWS's Hydraulic Simulation (HYDSIM) model.

2.7.1 Target Calibration Flows

Target calibration flows were the same as those used in Study 3.10, were based on the range of flows typically released during standard powerhouse operation, and did not consider the influence of accretion. For purposes of hydraulic modeling, four calibration flows (i.e., low, middle, high and high-high) were selected with the goal of achieving an even, logarithmic spacing of flows that allows for development of an adequate stage/discharge relationship in the HYDSIM model.

The target calibration flow is defined as the discharge released at the control point (i.e., New Colgate Powerhouse), whereas the measured calibration flow was the target flow plus upstream flow and accretion flow between the control point and the study site. Table 2.7-1 shows the target and measured calibration flows.

Table 2.7-1. Target and measured calibration flows.

Reach	Study Site	Existing Lowest Minimum Flow Requirement (cfs)	Target % Exceedance [Unregulated (u) or Regulated (r)] (%)	Target Calibration Flow / Measured Calibration Flow (cfs)			
New Colgate Powerhouse Reach	Downstream of Colgate	43[1]	10 (r)	100 / 253	600 / 640	1,570 / 1,529	3,260 / 3,749

[1] Result of the combined minimum flows for New Bullards Bar Dam, Log Cabin Diversion Dam and Our House Diversion Dam.

All four calibration measurements in the reach below New Colgate Powerhouse were collected from July 9 through July 15, 2012. In some cases, the combination of minimum flow releases from Our House Diversion Dam, Log Cabin Diversion Dam and New Bullards Bar Dam with watershed accretion, resulted in measured flows which were higher than the target calibration flow. In other cases, measured flows were less than the target calibration flows due to lower release rates through the powerhouse. (Table 2.7-1.)

2.7.2 Surveying and Controls

All elevations were surveyed by standard differential survey techniques using an auto-level or total station instrument. Headpin and tailpin elevations, WSEs, hydraulic controls, and above-water bed and bank elevations were referenced to a temporary benchmark serving a single transect or transect cluster. The surveyed portion of the streambed extended up to the field-estimated flood-prone elevation of both banks on all riffles and on other cross sections. Where possible (i.e., where line of sight or one turning point occurred), multiple benchmarks were tied together permitting multiple transects in a study site to share a common datum. At a minimum, all transects surveyed in a single mesohabitat unit had a common datum. A common datum is particularly useful when using the step-backwater model in PHABSIM. Transect locations were fixed using a handheld Trimble Global Positioning System (GPS) instrument with a possible horizontal accuracy of ±3 ft.

2.7.3 Water Surface Elevation-Discharge

WSEs were measured at multiple points across the channel except when conditions were unsafe at the highest flows. In these circumstances measurements were taken as far out from the accessible shoreline as was safe and physically possible. When only stage/discharge measurements were taken (i.e., velocities at each transect were not measured), discharge through the site was measured using calibrated digital Swoffer® brand velocity meters or a combination of an Acoustic Doppler Current Profiler (ADCP) and manual velocity meters at an appropriate cross section(s). The model of Swoffer meter used is accurate at velocities ranging from 0.1 to 25.0 ft per second. Published technical specifications for the Teledyne RDI Rio Grand ADCP are: velocity accuracy: ±0.25 percent of the (water + boat) velocity ±0.25 cm/s a velocity resolution of 0.1 cm/s and up to a maximum water velocity of ±20 m/s.

2.7.4 Water Level Recorders

YCWA deployed water level recorders at all seven ramping transects to remotely measure WSEs and develop estimates of travel time. Each transducer, encased in a small stilling well and mounted to bedrock or a large boulder on transect, recorded pressure (kPa) and water temperature (°F) on a 5 minute interval. Pressure was converted to a WSE (ft) in Hoboware Pro™ a third party program developed by the Onset® Computer Corporation. To compensate for air pressure changes during the period of data collection, a barometer was placed in the reach. The transducers have a stated range of 0 to 30 ft and an accuracy of ±0.015 ft.

At the time of installation, the water surface above each transducer was differentially surveyed to the transect datum. Stage information was downloaded from the transducers for the entire deployment period, but data analysis corresponded to the dates and times of each ramping test release from New Colgate Powerhouse.

2.7.5 Calibration Velocity

One velocity calibration set was collected at each transect. Ideally, velocities were measured at the high or middle flow depending on the reach and the physical conditions. Where personnel safety was a concern at high flow or mid flow, all or a portion of the velocity calibrations were measured at mid or low flow with WSE/discharge collected at all flows.

Velocities were measured manually using velocity meters mounted on standard USGS top-set wading rods in depths less than approximately 4 ft or where use of the ADCP was not practical. To assure adequate characterization of microhabitat[6] for all life stages (e.g., adult, juvenile, and spawning), manual velocity measurement locations along each transect were purposefully placed to describe points where changes in substrate, bed elevation, and velocity occurred. The number of stations was adjusted in the field to accomplish microhabitat stratification as dictated by site-specific conditions. The placement and number of stations along each transect was designed to limit discharge in any one cell to no more than 10 percent of total discharge. The total number of stations per transect varied depending upon the length of each cross section, and typically ranged from approximately 100 to 250 stations.

When applicable, YCWA followed USGS standards for ADCP pre-deployment setup, configuration considerations, quality assurance and instrument deployment (Mueller et al. 2009). However, guidelines for selection of discharge locations such as, "*The cross section of [the] stream lies within a straight reach, and streamlines are parallel to each other. Flow is relatively uniform and free of eddies, slack water and excessive turbulence*" are often contrary to the purposeful placement of transects selected for modeling fish habitat in PHABSIM.

Post-processing of ADCP data for purposes of Study 3.10 modeling adhered to the following guidelines: 1) velocities in each ADCP ensemble (vertical) will be reported as a mean column value in the horizontal plane (magnitude and direction); 2) mean column velocities will be interpolated or averaged to user defined stations across the transect; 3) mean column velocities at each station from 'good' passes will be averaged together, and; 4) discharge will be calculated using averaged data.

Temporary staff gage levels and the time of day were recorded at the beginning and end of each transect measurement to note potential changes in stage for later adjustment of that stage/discharge pair.

---

6 Microhabitat is defined as a subset of mesohabitat defining the spatial attributes (e.g., depth, mean column velocity, cover type and substrate) of physical locations occupied or used by a lifestage of a target species sometime during its life cycle (Bovee 1998).

2.7.6 Substrate

Substrate was classified visually according to size classes presented in Table 2.7-2. Typically, the classification was conducted during low flow conditions for increased in-water clarity. Along each transect, estimates of percent occurrence of all substrate sizes within a 1 to 2 foot radius of the cross section were recorded. Rather than recording substrate composition for each vertical (there can be hundreds), a technique called "natural breaks' was employed. This technique defines major changes in substrate assemblage, regardless of the location along the transect. To limit the number of substrate size classes recorded in each group, percentiles were recorded in increments of 10 or greater.

Table 2.7-2. Substrate code used to represent rainbow trout spawning suitability.

Substrate Type	Size (inches)	Code
Organics, vegetation	--	0
Clay, silt (fines)	<0.1	1
Sand (coarse)	0.1-0.2	2
Small gravel	>0.2-1.0	3
Medium gravel	>1.0-2.0	4
Large gravel	>2.0-3.0	5
Small cobble	>3.0-6.0	6
Medium cobble	>6.0-9.0	7
Large cobble	>9.0-12.0	8
Boulder	>12.0	9
Bedrock	--	10

Once entered into the PHABSIM input databases, substrate data were converted into the Bovee substrate code system (Bovee and Cochnauer 1978) to be compatible with the codes used for Habitat Suitability Criteria (HSC) (Table 2.5-2). The Bovee substrate code is written as "x, y," where "x" is the code number for the smaller of the two dominant and adjacent particle sizes, and "y" is the percentage (i.e., from 0.0 to 0.9) of the larger of the two dominant and adjacent particle sizes.

2.7.7 Miscellaneous Data Collection

Photographs were taken of all transects from downstream and other points, as necessary, at each measured flow. To the extent possible, each photograph was taken from the same location at each of the three levels of flow. Because field data collection for this study is not complete, all photos are not yet available. Representative PHABSIM transect photos are available in Attachment 3-12D – Hydraulic Calibration Report.

In addition to transect photos, the following information and data were recorded at each site:

- Photo Log – for each flow/visit
- Site Documentation – map showing location, and numbering of transects
- GPS Universal Transverse Mercator (UTM) coordinates for each transect
- WSE and Level Loop – WSE completed at each calibration flow, level loop completed once, pin heights validated at each visit

- Cover – (cover collected but is not a component of collaboratively developed HSC)
- Discharge – for each flow; at one, two, or more transects
- Depth and Velocity – at each transect for one calibration flow (low, middle or high depending on safety and air entrainment considerations)
- Stage of Zero Flow (hydraulic control) – collected once for each transect
- Cross-Section Profile and Substrate Composition – completed once for each transect
- Distance between Transects – completed once for transects placed in the same mesohabitat unit

2.8 Hydraulic Modeling of Transects

The purpose of hydraulic model calibration is to accurately simulate the measured velocities and WSEs at the observed flows while at the same time providing reasonable velocities and WSEs at the range of simulated flows. Changes to velocities were kept to a minimum and the decks revised only when specific changes improve model performance.

2.8.1 Model Used

The hydraulic model for the ramping transects in the Colgate Powerhouse reach was calibrated by HDR Inc. using RHABSIM 3.0 (Riverine Habitat Simulation), a commercial software program written by Thomas R. Payne and Associates of Arcata, California. RHABSIM is a commercial version of the PHABSIM computer model (Milhous et al. 1984).

2.8.2 Modeling Methods

A detailed hydraulic modeling report for the reach downstream of New Colgate Powerhouse is included as Attachment 3-12D – Hydraulic Calibration Report. All transects selected both in support of Study 3.12 and 3.10 are included. In the hydraulic calibration report, the seven ramping transects are labeled using the following structure: PHABSIM transect (Ramping Transect) or T-18 (R7).

2.8.2.1 Water Surface Elevations

For modeling WSEs procedures included: the development of stage/discharge rating curves using log-log regression (IFG4); Manning's formula (MANSQ); and/or step backwater models (WSP); direct comparison of results; and selection of the most appropriate and accurate method. Log-log and MANSQ were run for each transect, with MANSQ set as the default modeling method. If individual transects did not calibrate sufficiently well using MANSQ, based on general guidelines of maximum Beta (β)[7] (0.5), and/or professional judgment, then log/log or WSP was selected. The WSP model was used where suitable sections of the study site were surveyed to a common datum and a reliable rating curve at the downstream control or transect

[7] A measure of the change in channel roughness with changes in streamflow.

was available. For transects that the WSP model was calibrated, results were compared to results from Log/Log and MANSQ. WSP was generally preferred in pools or where uphill flow between transects was predicted by either Log/Log or MANSQ. Data file construction, calibration, and simulation followed standard procedures and guidelines outlined in the PHABSIM Reference Manual Version II, Instream Flow Information Paper No.26 (Milhous et al. 1989).

2.8.2.2 Water Velocity Calibration

The hydraulic model utilizes two basic methods for predicting velocities over a range of flow simulations. The primary approach, termed the "one-velocity set" method, uses measured velocities across a given transect and estimates a Manning's N value for each cell. Calibration techniques include adjustments to the Manning's N to obtain accurate predictions of measured velocities, as well as reasonable predictions of velocities at simulated flows. An alternative approach to modeling velocities, termed the "depth-calibration" method, can be used in the absence of measured velocities. In general, depth calibration procedures were only used to model sections of a transect if very high velocities and/or entrained air preclude data measurement.

The purpose of the velocity calibration is to accurately simulate the measured velocities and WSEs at the observed flows while at the same time providing reasonable velocities and WSEs at the range of simulated flows. Changes to velocities were kept to a minimum and the decks revised only when specific changes improved model performance.

2.8.2.3 Model Extrapolation

Model extrapolation in RHABSIM beyond the lowest calibration flow of 253 cfs and the highest calibration flow of 3,749 cfs (Table 2.7-1) was necessary to achieve as much of the range of the hydrograph as possible because a ramping event can occur when there is substantial flow in the river channel. In general, hydraulic models based upon Manning's equation are most accurate when predicted flows fall within a range of 0.4 to 2.5 times the measured flows (Bovee 1982). Therefore, extrapolation beyond the measured calibration stage/discharge pairs collected in the field was set at 0.4 times (or 40% of the lowest stage/discharge pairs) and 2.5 times (or 250% of the highest stage/discharge pairs). Based on this analysis, the modelable flow range was 101.2 cfs to 9,372.5 cfs.

3.0 Results

3.1 Fish Species Present in Vicinity of New Colgate Powerhouse

YCWA's relicensing Study 3.8, *Stream Fish Populations Upstream of Englebright Reservoir*, documented two fish species in the Yuba River from the confluence of the North Yuba River and Middle Yuba River to New Colgate Powerhouse and seven fish species in the Yuba River from New Colgate Powerhouse to Englebright Reservoir. The fish species immediately upstream of New Colgate Powerhouse were: 1) rainbow trout; and 2) Sacramento sucker (*Catostomus* *occidentalis*). The species in the river downstream of the powerhouse were 1) rainbow trout; 2) Sacramento sucker; 3) brown trout (*Salmo trutta*); 4) smallmouth bass (*Micropterus dolomieu*); 5) kokanee (*Oncorhynchus nerka*); 6) green sunfish (*Lepomis cyanellus*); and 7) unidentified species of sculpin (*Cottoidea*).

Surveys conducted in support of Study 3.7, *Reservoir Fish Populations* reported 11 fish species in Englebright Reservoir. Table 3.1-1 provides a summary of the species found in the reservoir ordered by abundance. Six of the species were reported to occur in the reservoir, but were not documented in the river. These were: 1) spotted bass (*Micropterus punctulatus*); 2) hardhead (*Mylopharodon conocephalus*); 3) bluegill (*Lepomis macrochirus*); 4) Sacramento pikeminnow (*Ptychocheilus grandis*); 5) common carp (*Cyprinus carpio*); and 6) redear sunfish (*Lepomis microlophus*).

Table 3.1-1. Summary of relative abundance of all fish species collected at Englebright Reservoir in June 2012 in order of abundance during Study 3.7 sampling.

Fish Species (Common Name/Scientific Name)	Number	Abundance in Catch (%)
Sacramento sucker *Catostomus occidentalis*	114	31.5%
Spotted bass *Micropterus punctulatus*	96	26.5%
Hardhead *Mylopharodon conocephalus*	49	13.5%
Rainbow trout *Oncorhynchus mykiss*	30	8.3%
Bluegill *Lepomis macrochirus*	27	7.5%
Sacramento pikeminnow *Ptychocheilus grandis*	25	6.9%
Common carp *Cyprinus carpio*	7	1.9 %
Brown trout *Salmo trutta*	6	1.7%
Smallmouth Bass *Micropterus dolomieu*	5	1.4%
Green sunfish *Lepomis cyanellus*	2	0.6%
Redear sunfish *Lepomis microlophus*	1	0.3%
Total	**362**	**100.0%**

3.2 Visual Observation Stranding Results

Visual observation surveys were conducted to document fish presence in the varial littoral zone by walking or snorkeling before and after down-ramp events. Results of these surveys show that fish rainbow trout, sculpin spp., green sunfish and unidentified species were present in the survey area before and after down-ramp occurred. The intent of these surveys was not to quantify the number of fish present but rather to confirm fish presence, thereby implying a potential for stranding. Snorkel/walking results for each location by sampling date are provided in Attachment 3-12A.

Fish stranding surveys were conducted via walking along the littoral zones at both locations during each of the six down-ramp events. Detailed results of stranding observations for each location by sampling date are provided in Attachment 3-12B. While conducting stranding surveys, stranded fish were observed in one of three general areas. These areas are referred to as Stranding Zone A and Stranding Zone B on Condemned Bar (see Figure 2.1-1) and Stranding Zone C on French Bar (see Figure 2.1-2).

Table 3.2-1 provides a summary of survey effort. Pre- and post-down ramp survey effort was calculated as the average total time for each survey while stranding survey effort was calculated as the average length of time for each pass.

Table 3.2-1. Summary of survey effort for pre- and post-down ramp and stranding surveys.

Location	Dates	Flow Range (cfs)	Survey	Average Survey Effort[1] (min)
Condemned Bar	6/12/2012	3,059 → 1,561	Pre-Down Ramp	45
			Stranding	17
			Post-Down Ramp	30
	6/13/2012	1,541 → 541	Pre-Down Ramp	20
			Stranding	17
			Post-Down Ramp	25
	7/27/2012	3,261 → 1,599	Pre-Down Ramp	40
			Stranding	22
			Post-Down Ramp	40
	7/28/2012	1,609 → 176	Pre-Down Ramp	35
			Stranding	35
			Post-Down Ramp	35
	8/25/2012	3,109 → 1,502	Pre-Down Ramp	15
			Stranding	14
			Post-Down Ramp	15
	8/30/2012	1,509 → 130	Pre-Down Ramp	15
			Stranding	14
			Post-Down Ramp	18
French Bar	6/12/2012	3,059 → 1,561	Pre-Down Ramp	45
			Stranding	10
			Post-Down Ramp	55
	6/13/2012	1,541 → 541	Pre-Down Ramp	45
			Stranding	11
			Post-Down Ramp	37
	7/27/2012	3,261 → 1,599	Pre-Down Ramp	36
			Stranding	13
			Post-Down Ramp	92
	7/28/2012	1,609 → 176	Pre-Down Ramp	70
			Stranding	15
			Post-Down Ramp	45
	8/25/2012	3,109 → 1,502	Pre-Down Ramp	55
			Stranding	12
			Post-Down Ramp	49
	8/30/2012	1,509 → 130	Pre-Down Ramp	46
			Stranding	12
			Post-Down Ramp	50

[1] Pre- and post-down ramping survey effort calculated as the average total time for each survey. Stranding survey effort calculated as the average length of time for each pass.

All stranded fish observed on French Bar were found in Stranding Zone C located just upstream of Transect R1 on the right bank ascending. These fish were found in a number of small residual pools that were formed as the backwater habitat drained during the ramp down process.

Of the 12 stranded fish observed at Condemned Bar, four were deceased and found on dry substrate. The remaining eight fish were found in residual pools varying in depths from 0.1 ft to 1.5 ft. Of the seven stranded fish observed at French Bar, none were deceased. The fish were found in residual pools varying in depths from 0.25 ft to 1.0 ft. Table 3.2-2 provides a summary of findings from stranding surveys conducted on both cobble bars.

Table 3.2-2. Summary of stranded fish observations during Study 3.12, *New Colgate Powerhouse Ramping*.

Location	Dates	Flow Range (cfs)	Species	Number	Size Range (mm)
Condemned Bar	6/12/12	3,059 → 1,561	None	0	--
	6/13/12	1,541 → 541	Unidentified[1]	6	10 - 15
			Rainbow trout	1	40
	7/27/12	3,261 → 1,599	Unidentified[1]	1	20
	7/28/12	1,609 → 176	None	0	--
	8/25/12	3,109 → 1,502	None	0	--
	8/30/12	1,509 → 130	Unidentified[1]	1	15
		Subtotal	*Rainbow Trout*	*1*	--
		Subtotal	*Unidentified*	*8*	--
French Bar	6/12/12	3,059 → 1,561	None	0	--
	6/13/12	1,541 → 541	Unidentified[1]	6	10 - 12
	7/27/12	3,261 → 1,599	None	0	--
	7/28/12	1,609 → 176	None	0	--
	8/25/12	3,109 → 1,502	None	0	--
	8/30/12	1,509 → 130	Unidentified[1]	1	10
		Subtotal	*Rainbow Trout*	*0*	--
		Subtotal	*Unidentified*	*7*	--
		Total	**Rainbow Trout**	**1**	--
		Total	**Unidentified**	**15**	--

[1] Species not identified due to their small size and YCWA did not collect the fish to identify them.

3.2.1 Reconnaissance Survey

A reconnaissance survey was conducted on June 11, 2012 at a flow of approximately 622 cfs[8] under clear skies. At the upper end of Condemned Bar near Dobbins Creek, over 100 fish of an unidentified species between 10 mm and 15 mm in length were observed. On French Bar, one 10 mm to 15 mm salmonid and between 250 and 300 fish of an unidentified species approximately 10 mm to 8 mm in length were observed.

3.2.2 Ramping Events

Provided below is a description of fish observations at Condemned Bar and French Bar prior to, during and following each of the six ramping events

3.2.2.1 Condemned Bar

One 40-mm long rainbow trout and eight 20-mm or less long unidentified species were observed stranded during six down ramp events that ranged in reduced flows from 1,000 cfs to 1,662 cfs.

[8] Approximately 86 cfs was in the Yuba River immediately upstream of New Colgate Powerhouse and the powerhouse was releasing 536 cfs, for a total flow of 622 cfs.

In all but one instance, rainbow trout and unidentified species were observed in the river before and after each down ramp event.

3.2.2.1.1 June 12, 2012

Pre-Ramp Down Survey Results

Pre-ramp down surveys were conducted under clear skies with a river flow of 3,059 cfs. The average time spent for each snorkel/walking survey was 45 minutes. A total of 252 fish was documented, consisting of a combination of unidentified species as well as two rainbow trout. The size range for the observed fish was from 10 mm to 30 mm for all unidentified species, and 40 mm for rainbow trout. Large cobble was the most common substrate where fish were observed. Observed rainbow trout were located over sand and small gravel. The general depth range of observed fish was from 0.5 to 2.0 ft.

Stranding Survey Results

The stranding survey occurred as flow was reduced from 3,059 cfs to 1,561 cfs over approximately 20 to 25 minutes. A total of five survey passes were conducted. An average of approximately 17 minutes was spent looking for stranded fish during each pass. No stranded fish were observed.

Post-Ramp Down Survey Results

Post-ramp down surveys were conducted with a river flow of 1,561 cfs. The average time spent for each snorkel/walking survey was 30 minutes. A total of 220 fish were documented consisting of unidentified species. The size ranges for the observed fish were from 10 to 30 mm. Large cobble and small gravel were the most common substrates where fish were observed. The general depth range of observed fish was from 0.5 to 2.0 ft.

3.2.2.1.2 June 13, 2012

Pre-Ramp Down Survey Results

Pre-ramp down surveys were conducted under clear skies with a river flow of 1,541 cfs. The average time spent for each snorkel/walking survey was 20 minutes. A total of 121 fish was documented, consisting of a combination of unidentified species as well as one rainbow trout. The size ranges for the observed fish were from 10 mm to 40 mm for all unidentified species, and 40 mm for rainbow trout. Large cobble and small gravel were the most common substrate where the unidentified species occurred. The one rainbow trout was located over small gravel. The general depth range of observed fish was from 0.5 to 2.0 ft.

Stranding Survey Results

The survey occurred as flow reduced from 1,059 cfs to 541 cfs over 20 to 25 minutes. A total of seven survey passes were conducted during the down-ramp event. An average of approximately

17 minutes was spent looking for stranded fish during each pass. A total of seven fish was found stranded. Six of the fish observed were of an unidentified species and one was a rainbow trout. All seven fish were observed in Stranding Zone A. The unidentified species ranged in length from 10 to 15 mm and the rainbow trout was approximately 40 mm. Pool habitat was the most common habitat where stranding occurred but no particular substrate appeared to increase susceptibility to stranding. Stranding occurred in sand, small cobble, and medium cobble substrates. The fish were observed from 2 to 5 ft from the main channel. Photos characterizing the habitat where the single rainbow trout and unidentified species were stranded are provided in Figures 3.2-1 and 3.2-3, respectively. Photos of the stranded rainbow trout and the unidentified species are provided in Figures 3.2-2 and 3.2-4, respectively.

Figure 3.2-1. Location and site characteristics of stranding observation of a rainbow trout near Dobbins Creek in Stranding Zone A.

Figure 3.2-2. Stranded rainbow trout observation near Dobbins Creek in Stranding Zone A.

Figure 3.2-3. Location and site characteristics of stranding observation (unidentified sp.) near Dobbins Creek in Stranding Zone A.

Figure 3.2-4. Stranding observation of unidentified sp. near Dobbins Creek in Stranding Zone A. Red circle indicates location of larval fish.

Post-Ramp Down Survey Results

Post-ramp down surveys were conducted with a river flow of 541 cfs. The average time spent for each snorkel/walking survey was 25 minutes. A total of 123 fish was documented, consisting of unidentified species and three rainbow trout. The size ranges for the observed fish were 10 to 30 mm for all unidentified species and 40 to 100 mm for rainbow trout. Large cobble and small gravel were the most common substrates where the unidentified species were observed, and rainbow trout were observed over small cobble. The general depth range of observed fish was from 0.5 to 2.0 ft.

3.2.2.1.3 July 27, 2012

Pre-Ramp Down Survey Results

Pre-ramp down surveys were conducted under clear skies with a river flow of 3,261 cfs. The average time spent for each snorkel/walking survey was approximately 40 minutes. A total of 39 fish was documented consisting of a combination of unidentified species and nine rainbow trout. The size of the unidentified species was approximately 20 mm, and the rainbow trout ranged in size from 252 to 336 mm. The rainbow trout were observed in the main channel. Boulder was the most common substrate where all species were observed, and the general depth range of observed fish was from 0.5 to 10.0 ft.

Stranding Survey Results

The stranding survey was conducted as flow reduced from 3,261 cfs to 1,599 cfs over 20 to 25 minutes. A total of two survey passes were conducted. An average of about 22 minutes was spent looking for stranded fish during each pass. Only one stranded fish was observed. The fish was observed in Stranding Zone A. This unidentified species was approximately 20 mm long and was found on moist, dewatered sand along the margin of a pool 2 ft from the main channel. A photo of the stranding location is provided below in Figure 3.2.5.

Figure 3.2-5. Stranding observation of unidentified sp. near Dobbins Creek in Stranding Zone A.

Post-Ramp Down Survey Results

Post-ramp down surveys were conducted with a river flow of 1,599 cfs. The average time spent for each snorkel/walking survey was approximately 40 minutes per event. A total of 15 fish was documented consisting of one unidentified species and 14 rainbow trout. The size ranges for the observed fish were from 10 to 20 mm for all unidentified species, and from 252 to 336 mm for rainbow trout. The rainbow trout were observed in the deep water habitat. Boulder was the most common substrate where the fish were observed, and the depth ranged from 0.5 to 10 ft.

3.2.2.1.4 July 28, 2012

Pre-Ramp Down Survey Results

Pre-ramp down surveys were conducted under clear skies with a river flow of 1,609 cfs. The average time spent for each snorkel/walking survey was approximately 35 minutes. A total of 14 fish was documented consisting of two fish of an unidentified species and 12 rainbow trout. The sizes of the observed fish were 20 mm for the unidentified species, and from 170 to 310 mm for the rainbow trout. The rainbow trout were observed in the deep water habitat. Boulder was the most common substrate where the fish were observed, and the depth ranged from 0.5 to 10 ft.

Stranding Survey Results

The stranding survey was conducted as flows reduced from 1,609 cfs to 176 cfs over approximately 35 minutes. A total of three passes were made during the event. Over both events, an average of about 22 minutes was spent looking for stranded fish during each pass. No stranded fish were observed.

Post-Ramp Down Survey Results

Post-ramp down surveys were conducted with a river flow of 176 cfs. The average time spent for each snorkel/walking survey was approximately 35 minutes. A total of 38 fish was documented consisting of unidentified species and 18 rainbow trout. The size ranges for the observed fish were from 10 to 20 mm for all unidentified species, and from 170 to 310 mm for rainbow trout. The rainbow trout were observed in the deep water habitat. Sand was observed below the unidentified species while the rainbow trout were observed over boulder substrate. The general depth range of all observed fish was 0.5 to 10.0 ft.

3.2.2.1.5 August 25, 2012

Pre-Ramp Down Survey Results

Pre-ramp down surveys were conducted under clear skies with a river flow of 3,109 cfs. The average time spent for each snorkel/walking survey was approximately 15 minutes. No fish were observed in the shallow littoral zone. However, eight rainbow trout were documented in the deeper water habitat; no other species were observed. Rainbow trout ranged in size from 170 to 310 mm, and were found over boulder substrate in depths of 5 to 10 ft.

Stranding Survey Results

The stranding survey was conducted as flows reduced from 3,109 cfs to 1,502 cfs. A total of two survey passes were conducted during the event. An average of about 14 minutes was spent looking for stranded fish during each pass. No stranded fish were observed.

Post-Ramp Down Survey Results

Post-ramp down surveys were conducted at a river flow of 1,502 cfs. The average time spent for each snorkel/walking survey was approximately 15 minutes. No fish were observed in the shallow littoral zone. However, 12 rainbow trout were documented in the main channel; no other fishes were observed. The trout ranged in length from 170 to 310 mm, and were found over boulder substrate at depths of 5 to 10 ft.

3.2.2.1.6 August 30, 2012

Pre-Ramp Down Survey Results

Pre-ramp down surveys were conducted under clear skies with a river flow of 1,509 cfs. The average time spent for each snorkel/walking survey was approximately 15 minutes. No fish were observed in the shallow littoral zone. However, eight rainbow trout were documented in the main channel; no other fishes were observed. The trout ranged in length from 170 to 310 mm, and were observed over boulder substrate at depths from 5 to 10 ft.

Stranding Survey Results

The stranding survey was conducted as flows reduced from 1,509 cfs to 130 cfs. A total of six survey passes were conducted during the event. An average of about 14 minutes was spent looking for stranded fish during each pass. Only one stranded fish was observed. The fish was observed in Stranding Zone A. The unidentified species was approximately 15 mm long and was observed in 0.2 ft of isolated pocket-water along the margin of a pool with medium cobble substrate. At the time of survey, the residual pool was 5 ft from the main channel. A photo of the stranding location is provided below in Figure 3.2.6.

Figure 3.2-6. Stranding location of unidentified sp. near Dobbins Creek in Stranding Zone A.

Post-Ramp Down Survey Results

Pre-ramp down surveys were conducted with a river flow of 130 cfs. The average time spent for each snorkel/walking survey was approximately 18 minutes. No fish were observed in the shallow littoral zone. However, 12 rainbow trout were documented in the main channel; no other fishes were observed. The rainbow trout ranged in length from 170 to 505 mm, and were observed over boulder substrate at a depth of about 5 ft.

3.2.2.2 French Bar

No rainbow trout and seven 20-mm or less long unidentified species were observed stranded at French Bar during six down ramp events that ranged in reduced flows from 1,000 cfs to 1,662 cfs. Unidentified species were observed in the river before and after each down ramp event. Rainbow trout occur in the area and were observed rising in deep pools adjacent to French Bar and being caught by fishermen. The pre- and post-ramp surveys did not include the deep pools since the pools are not habitat where stranding would occur.

3.2.2.2.1 June 12, 2012

Pre-Ramp Down Survey Results

Pre-ramp down surveys were conducted under clear skies with a river flow of 3,059 cfs. The average time spent for each snorkel/walking survey was approximately 45 minutes. A total of 74 fish of an unidentified species were observed. The fish ranged in size from 10 mm to 15 mm. The majority of the fish were over sand and small cobble substrate and in depths of 0.5 to 3 ft.

Stranding Survey Results

The stranding survey was conducted as flows were reduced from 3,059 cfs to 1,561 cfs. Two survey passes were conducted. An average of about 10 minutes was spent looking for stranded fish during each pass. No stranded fish were observed.

Post-Ramp Down Survey Results

Post-ramp down surveys were conducted at a flow of 1,561 cfs. The average time spent for each snorkel/walking survey was 55 minutes. A total of 117 fish of an unidentified species were documented. The size ranges for the observed fish were from 8 to 15 mm. The fish were observed over sand and small cobble substrate and at depths of 0.2 to 1.5 ft.

3.2.2.2.2 June 13, 2012

Pre-Ramp Down Survey Results

Pre-ramp down surveys were conducted under clear skies with a river flow of 1,541 cfs. The average time spent for each snorkel/walking survey was approximately 45 minutes. A total of 74 fish of an unidentified species were documented. The fish ranged in length from 10 to 15 mm. The majority of the fish were found over sand and small cobble substrate at depths of 0.5 to 3 ft.

Stranding Survey Results

The stranding survey was conducted as flows reduced from 1,561 cfs to 541 cfs. Five passes were made. An average of 11 minutes was spent looking for stranded fish during each pass. Six stranded fish were observed. The unidentified species were found together in 0.3 ft of isolated pocket-water along the margin area of a backwater pool habitat with sand substrate. The fish ranged in length from 10 to 12 mm. At the time of survey, the residual pool was 7 to 10 ft from the main channel. A photo of the location and the stranded fish are provided in Figures 3.2-7 and 3.2-8, respectively.

Figure 3.2-7. Location and site characteristics of stranding observation of unidentified sp. in Stranding Zone C.

Figure 3.2-8. Close up of stranding observation of an unidentified species in Stranding Zone C. Red circle indicates location of larval fish.

Post-Ramp Down Survey Results

Post-ramp down surveys were conducted at a river flow of 541 cfs. The average time spent for each snorkel/walking survey was approximately 37 minutes. A total of 34 fish of an unidentified species were observed. The fish ranged in length from 10 to 15 mm. The majority of the fish were over sand and small cobble substrate at depths of 0.5 to 3 ft.

3.2.2.2.3 July 27, 2012

Pre-Ramp Down Survey Results

Pre-ramp down surveys were conducted under clear skies with a river flow of 3,261 cfs. The average time spent for each snorkel/walking survey was approximately 36 minutes. A total of 31 fish of an unidentified species were documented. The fish ranged in length from 12 to 18 mm, and were found over sand substrate at depths of 0.3 to 0.8 ft.

Stranding Survey Results

The stranding survey was conducted as flows were reduced from 3,261 cfs to 1,599 cfs. Three passes were made. An average of 13 minutes was spent looking for stranded fish during each pass. No stranded fish were observed.

Post-Ramp Down Survey Results

Post-ramp down surveys were conducted at a river flow of 1,599 cfs. The average time spent for each snorkel/walking survey was approximately 92 minutes. A total of 25 fish of an unidentified species were documented. The size ranges for the observed fish were from 12 to 20 mm. The fish were over sand and very small cobble substrate at a depth range of 0.3 to 1.0 ft.

3.2.2.2.4 July 28, 2012

Pre-Ramp Down Survey Results

Pre-ramp down surveys were conducted under clear skies with a river flow of 1,609 cfs. The average time spent for each snorkel/walking survey was approximately 70 minutes. A total of 11 fish of an unidentified species were documented. The fish ranged in length from 10 to 20 mm, and were observed over sand and small cobble substrate at depths of 0.3 to 2.5 ft.

Stranding Survey Results

The stranding survey was conducted as flows were reduced from 1,609 cfs to 176 cfs. Four passes were made during the event. An average of 15 minutes was spent looking for stranded fish during each pass. No stranded fish were observed.

Post-Ramp Down Survey Results

Post-ramp down surveys were conducted at a flow of 176 cfs. The average time spent for each snorkel/walking survey was approximately 45 minutes. A total of 39 fish, consisting of two sculpin and 37 fish of an unidentified species were observed. The size ranges for the fish were from 15 to 70 mm. The fish were over small cobble substrate at depths that ranged from 0.8 to 1.0 ft.

3.2.2.2.5 August 25, 2012

Pre-Ramp Down Survey Results

Pre-ramp down surveys were conducted under clear skies with a river flow of 3,109 cfs. The average time spent for each snorkel/walking survey was approximately 55 minutes. No fish were observed.

Stranding Survey Results

The stranding survey was conducted as flows were reduced from 3,109 cfs to 1,502 cfs. A total of six passes were made during the event. An average of 12 minutes was spent looking for stranded fish during each pass. No stranded fish were observed.

Post-Ramp Down Survey Results

Post-ramp down surveys were conducted with a river flow of 1,502 cfs. The average time spent for each snorkel/walking survey was approximately 49 minutes. Three green sunfish and one unidentified species were observed. The fish were observed along the river margin. The size ranges for the green sunfish were from 150 to 170 mm; the unidentified species were approximately 10 mm long. The fish were found over very small cobble and sand substrate and at depths of 0.4 to 1.5 ft.

3.2.2.2.6 August 30, 2012

Pre-Ramp Down Survey Results

Pre-ramp down surveys were conducted under clear skies with a river flow of 1,509 cfs. The average time spent for each snorkel/walking survey was approximately 46 minutes. No fish were observed.

Stranding Survey Results

The stranding survey was conducted as flows were reduced from 1,509 to 130 cfs. Six passes were made. An average of 12 minutes was spent looking for stranded fish during each pass. One fish of an unidentified species was observed. The fish was approximately 10 mm long, over sand substrate in a backwater pool with a residual depth of 1.0 ft. At the time of the survey, the residual pool was 1 ft from the main channel. The observation was made at the same location as the survey on June 13. A site photo is provided in Figure 3.2-9.

Figure 3.2-9. Close up of stranding location of an unidentified species in Stranding Zone C.

Post-Ramp Down Survey Results

Post-ramp down surveys were conducted at a flow of 130 cfs. The average time spent for each snorkel/walking survey was approximately 50 minutes. No fish were observed.

3.2.4 Incidental Sightings

At times, field crews observed stranded fish while the crew was not actively surveying for stranded fish. Since these observations did not occur during the designated survey times they were not included in the body of the data. The following is an account of all incidental stranding observations.

3.2.4.1 Condemned Bar

On June 13, after stranding surveys had been completed, three fish of an unidentified species were observed in a pocket pool approximately 7 ft from the main channel under a very large boulder at Stranding Zone B. The fish were approximately 15 mm long and were seen in about 1.5-ft deep water. A photo of this location is provided below in Figure 3.2-10.

Figure 3.2-10. Location of incidental stranding observation (unidentified sp.) in Stranding Zone B.

On August 30, a single fish of an unidentified species was observed in a small depression between boulders and cobbles next to Dobbins Creek mouth.

On November 10, a single deceased rainbow trout approximately 50 mm long was observed at Stranding Zone B. There was no residual water in the depression. Cause of death is not certain as flows in the reach had been below 100 cfs for just over 24 hrs. The level of decomposition suggests this individual had been deceased for longer than 24 hrs. A photo of this fish is provided below in Figure 3.2-11.

Figure 3.2-11. Incidental observation of a deceased rainbow trout during Study 3.8 survey at Stranding Zone B.

3.2.4.2 French Bar

On June 12 near Transect R3, 50 to 60 fry sized fish of an unidentified species were spotted along the bank margin of a large back eddy. The fish were approximately 0.5 ft to 4.0 ft’ from the waters edge in the main channel. The fish were in 0.5 ft to 1.0 ft deep water over very small cobble. No photo was provided.

3.3 Visual Observation Stranding Analysis

Visual stranding surveys were conducted downstream of YCWA’s New Colgate Powerhouse during daylight hours in June, July, and August, 2012.

3.3.1 Fish Presence Before and After Ramping

Of the total 1,628 fish observations from the six surveys, 6 percent (n=100) were rainbow trout ranging from 40 mm to 505 mm in length. The remaining 94 percent (n=1,528) of all observations consisted primarily of an unidentified species, with only two sculpin and three green sunfish observations. No rainbow trout were observed in the vicinity of French Bar. Figure 3.3-1 shows the total observation counts for Condemned Bar and French Bar grouped by other spp. and rainbow trout.

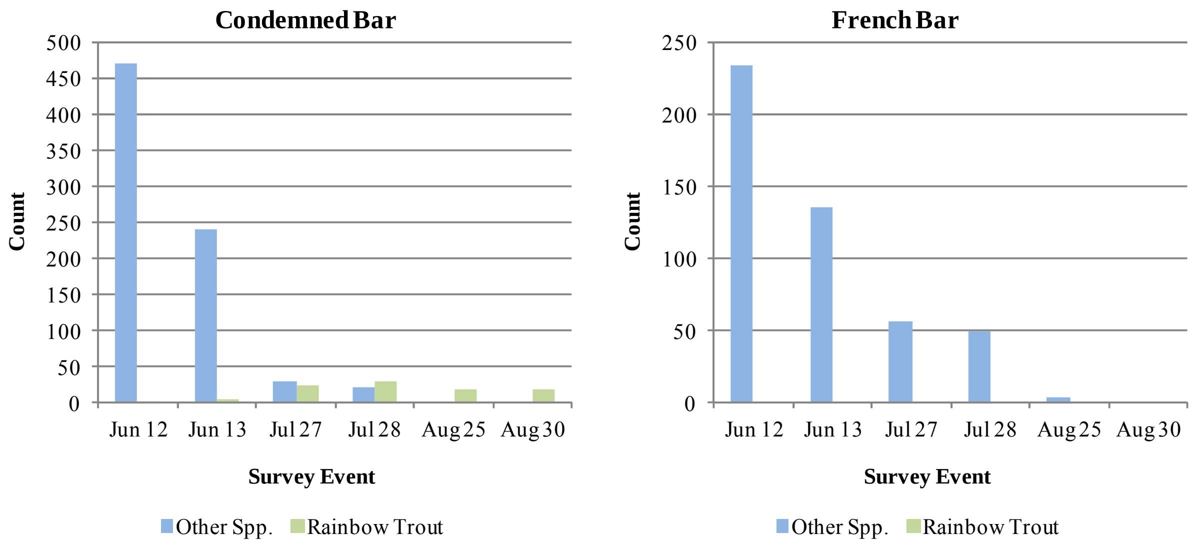

Figure 3.3-1. Condemned Bar and French Bar survey counts for rainbow trout and all other species by month and event.

Surveyors were unable to identify the abundant unidentified species for a variety of reasons. First, all individuals were very small and less than 30 mm in length with most individuals less than 20 mm in length. Second, because the surveys were visual, fish were not captured or handled making identification of fish this size particularly difficult. Third, the most predominant non-salmonid fish species potentially occurring in the study area (i.e., Sacramento sucker and pikeminnow) are difficult to differentiate when in the larval or young-of-year life stage.

Results of the pre- and post-ramp down surveys showed that fish (e.g., rainbow trout, sculpin, green sunfish and unidentified spp.), were present in similar composition in the survey areas before and after down-ramp occurred. While the pre- and post-ramp surveys were not quantitative, some examination of the data was warranted. For example, there was a high degree of variability betweens months for both cobble bar sites. There was a strong trend in total fish counts at both cobble bars, where counts were highest in June and lowest in August. This corresponds to the primary emergence period and high mortality for this age class of salmonids, sucker and pikeminnow. Between each survey event, variability was lower on Condemned Bar whereas between survey variability was higher on French Bar. However, there is no trend toward higher or lower counts at either cobble bar as a result of each ramping event. Of the 12 surveys, seven reported more observations of fish during the post-ramp down survey than the pre-ramp survey. Figure 3.3-2 shows fish counts by survey date for Condemned Bar and French Bar.

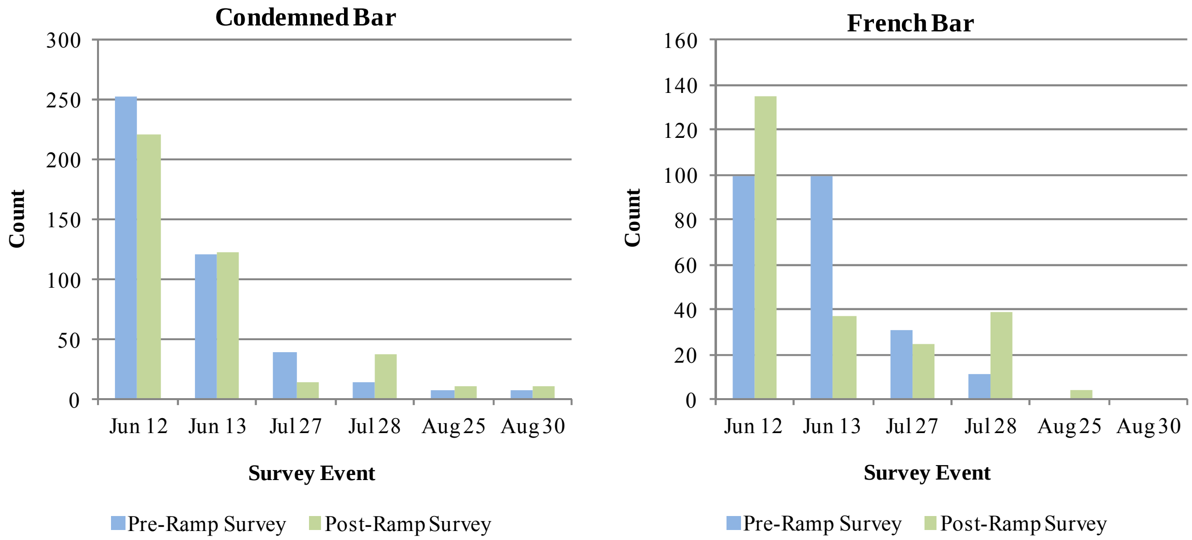

Figure 3.3-2. Condemned Bar and French Bar pre- and post-ramp down survey counts by month and event.

3.3.2 Fish Stranding

Stranding surveys conducted during all six down-ramp events resulted in 16 stranding observations, or less than 1 percent of all observations made. Like the pre- and post-ramp down surveys, 94 percent (n=15) of the stranding observations were of a very small (<20 mm) unidentified species, and 6 percent (n=1) rainbow trout was found stranded. All stranded fish observations were less than 40 mm long, and 75 percent were less than 15 mm long.

The composition of the two species found stranded are consistent with the species composition recorded during prior surveys. In addition, stranding results totaled by month followed a similar seasonal trend in total monthly abundance of all species. June had the most stranded fish observed with 13 individuals, while July had one and August had two. There was a similar number of fish stranded at Condemned Bar (n=9) as compared to French Bar (n=7). Figure 3.3-3 shows stranding counts by survey date for Condemned Bar and French Bar.

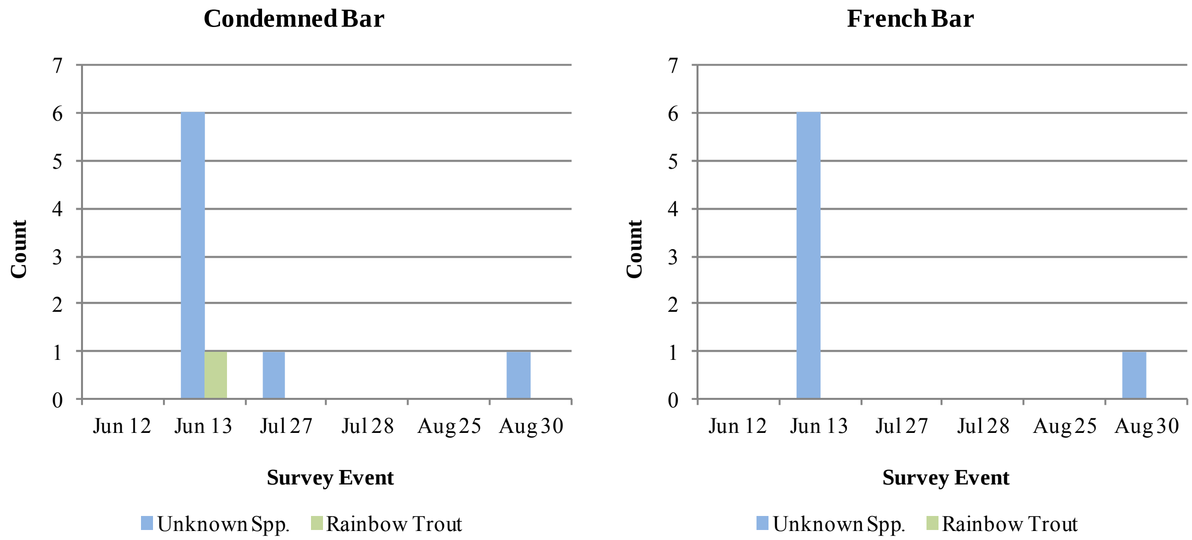

Figure 3.3-3. Condemned Bar and French Bar stranding survey counts by event.

On Condemned Bar, many of the observations were located at the head of the bar, near the confluence of Dobbins Creek, indicated on Figure 2.2-1 above as Stranding Zone A. The fish observed were congregated at this location, presumably due to the warm water input of the Dobbins Creek. Mean monthly temperatures in Dobbins Creek for June, July and August were on average 12°C warmer than the Yuba River water. The confluence habitat was characterized by low gradient and very low velocities dominated by boulder and sand substrate. This location has strong hydraulic connectivity to New Colgate Powerhouse and experiences rapid stage changes once down ramping is initiated.

Of the 12 stranded fish observed on Condemned Bar, four were deceased and found on dry substrate. The remaining fish were found in residual pools varying in depths from 0.1 ft to 1.5 ft. Of the seven stranded fish observed at French Bar, none were deceased. The fish were found in residual pools varying in depths from 0.25 to 1.0 ft.

3.4 Topographic and Hydraulic Results

3.4.1 Cross Section Topography and Velocity Profiles

Figures 3.4-1 through 3.4-7 show each of the seven ramping transects. Each chart contains the graphical results of the physical data collected. These data include: 1) cross sectional profiles where each vertical represents a surveyed bed elevation; 2) WSEs at each of the four calibration discharge measurements; and 3) the measured velocity profile at one of the calibration discharges. Cross section charts showing model results, including the simulated velocity profiles and WSEs to the highest and lowest modeled flows are included in Attachment 3-12D.

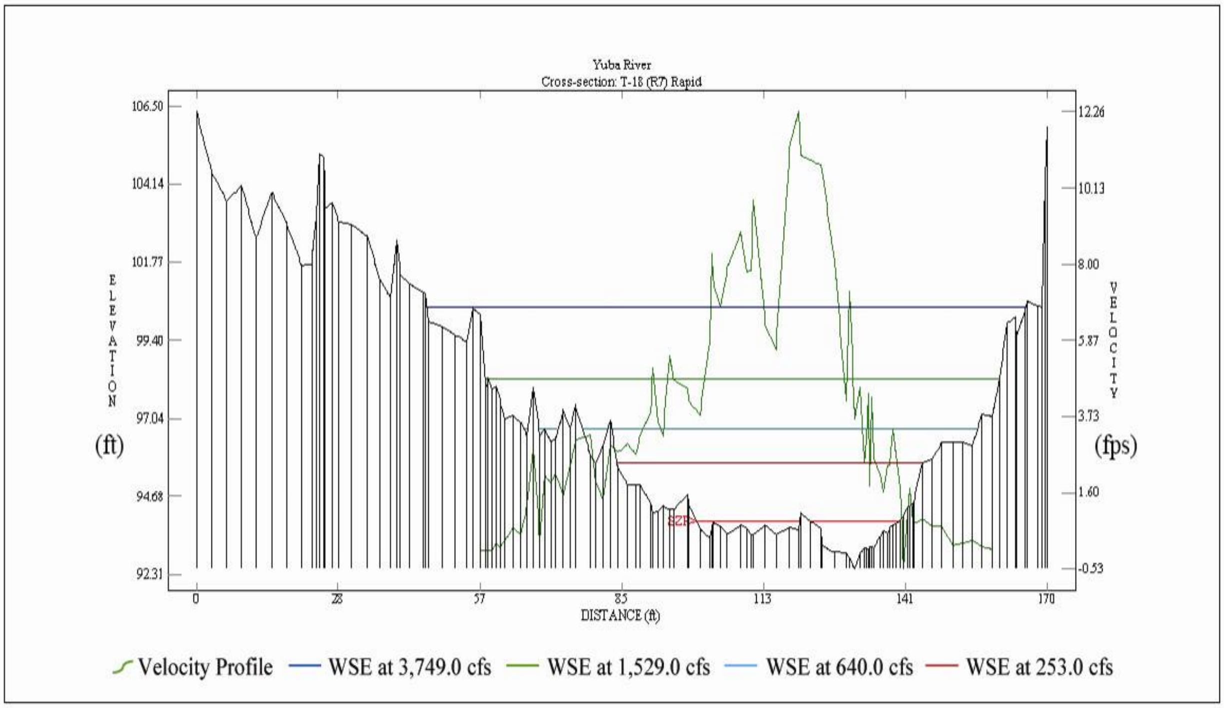

Figure 3.4-1. New Colgate Powerhouse ramping study cross sectional profile of Transect R7, a rapid, looking upstream. Velocity data were collected at 1,529 cfs.

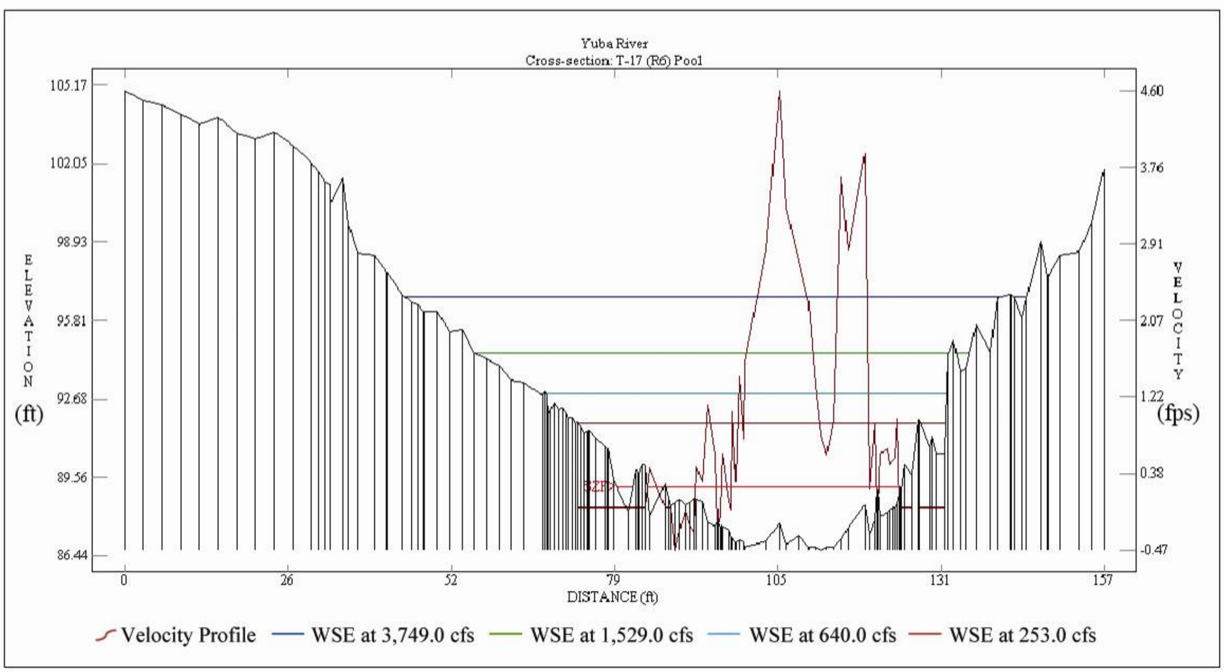

Figure 3.4-2. New Colgate Powerhouse ramping study cross sectional profile of Transect R6, a pool, looking upstream. Velocity data were collected at 253 cfs.

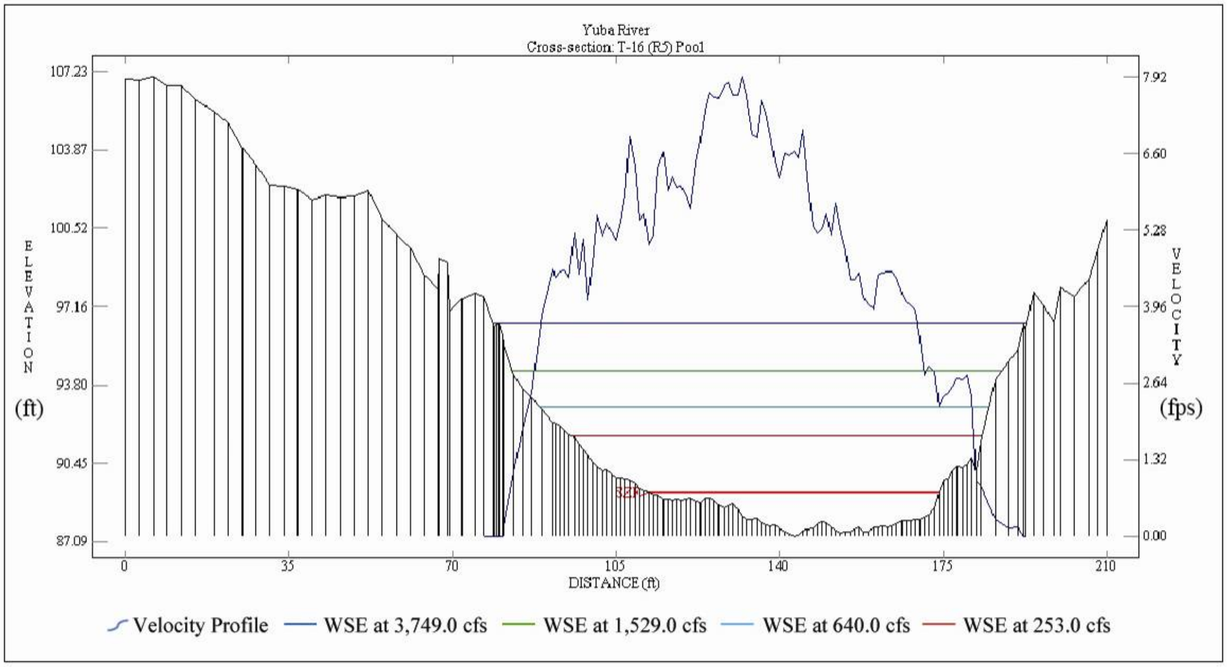

Figure 3.4-3. New Colgate Powerhouse ramping study cross sectional profile of Transect R5, a pool, looking upstream. Velocity data were collected at 3,749 cfs.

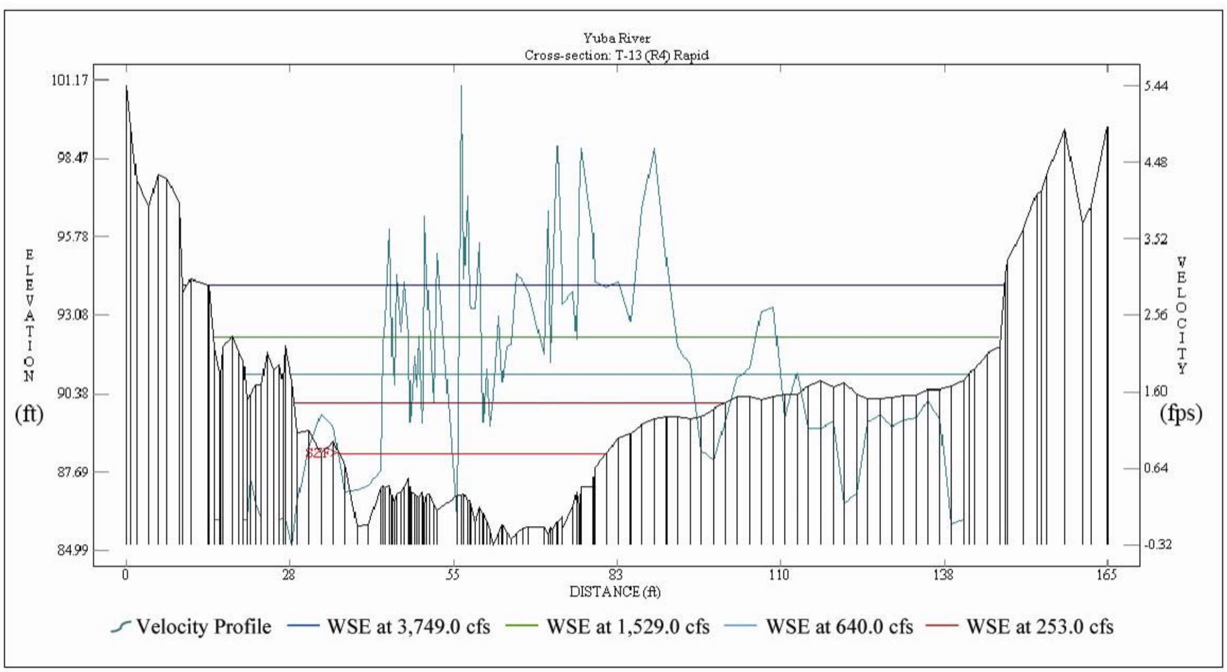

Figure 3.4-4. New Colgate Powerhouse ramping study cross sectional profile of Transect R4, a run, looking upstream. Velocity data were collected at 640 cfs.

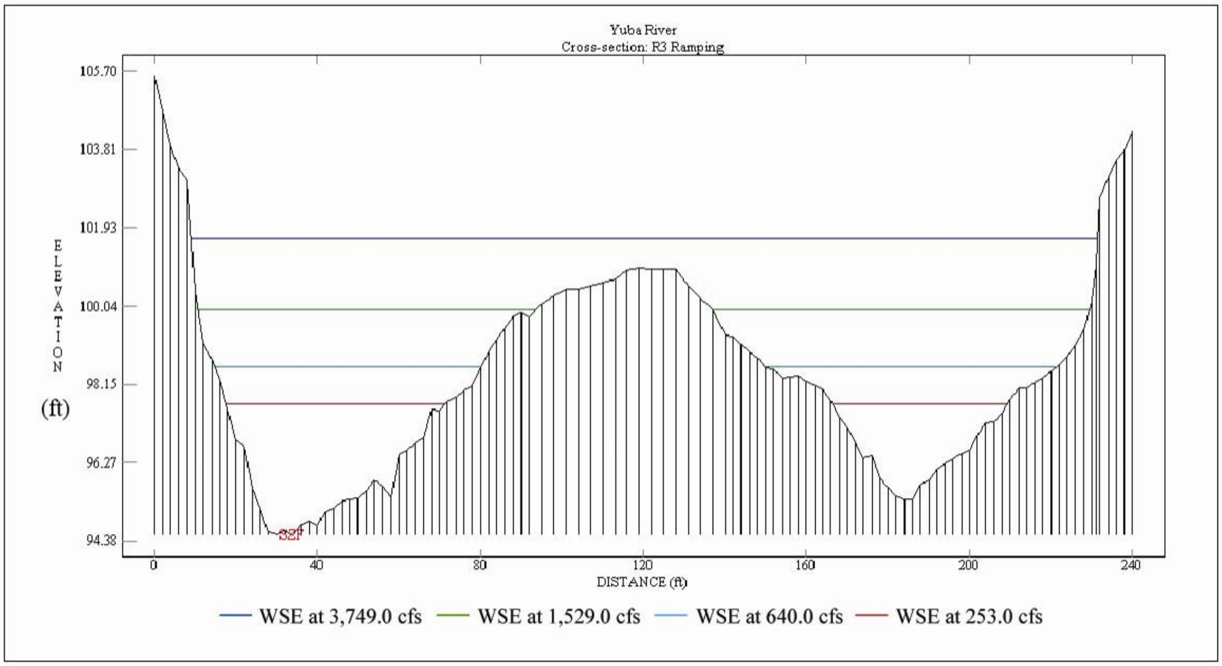

Figure 3.4-5. New Colgate Powerhouse ramping study cross sectional profile of Transect R3, a run – backwater split, looking upstream. No velocity data were collected.

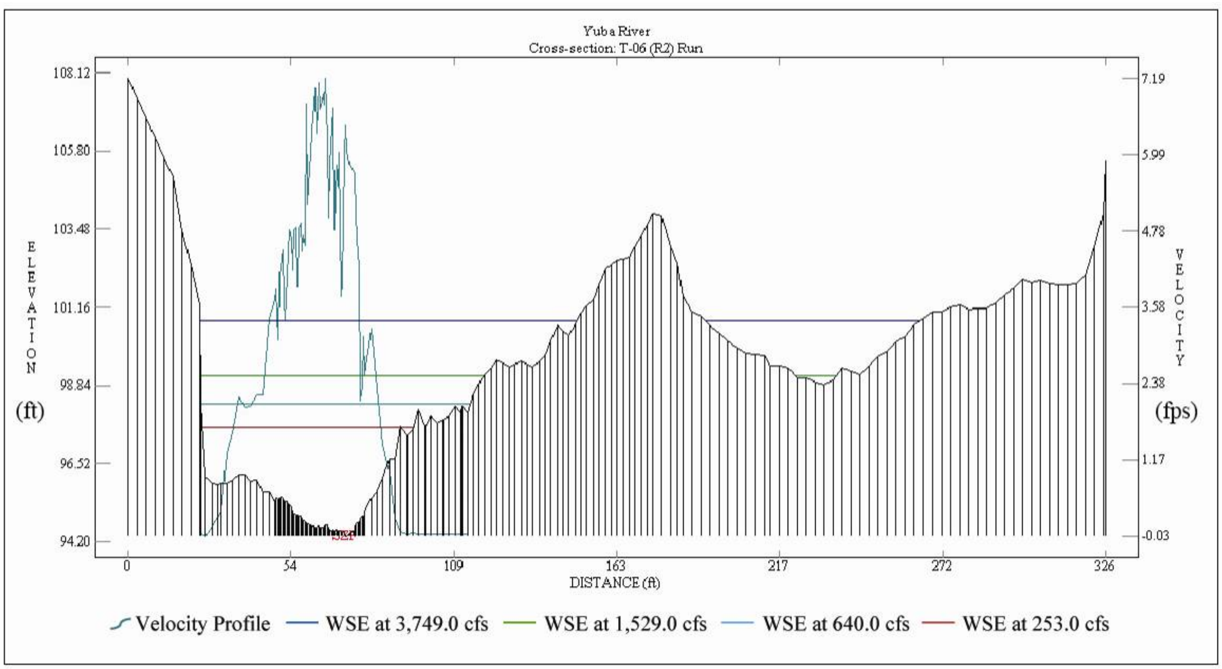

Figure 3.4-6. New Colgate Powerhouse ramping study cross sectional profile of Transect R2, a run – backwater split, looking upstream. Velocity data were collected at 640 cfs.

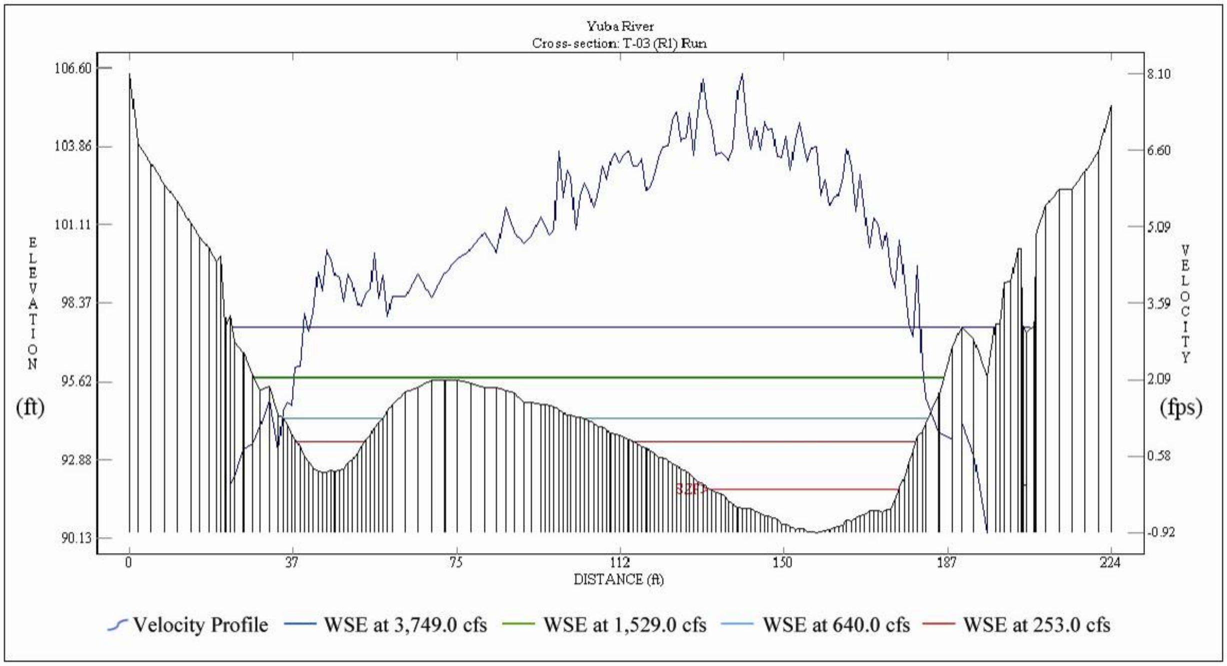

Figure 3.4-7. New Colgate Powerhouse ramping study cross sectional profile of Transect R1, a run, looking upstream. Velocity data were collected at 3,749 cfs.

3.4.2 Bar Slope Gradient

Bar locations, slope gradients, and stationing along each transect from which bar slopes were calculated are shown below in Table 3.4-1. Calculations were made using the topographic and stage/discharge information collected during Study 3.10. Cobble bar slopes in the varial zone were calculated by identifying the stations and elevations that corresponded to the lowest gradient zone of interest along each transect. These areas are all encompassed by the range of discharge values released at the New Colgate Powerhouse during each observation survey. For transects R3 and R2 however, the lower most elevation was defined as the bottom of the right bank side channel, due to the perched pool.

Table 3.4-1. Bar slope gradients for observation sites on all study transects

Transect	Location of Varial Zone on Transect[1]	Stationing (ft)	Elevation[2] (ft)	Slope (%)	Wetted Perimeter[3] (ft)
R7	Left bank	46.30 to 86.0	99.96 to 94.92	12.7	126.7
R6	Left bank	44.5 to 75.5	96.86 to 91.01	18.9	115.1
R5	Left bank	78.8 to 98.0	96.36 to 90.88	28.5	116.4
R4	Mid channel	94.8 to 146.8	89.41 to 91.95	4.9	149.5
R3	Mid channel and right bank	119.0 to 184.0	101.0 to 96.20	7.4	225.7
R2	Right bank	185.0 to 232.0	101.2 to 103.9	5.7	186.3
R1	Left bank	72.0 to 124.0	95.96 to 92.54	6.6	174.2

[1] Locations looking upstream, indicate the section of the transect that was identified as the primary observation site
[2] Transects R2 and R3 had adjustments made to the cross sectional geometry to allow the model to more accurately represent flow conditions in the perched pool (right bank). However the elevations and slopes on this table represent the actual field-measured values.
[3] Wetted perimeter calculated at 3,300 cfs.

3.4.3 Hydraulic Modeling

A brief summary of the hydraulic modeling results for the seven ramping transects are provided below. A complete Hydraulic Calibration Report including all 21 transects modeled in support of Study 3.10, has been provided in Attachment 3-12D.

3.4.3.1 Hydraulic Model Results

The New Colgate Powerhouse reach model was calibrated using four stage/discharge calibration data sets: 3749 cfs, 1529 cfs, 640 cfs, and 253 cfs. All transects in the study site were calibrated using both Log/Log and MANSQ and four groups of transects were modeled using WSP. These groups generally represented pool and run dominated sections of the reach. For model calibration, WSEs were selected within the range of field collected data only. All model calculated discharges based on field measured velocities, were within 10 percent of the best estimate of discharge. MANSQ and Log/Log percent mean error[9] and Beta (β) values can be seen in Table 3.4-2 below. No mean error values are available for the WSP routine in RHABSIM.

Table 3.4-2. Percent mean error for stage/discharge relationships.[1]

Statistic	Transect #						
	R7	R6	R5	R4	R3	R2	R1
Log/Log	1.679	1.042	5.143	1.257	3.692	10.710	3.852
MANSQ	2.576	4.977	6.312	6.736	4.631	14.631	6.207
MANSQ BETA	0.081	0.313	0.322	0.256	0.174	0.294	0.102

[1] Mean error not available for the WSP routine in RHABSIM

Based on the modeling guidelines outlined above in Section 2.8.2, *Modeling Methods*, and the detailed model analysis provided in Attachment 3-12D, one model was selected for each transect. Table 3.4-3 provided below summarizes the model selected for each transect as well as the discharge that each velocity data set was collected.

Table 3.4-3. Hydraulic models selected for use in Study 3.12, *New Colgate Powerhouse Ramping* and the associated discharge when velocities were collected.

Transect #	Model Selected	Discharge at Velocity Collection (cfs)
R7	Log/Log	1,529
R6	WSP	253
R5	WSP	3,749
R4	Log/Log	640
R3	Log/Log	Not Collected[1]
R2	Log/Log	640
R1	WSP	3,749

[1] Velocity data collection was conducted during implementation of Study 3.10 only. Since Transect-R3 was selected for Study 3.12 only, field crews did not collect velocities.

[9] Percent mean error can be defined as: an evaluation of the difference between the predicted water surface elevations and the observed water surface elevations measured in the field.

The RHABSIM model used the "one-velocity" method, as any given transect only has one velocity set. All transect velocity measurements in the reach downstream of New Colgate Powerhouse, were collected at the highest target flow possible for that transect. Limiting physical parameters included swift water too deep to safely wade or deep water with entrained air which limited ADCP data collection. Table 3.5-2 above, indicates the target discharge at each transect for which velocity data was collected. No velocity data were collected on Transect R3 because velocity data collection occurred only during the implementation of Study 3.10. Therefore, to predict velocities over the range of simulated flows, the depth-calibration method in RHABSIM was used. This method applies a uniform roughness coefficient to each cell across the cross section to achieve the user supplied discharge. The calibration procedure adjusts the roughness coefficients to create an appropriate velocity distribution across the channel, based on field knowledge and professional judgment. Since Transect R3 was placed in the same channel type and mesohabitat as Transect R2, 91 ft upstream, the velocity distribution profile for Transect R3 was based largely on Transect R2.

3.4.3.2 Stage/Discharge Relationships - Rating Curves

The primary product of each selected hydraulic model is a stage/discharge relationship. Graphically, these relationships are represented by a rating curve. For comparison purposes, the rating curve for all seven transects have been plotted and are shown in Figure 3.4-8 below. A steeper curve indicates a greater change in WSE with changes in discharge than curves that are less steep.

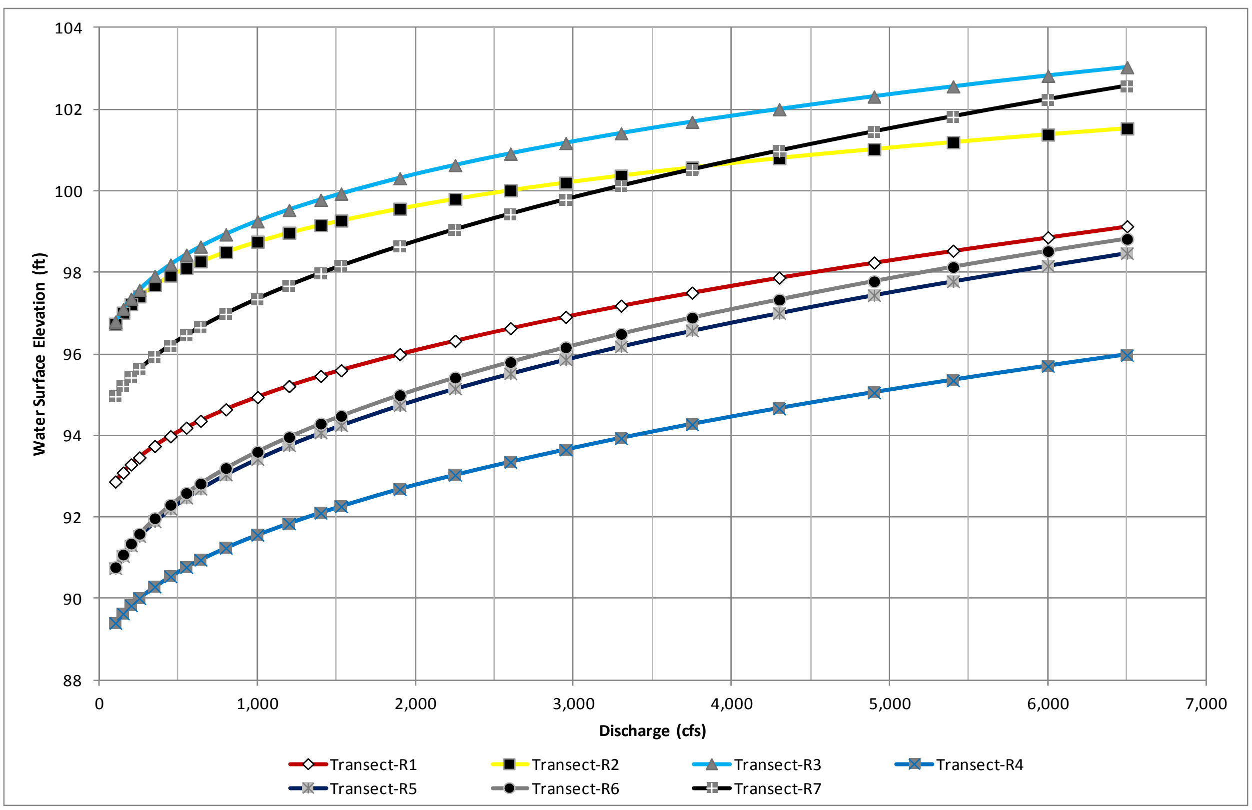

Figure 3.4-8. Rating curves for the seven New Colgate Powerhouse ramping study transects.

Tabular results for the stage/discharge rating curves are presented as a series of wedge tables in Attachment 3-12E. These wedge tables present the magnitude change or percent change in stage, when going from one discharge to a lower discharge.

3.4.3.3 Wetted Perimeter

The wetted perimeter[10] for each transect at each given discharge can be calculated based on the stage/discharge relationships developed in the hydraulic models. Graphically, these relationships are represented with a wetted perimeter curve. For comparison purposes, the wetted perimeter relationships for all seven transects have been plotted and are shown in Figure 3.4-9 below. Distinct changes or inflections in the wetted perimeter curve are directly related to a topographic change in channel shape at that WSE.

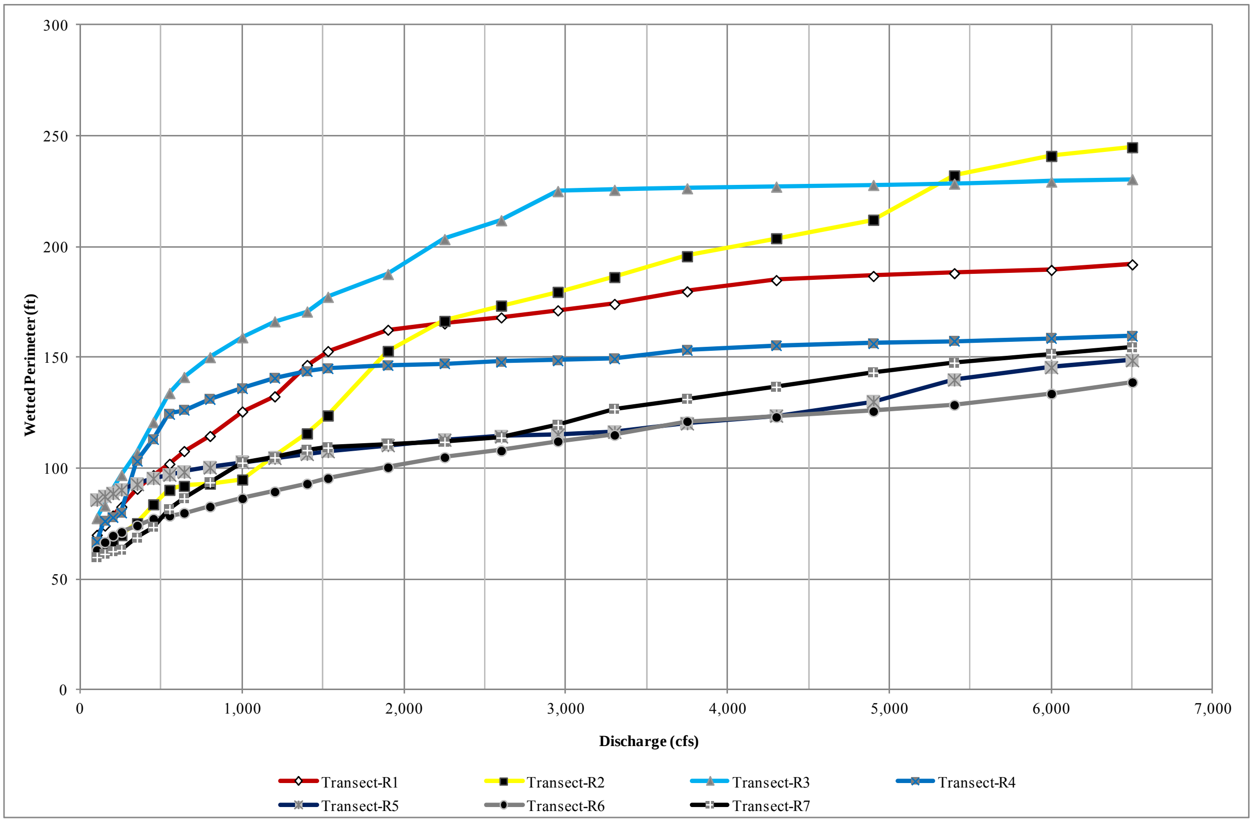

Figure 3.4-9. Wetted perimeter relationships for the seven New Colgate Powerhouse ramping study transects.

Tabular results for the wetted perimeter/discharge rating curves are presented as a series of wedge tables in Attachment 3-12E. These wedge tables present the magnitude change or percent change in wetted perimeter, when going when going from one discharge to a lower discharge.

[10] Wetted perimeter is defined as the distance along the bottom and sides of a channel cross section in contact with the water at a specific discharge and is roughly equal to the stream width plus 2 times the mean depth.

3.4.3.4 Average Transect Velocity

The primary result of velocity modeling in RHABSIM is a predicted mean column velocity at each wetted station along the cross section for any given discharge. To summarize the relationship between discharge and water velocity at each ramping transect, mean column velocities at each station along the cross section were averaged resulting in an average transect velocity. The average velocity and discharge relationship for all seven transects are shown below in Figure 3.4-10.

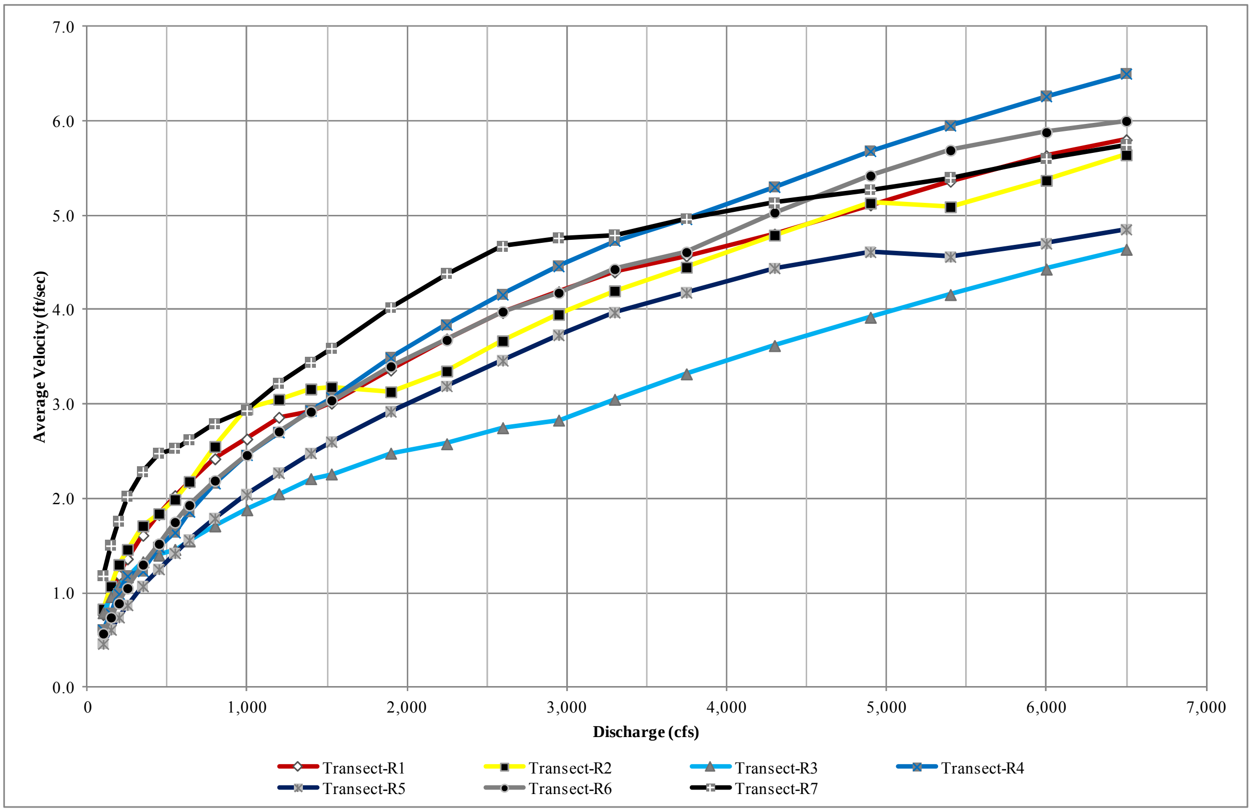

Figure 3.4-10. Average velocity relationships for the seven New Colgate Powerhouse ramping study transects.

Tabular results for the average velocity/discharge rating curves are presented as a series of wedge tables in Attachment 3-12E. These wedge tables present the magnitude change or percent change in average velocity, when going from one discharge to a lower discharge.

3.5 Topography and Hydraulics Analysis

3.5.1 Cobble Bar Gradient and Morphology

A total of seven cross sections were surveyed on the two cobble bars. Transects were intentionally placed to represent the variety of potential stranding locations identified during a field visit by Relicensing Participants. Of primary interest, were areas along each cobble bar with low topographic gradients (i.e., <5%). Much of Condemned Bar and French Bar consisted of steep sided banks. For example, on Condemned Bar, Transect R7 had a slope of 12.7 percent, R6 had a slope of 18.9 percent and R5 had a slope of 24.7 percent. All three transects were dominated by substrate composed of large cobble and boulder. Though the cobble bar did not exhibit low gradient bar features, due to the coarse structure of the littoral zone along the bar, numerous interstitial spaces in between and under the large substrate were identified as potential stranding areas. These areas were later mapped by surveyors as potholes. While not directly on Condemned Bar, Transect R4 was selected because of the relatively low gradient (i.e., 6.1 %) mid channel cobble bar feature that was exposed during low flow periods.

Like Condemned Bar, much of French Bar had steep sided banks. Unlike Condemned Bar however, no transects were placed at these locations. The focus was on the upstream section of French Bar, which is characterized by a low gradient cobble bar and consists of a perched pool that becomes an isolated backwater pool at low flows. Two transects, R3 and R2 were placed at this location. Transect R1 was placed approximately 150 ft downstream of French Bar where it was determined that a low gradient gravel/cobble bar may have stranding potential.

3.5.2 River Flow and Stranding Potential

Cross sectional profiles were established at all seven transects to investigate the relationship between discharge and stranding potential. One primary factor in predicting stranding potential is the base river flow at the time of Project down ramping. This is because all potential stranding features, such as mid-channel gravel bars, perched pools or potholes are only exposed below certain flow levels. Stranding potential at each transect is then a function of the base flow in the river during down ramping events and the flow at which the potential stranding feature becomes dewatered or disconnected from the main channel.

From a topographic perspective, stranding potential at all of the transects appears to be low when base flows were high, and stranding potential appears to be high when base flows were low. Stranding survey results support the topographic evidence - there was a large difference in total stranding observations between down-ramp events from flows of approximately 3,200 cfs to 1,570 cfs (n=1) and down-ramp events from flows of approximately 1,570 cfs to 500 or 100 cfs (n=15).

To demonstrate the relationship between season and stranding potential, mean monthly flows were calculated and provided in Table 2.6.1 above. Based on the stranding survey results and topographic surveys, during months with high base flows such as December through May, stranding potential is reduced while during low base flow periods in June through November, standing potential is increased. In addition to the monthly flow dynamic, there may be significant differences in base flows from year to year depending on the type of water year (e.g., Wet, Above Normal, Below Normal, Dry or Critically Dry).

3.5.3 Detailed Topographic Analysis

The topography of the three upper Condemned Bar transects had narrow channels with steep littoral zones. Since Transect R6 and R5 were placed in a mid-channel pool, the transects retained a considerable residual pool at the lowest summer base flows (i.e., <100 cfs). Transect

R7 showed the most significant topographic heterogeneity along the left bank, primarily due to the mix of boulder and cobble substrates.

Based on the cross sectional topography, the three upper transects do not have a high potential for stranding because there are no significant residual pools, perched pools or clearly identifiable stranding zones. In addition, the narrow channel and high longitudinal gradient between transects R7 and R6 result in high transect velocities, thereby limiting the habitat for all but the strongest swimming species and older life stages. Survey data did not document any stranded fish near these locations.

Based on model results, the low gradient cobble bar on Transect R4 becomes exposed at flows less than approximately 550 cfs. Photos from stranding surveys however indicate that lower downstream, the bar becomes exposed at flows lower than 1,500 cfs. Disconnected residual pools were present at flows of 176 cfs. No stranded fish were observed in the zone represented by this transect. However, in the vicinity upstream of this transect (labeled as Stranding Zone B on Figure 2.2-1) on the right bank ascending, surveyors detected stranded fish on two occasions.

At French Bar, when flows drop below approximately 2,600 cfs, the point bar begans to form. When this occurs, a large backwater pool forms. However, surficial hydraulic connectivity with the main channel is not lost until approximately 450 cfs. When main channel connectivity is lost, the residual pool depth at Transect R3 was 2.92 ft and width was 56 ft and is over 200 ft long. These data suggest that if fish were in this location during a rapid drawdown, survivabilty would be very high provided flows higher than 450 cfs were released before water temperatures reached lethal levels, oxygen was depleted or predation occured. On the point bar that bisects the main channel from the back water there was one depression or pothole documented. No fish were found stranded at this feature during any survey. Due to the strong hydrualic lateral control caused by the point bar, the perched pool had little or no velocity at flows less than approximately 1,500 cfs and gradually increased as flows increased above that. No stranded fish were observed in the backwater at French Bar. The topographic and hydraulic results in addition to no stranding observations during this Study, suggest that stranding at this location is not a significant source of fish mortality.

Transect R1 was selected because of a low gradient gravel bar near the left bank ascending. In fact, the gravel bar became a potential stranding pool and shallow depressions were discovered on the right bank ascending. While the hydraulic model indicates initial bar exposure at 1,400 cfs, flows of approximately 200 cfs were necessary to lose hydraulic connectivity at the downstream terminus of the bar. In this survey area, stranding was observed in a backwater pool at the downstream end of French Bar in what is labeled as Stranding Zone C in Figure 2.2-2. The backwater pool appears to be the result of scour from a dry side channel that becomes wetted infrequently and only at very high flows. The flow at which the side channel becomes wetted was not determined in this study as field surveys did not measure the height of the upstream control of the side channel.

Because there are thousands of possible river base flow and Project release combinations, ramping wedge tables were developed to assist with calculating the changes at each transect in wetted perimeter, stage change and velocity. These have been provided in Attachment 3-12E

Wedge Tables. For example, wedge tables will show the magnitude change in river stage from a starting discharge to an ending discharge where changes are calculated based on the starting river stage. Each transect table has starting discharges in descending order along the left side and ending discharges are in descending order along the top.

3.6 Travel Time Results

YCWA deployed water level recorders at all seven transects with the primary objective of calculating the time between flow changes made at the New Colgate Powerhouse and water surface stability at each transect as well as the rate of stage change at each transect. Water level recorder data was collected from June 10 to August 24, 2012 where the end date was determined by limited internal memory capacity. Water level recorders were not recording during the final stranding surveys which were postponed until August 25 and August 30, 2012 due to New Colgate Powerhouse maintenance.

3.6.1 Down-ramp Events

Plots of each down-ramp event have been included below in Figures 3.6-1 through 3.6-4. Starting WSEs were normalized to a common elevation for comparison purposes. Each plot shows the 15-minute water surface data for all seven transects over a discrete period of time where flows were changed to when flows stabilized. The solid black line represents the time at which the Project initiated the down ramp event.

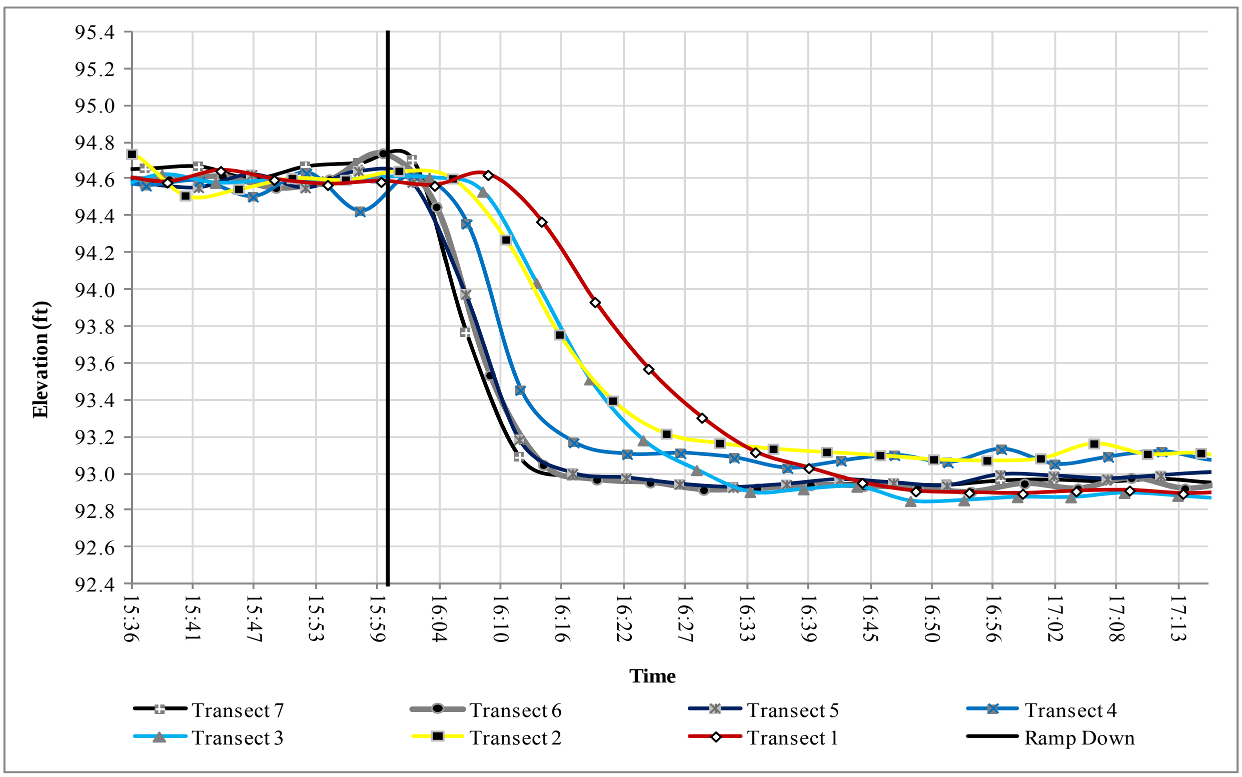

Figure 3.6-1. Water level recorder data at each of the seven transects during the June 12, 2012 ramp down event from 2,973 cfs to 1,475 cfs downstream of the New Colgate Powerhouse.

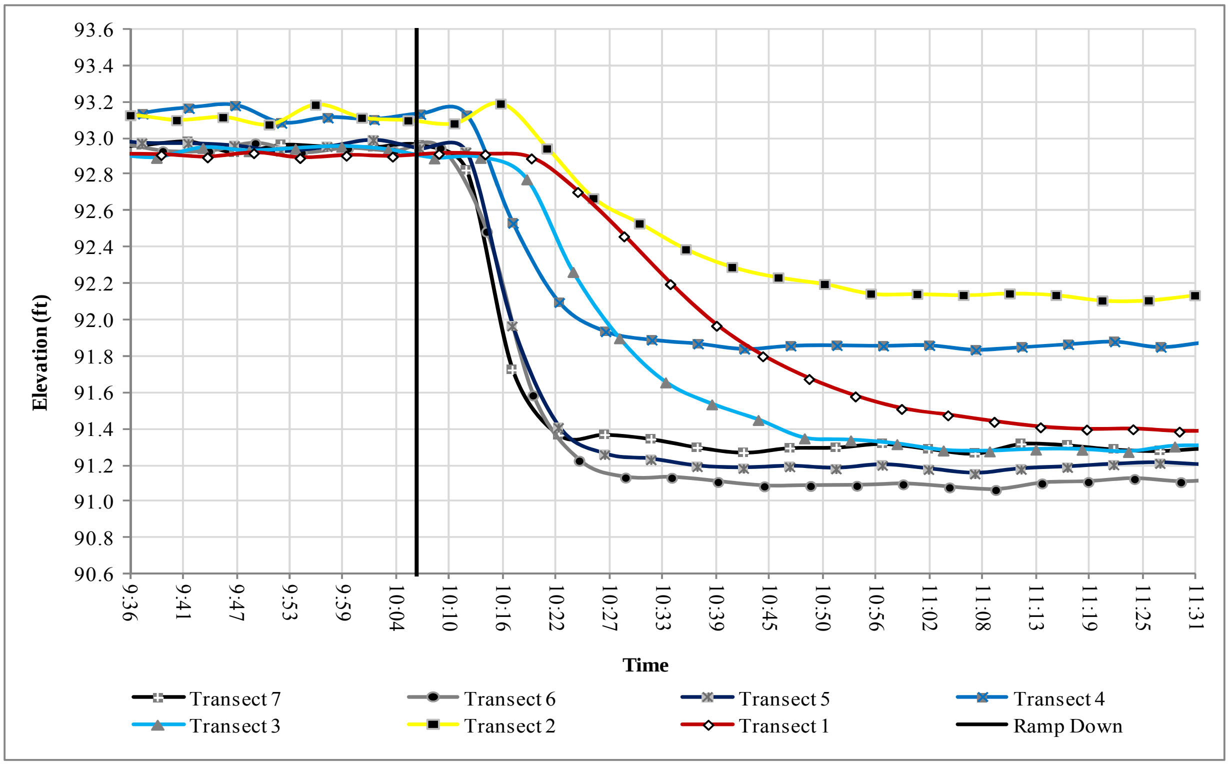

Figure 3.6-2. Water level recorder data at each of the seven transects during the June 13, 2012 ramp down event from 1,455 cfs to 455 cfs downstream of the New Colgate Powerhouse.

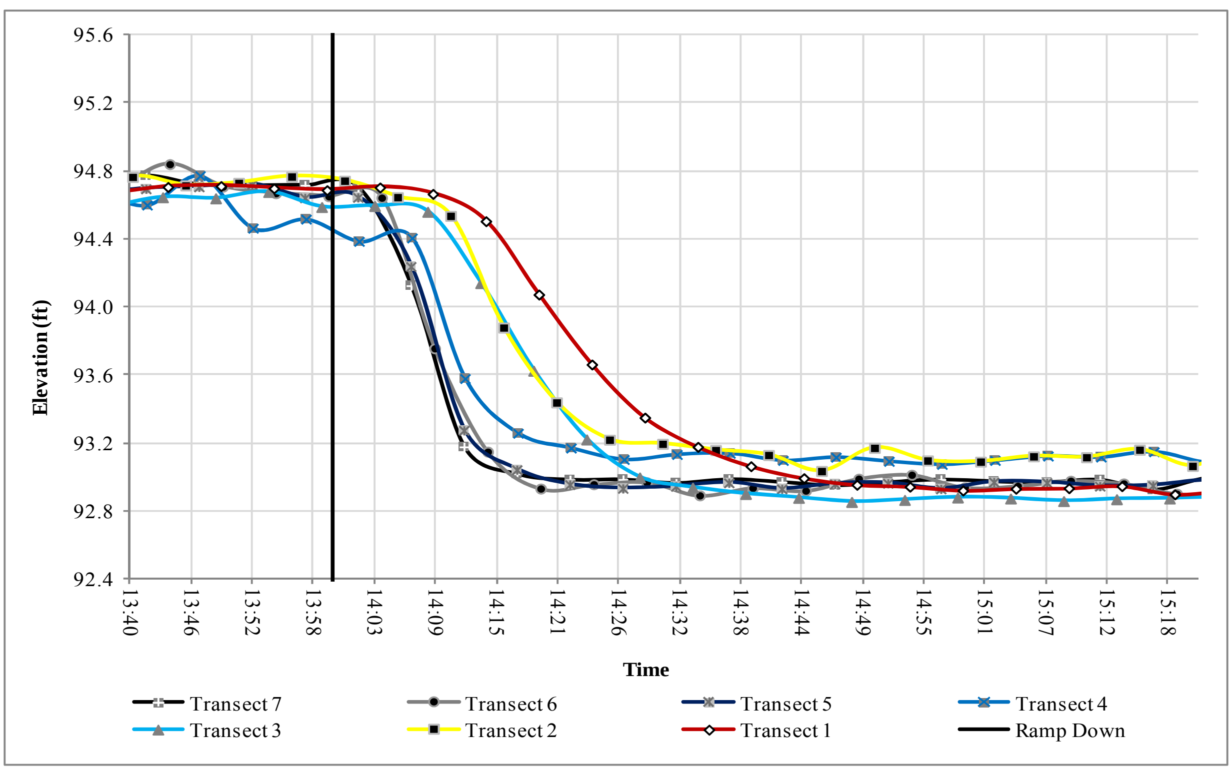

Figure 3.6-3. Water level recorder data at each of the seven transects during the July 27, 2012 ramp down event from 3,211 cfs to 1,549 cfs downstream of the New Colgate Powerhouse.

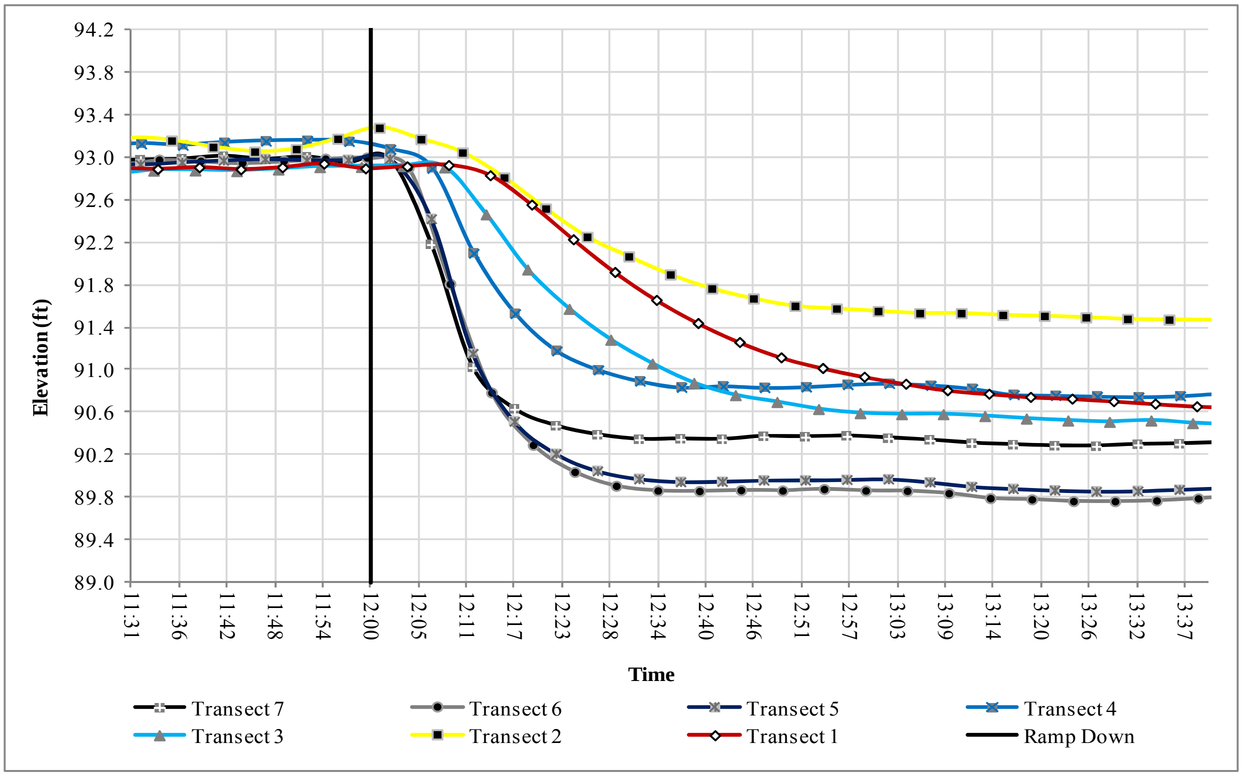

Figure 3.6-4. Water level recorder data at each of the seven transects during the July 28, 2012 ramp down event from 1,559 cfs to 126 cfs downstream of the New Colgate Powerhouse.

At all seven transects, two distinct elements of travel time were calculated during each down ramp event. These elements are described below.

- Drawdown Duration. The length of time from the initiation of the ramp down event at the powerhouse until WSEs stabilized at the transect.
- Rate of Stage Change. Calculated using the total difference in WSE between the starting WSE to the ending WSE over the duration of the drawdown event at each transect.

Stabilization was defined as the first data point that remained within 0.05 ft of the average over a 25 minute period. Travel time calculations for the June ramping events are presented in Table 3.6-1 and in Table 3.6-2 for the July ramping events.

Table 3.6-1. Travel times for June down ramp events from Powerhouse to transect.

Date	Transect	Distance Downstream from Powerhouse (ft)	Base River Flow (cfs)	Starting Flow (cfs)	Ending Flow (cfs)	Time Ramp Down Initiated at New Colgate Powerhouse	Drawdown Duration (min)	WSE Stability[1] (min)	Stage Change (ft)	Rate of Stage Change (ft / min)
12-Jun-12	R7	1,474	85.8	2,973	1,475	16:00	20	≤25	1.729	0.115
	R6	1,674					20	≤25	1.789	0.090
	R5	2,030					20	≤25	1.606	0.080
	R4	2,501					25	≤30	1.512	0.060
	R3	5,016					35	≤40	1.694	0.048
	R2	5,112					30	≤40	1.469	0.049
	R1	6,445					40	≤50	1.719	0.043
13-Jun-12	R7	1,474	85.8	1,455	455	10:06	20	≤25	1.594	0.080
	R6	1,674					25	≤30	1.815	0.073
	R5	2,030					20	≤30	1.694	0.085
	R4	2,501					20	≤30	1.236	0.062
	R3	5,016					40	≤50	1.555	0.039
	R2	5,112					45	≤55	1.048	0.023
	R1	6,445					55	≤70	1.414	0.026

[1] Travel time was calculated from the initiation of Project down ramp until water surface stabilization. Stabilization was defined as the first measured point that remained within 0.05 ft of the average over 25 minutes. Because the recording interval of the pressure transducers was 5 minutes, all times are calculated on a five minute time step.

Table 3.6-2. Travel times for July down ramp events from Powerhouse to transect.

Date	Transect	Distance Downstream from Powerhouse (ft)	Base River Flow (cfs)	Starting Flow (cfs)	Ending Flow (cfs)	Time Ramp Down Initiated at New Colgate Powerhouse	Drawdown Duration (min)	WSE Stability[1] (min)	Stage Change (ft)	Rate of Change (ft / min)
27-Jul-12	R7	1,474	50.0	3,211	1,549	14:00	20	≤25	1.717	0.086
	R6	1,674					20	≤25	1.684	0.084
	R5	2,030					25	≤30	1.710	0.068
	R4	2,501					25	≤35	1.301	0.052
	R3	5,016					30	≤40	1.658	0.055
	R2	5,112					30	≤45	1.405	0.047
	R1	6,445					40	≤50	1.709	0.043
28-Jul-12	R7	1,474	50.0	1,559	126	12:00	30	≤35	2.633	0.088
	R6	1,674					32	≤35	3.038	0.095
	R5	2,030					35	≤40	3.039	0.087
	R4	2,501					40	≤45	2.227	0.056
	R3	5,016					50	≤60	2.311	0.046
	R2	5,112					45	≤60	1.467	0.033
	R1	6,445					60	≤75	2.055	0.034

[1] Travel time was calculated from the initiation of Project down ramp until water surface stabilization. Stabilization was defined as the first measured point that remained within 0.05 ft of the average over 25 minutes. Because the recording interval of the pressure transducers was 5 minutes, all times are calculated on a five minute time step.

3.7 Travel Time Analysis

Travel time and the rate of stage change were analyzed for all down ramping events when stranding surveys were conducted to calculate how quickly the river reacts to changes in flow released from the powerhouse. For purposes of this Study, travel time was partitioned into two categories: Total Travel Time, and Rate of Stage Change. Both elements will be discussed below.

3.7.1 Total Travel Time

Total travel time (often termed transit or lag time) was determined for each transect and spanned the duration between the initiation of the down ramp or up ramp event at the powerhouse and the point at which WSE stabilized on transect. The stabilization point was defined as the first stage data point, as measured by each pressure transducer, which remained within 0.05 ft of the average WSE for no less than the following 25 minutes.

As would be expected, travel times were generally longer for downstream transects when compared to those closer to the powerhouse. The average total travel time at the most upstream transect, which was 1,474 ft downstream from New Colgate Powerhouse, was approximately 25 minutes. The average travel time of the most downstream transect, which was 6,445 ft downstream from New Colgate Powerhouse, was 60 minutes.

3.7.2 Rate of Stage Change

Rate of stage change, defined as the change in stage over the time between the initial response time to the point of stabilization, was calculated for each transect. Overall, the rates of stage change ranged from 0.115 ft per minute (ft/min) to 0.026 ft/min (6.9 ft per hour to 1.56 ft/hr). The results show a linear relationship with increasing distance from the powerhouse. Channel shape and gradient also influenced the attenuation of the ramping rates observed at each transect. To demonstrate, Figures 3.7-1 and 3.7-2 show the relationship between wetted perimeter, which is a function of stream width and depth, and rate of stage change for all transects observed during the June and July ramping events. The narrower transects located on Condemned Bar experienced rates of stage change up to 3.07 times higher than the wider transects measured on French Bar due to the fact that the average wetted perimeter of the Condemned Bar transects was 126.9 ft whereas the average wetted perimeter for transects on French Bar was 195.4 ft.

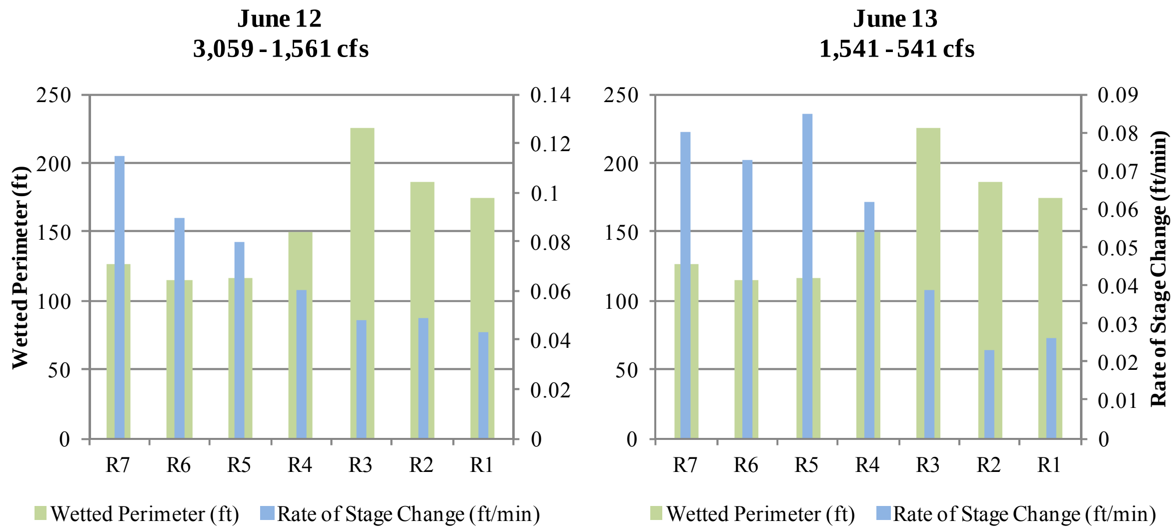

Figure 3.7-1. Wetted perimeter versus rate of stage change relationships for all transects during June ramp down events.

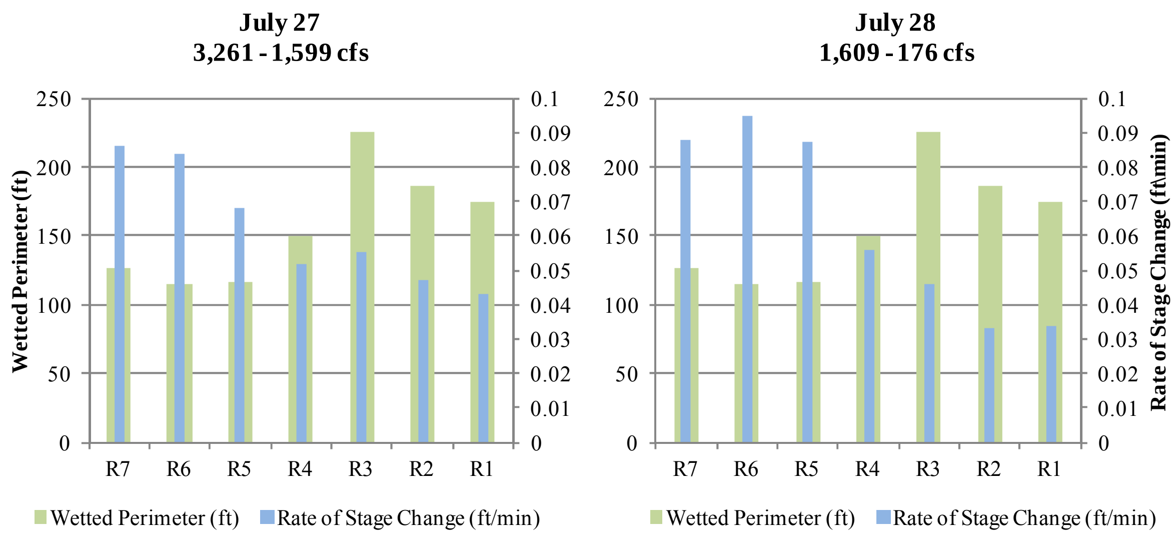

Figure 3.7-2. Wetted perimeter versus rate of stage change relationships for all transects during July ramp down events.

4.0 Discussion

YCWA was unable to find any historic information on fish stranding or fish stranding surveys of the resident fish population in the Yuba River between New Colgate Powerhouse and Englebright Reservoir. The primary objective of this study was to document fish stranding downstream of New Colgate Powerhouse during ramping.

The susceptibility of fish to stranding is a function of their behavioral response to changing flows, which depends on the species, body size (and related swimming ability), water temperature, time of year time of day and stream substrate as well as the wetted history and rate of flow reduction (Nagrodski 2012; Bradford 1996).

While this study documented all species observed, the primary focus was on rainbow trout. Of the 16 stranding observations made during the study, only one observation made during the stranding surveys was of rainbow trout. An additional observation of a potentially stranded rainbow trout was made during Study 3.8 surveys. Fish species listed as threatened or endangered under the federal Endangered Species Act or the California Endangered Species Act, or otherwise considered special-status, were not found stranded.

Results of the pre- and post-ramp down surveys showed that fish (e.g., rainbow trout, sculpin, green sunfish and unidentified spp.), were present in similar numbers and composition in the survey areas before and after down-ramp occurred. Of the total 1,628 fish observations from the six surveys, 6 percent (n=100) were rainbow trout ranging from 40 mm to 505 mm in length. All rainbow trout were in the vicinity of Condemned Bar, primarily in the deep, swift pool where transects R7, R6 and R5 were placed. The observation of adult rainbow trout in pre- and post-ramp surveys as well as in fish surveys conducted in support of Study 3.8, indicate a persistent population that is not forced downstream by daily pulsed flows. This finding is consistent with recent research on the South Fork American River where radio-tagged rainbow trout remained in the study area with significant daily pulse flows ranging from 176 cfs to 1,412 cfs (Cocherell et al. 2010).

All stranded fish of any species observed were less than 50 mm long, and 75 percent were less than 15 mm long. The two rainbow trout were 40 mm and 50 mm, the latter from an incidental observation. Though very limited, these results are consistent with studies that have shown limited stranding of salmonid fry after they reach 40 to 50 mm in length (Pacificorp 2004; Hunter 1992; Olson 1990).

All unidentified stranded fish were less than 15 mm long. This indicates a strong relationship between the number of newly emerged larvae and young-of-year and the likelihood of stranding during the early summer rearing period. Fish of this size have a reduced swimming capacity as compared to juvenile or adult fish of the same species (Vogel 2007; Moyle 2002). Native larval and fry life stages are more likely to use shallow habitat along the river margin (Lorig et al. 2012; Bradford 1996), and have reduced swimming abilities (Moyle 2002). Fish in these early life stages are oftentimes adapted to utilize these shallow margin habitats because they have favorable velocity refugia, refugia from larger piscovores, warmer water temperature, and relatively abundant invertebrate prey items associated with adjacent vegetation and fine grained sediments (Moyle 2002; Gadomski et al. 2001; Harvey et al. 2002).

Few studies have documented the influence of ramping on rainbow trout spawning behavior (Pacificorp 2004). In this study, no rainbow trout young-of-year or fry were observed during the pre- and post-ramping surveys. This suggests that the adult rainbow trout observed in the reach are not actively spawning or, newly emerged young-of-year are not using the varial zone. Since locations of suitable rainbow trout spawning gravel or evidence of spawning redds have not been identified in this reach, it is difficult to accurately predict the influence of daily flow changes in depth and velocity and the subsequent effect on spawning success. If rainbow trout are successfully spawning in this reach, the newly emerged rainbow trout were not documented in the nearshore habitats surveyed during this study. In a study on the effects of hydropeaking on nearshore habitat use by young-of-the-year rainbow trout, Korman 2009 reported limited use of areas frequently subjected to dewatering and inundation and suggested that they were therefore holding further offshore. Another possible reason for limited rainbow trout stranding is that native fish that are commonly exposed to variable hydrographs, as they are in this reach, are less likely to be stranded when compared to non-native species (i.e., centrarchid spp.) and are more adapted to flow fluctuation (Sommer et al. 2005).

Studies have shown that cold water temperatures of less than 7°C can increase the incidence of salmonid stranding (Halleraker 2003; Saltveit 2001; Bradford 1996). In the river directly downstream of New Colgate Powerhouse, an average monthly mean temperature 10°C was recorded during the period of study. As this temperature is within the tolerance of rainbow trout (Moyle 2002), it is unlikely that these temperatures would increase their stranding potential

Similarly, water quality does not appear to be a factor in stranding potential in the study reach. Turbidity measurements reported in YCWA's relicensing Technical Memorandum 2-3, *Water Quality,* was 0.0 NTU.

Numerous studies have documented that salmonid stranding due to rapid flow fluctuations is greatest when streambed gradients are less than 5 percent (Clarke et al. 2008; Hunter 1992; Olson 1990). Of the seven transect locations selected for intensive topographical survey, one transect - R3 - had a potential stranding zone gradient of 4.9 percent, though no stranding was documented at that location. Stranding was only observed on the right bank of R1, the furthest downstream transect in the study.

In the reach downstream of New Colgate Powerhouse, isolated pools and potholes along the stream margins that are created during dewatering events appear to influence stranding potential more than low gradient gravel or cobble bars. These areas remain wetted with enough depth to keep young fish from swimming toward the main channel. Bradford (1996) reported considerable numbers of fry and juvenile salmonids in isolated water pockets as flows were reduced, even at low rates of change. The three stranding zones identified in this study were characterized by large boulder and cobble substrates, though Stranding Zone A contained a significant amount of sand in the interstitial zones between boulders. The substrate characteristics at each of these stranding locations are consistent with findings from studies that documented increased salmonid stranding in boulder and cobble substrate when compared to gravel substrate (Clarke et al. 2008; Pacificorp 2004). The survivability of young rainbow trout in residual backwater pools, potholes and depressions is highly variable and dependant on factors such as the duration of stranding, residual water volume, substrate permeability and the rate of water loss, water temperature changes exceeding lethal thresholds, oxygen depletion, and predation.

A comparative analysis of the rate of stage change at each transect with stranding results was not conducted as no stranded fish were documented where water level recorders were installed. The value of such an analysis would be limited however, because even though there was a general decrease in the rate of stage change with increasing distance downstream, stranding rates were small and almost equal between the two surveyed cobble bars.

5.0 Study-Specific Consultation

The FERC-approved study included three study-specific consultation requirements. Each is described below.

5.1 Selection of Study Sites and Transects

The FERC-approved study states:

> YCWA will consult with interested and available Relicensing Participants regarding specific study sites and transects. YCWA will make a good faith effort to schedule the consultation on a day convenient to YCWA and interested Relicensing Participants (ideally, scheduling meetings at least 30 days in advance of the meeting or site visit to allow all Relicensing Participants to participate), and will provide an email notice confirming the meeting at least 10 days in advance of the meeting or site visit. If agreement regarding study sites and transects is not reached, YCWA will note the disagreements in its final report, including why YCWA did not adopt the recommendation. YCWA will offer a pre-field presentation and orientation meeting ahead of each field visit. The pre-field meeting will include a description of the study site, mesohabitat units, and possibly preliminarily selected transects. The basis for selection, still photos, aerial video (if available), and maps of these features will also be provided. (Steps 1 and 3.)

During a field visit on February 7, 2012, YCWA consulted with interested and available Relicensing Participants regarding selection of study sites and transects. YCWA provided the Relicensing Participants a description of the study site, mesohabitat units, and preliminarily selected transects. Agreement was reached on the sites and transects.

5.2 Hydraulic Model Calibration

The FERC-approved study states:

> Simultaneously with Study 3.10, YCWA will consult with interested and available Relicensing Participants regarding hydraulic calibration of the hydraulic model. YCWA will make a good faith effort to schedule the consultation on a day or days convenient to YCWA and interested Relicensing Participants (ideally, scheduling meetings at least 30 days in advance of the meeting to allow all Relicensing Participants to participate), and will provide an email notice confirming the meeting at least 10 days in advance of the meeting. If agreement regarding the hydraulic calibration is not reached, YCWA will note the

> disagreements in its final report, including why YCWA did not adopt the recommendation. Calibration reports will be provided to the Relicensing Participants at least 30 days prior to the meeting. (Step 4.)

On November 8, 2012 YCWA provided interested and available Relicensing Participants a review of the hydraulic calibration of the hydraulic model for the New Colgate Powerhouse Reach. The hydraulic calibration report has been provided in Attachment 3-12D.

5.3 Output Tables and Graphics

The FERC-approved study states:

> YCWA will consult with Relicensing Participants regarding the output tables and graphics to be included in the final report (Step 4 and Step 5).

On November 8, 2012, YCWA consulted with Relicensing Participants regarding the output tables and graphics to be included in the final report.

6.0 Variances from FERC-Approved Study

The study was conducted according to the Federal Energy Regulatory Commission (FERC)-approved Study 3.12, *New Colgate Powerhouse Ramping*, with one variance. The FERC-approved study specified the study be completed by the end of September 2012. Due to a series of powerhouse maintenance outages in August 2012, flow scheduling for purposes of visual observation stranding surveys was limited thereby resulting in a delay of study completion.

7.0 Attachments to This Technical Memorandum

This technical memorandum includes five attachments:

Attachment 3-12A	Pre- and Post-Ramp Down Survey Results [1 Adobe PDF file: 56 kb; 16 pages formatted to print on 8 ½ x 11 paper]
Attachment 3-12B	Stranding Survey Results [1 Adobe PDF file: 88 kb; 12 pages formatted to print on 8 ½ x 11 paper]
Attachment 3-12C	Stranding Survey Photos [1 Adobe PDF file: 15.2 MB; 70 pages formatted to print on 8 ½ x 11 paper]
Attachment 3-12D	Hydraulic Calibration Report [1 Adobe PDF file: 7.1 MB; 46 pages formatted to print on 8 ½ x 11 paper and 2 pages formatted to print on 11 x 17 paper]
Attachment 3-12E	Ramping Wedge Tables [1 Adobe PDF file: 612 kb; 8 pages formatted to print on 8 ½ x 11 paper and 58 pages formatted to print on 11 x 17 paper]

8.0 References Cited

Beck, R. W., 1989. Skagit River salmon and steelhead fry stranding studies. Prepared for Seattle City Light Environmental Affairs Division, Seattle, WA.

Bovee, K. 1982. A guide to stream habitat analysis using the instream flow incremental methodology. Instream Flow Information Paper No. 12. FWS/OBS-82/26. U.S. Fish and Wildlife Service, Office of Biological Services, Fort Collins, Colorado.

_____. 1997. Data collection procedures for the Physical Habitat Simulation System. U.S. Geological Survey, Biological Resources Division, Fort Collins, Colorado.

Bovee, K., B.L. Lamb, J.M. Bartholow, C.B. Stalnaker, J. Taylor and J. Henriksen. 1998. Stream habitat analysis using the instream flow incremental methodology. U.S. Geological Survey, Biological Resources Division Information and Technology Report USGS/BRD-1998-0004.

Clarke, K.D., Pratt, T.C, Randall, R.G, Scruton, D.A., and Smokorowski, K.E. 2008. Validation of the flow management pathway: effects of altered flow on fish habitat and fishes downstream from a hydropower dam. Can. Tech. Rep. Fish. Aquat. Sci. 2784: vi + 111 p.

Cocherell, S.A., Gardner, J. Jones, Javier B. Miranda, Dennis E. Cocherell, Joseph J. Cech Jr., Lisa C. Thompson and A. Peter Kimely. 2010. Distribution and movement of domestic rainbow trout, *Oncorhynchus mykiss*, during plused flows in the South Fork American River, California. Environ Biol Fish. 89:105-116.

Gadomski, D. M.; Barfoot, C. A.; Bayer, J. M.; Poe, T. P. 2001. Early life history of the northern pikeminnow in the lower Columbia River basin. Transactions of the American Fisheries Society, 130: 250 – 262

Halleraker, J. H., Saltveit, S. J., Harby, A., Arnekleiv, J. V., Fjelstad, H.-P., and Kohler, B. 2003. Factors influencing stranding of wild juvenile brown trout, *Salmo trutta*) during rapid and frequent flow decreases in an artificial stream. River Res. Appl. 19(5-6): 589-603. doi:10.1002/rra.752.

Harvey, B. C., J. L. White, and R. J. Nakamoto. 2002. Habitat Relationships and Larval Drift of Native and Nonindigenous Fishes in Neighboring Tributaries of a Coastal California River. Transactions of the American Fisheries Society 131:159-170.

Hunter, M.A., 1992. Hydropower Flow Fluctuations and Salmonids" A Review of the Biological Effects, Mechanical Causes, and Options for Mitigation. Habitat Management Division, Washington State Department of Fisheries. Technical Report Number: 119.

Korman, J., S.E. Campana. 2009. Effects of Hydropeaking on Nearshore Habitat Use and Growth of Age-0 Rainbow Trout in a Large Regulated River. Transactions of the American Fisheries Society. 138:76-78.

Lower Yuba Accord River Management Planning Group. 2010. Lower Yuba River Water Temperature Objectives – Technical Memorandum. November 2010.

Milhous, R.T., D.L. Wegner, and T. Waddle. 1984. User's Guide to the Physical Habitat Simulation System (PHABSIM). Instream Flow Information Paper No. 11. U.S. Fish and Wildlife Service. FWS/OBS-81/43 Revised.

Milhous, R.T., M.A. Updike, and D.M. Schneider. 1989. Physical Habitat Simulation System Reference Manual-Version II. Instream Flow Information Paper No. 26. U.S. Fish and Wildlife Service. Biological Report. 89(16).

Moyle, P.B. 2002. Inland Fishes of California. University of California Press, Berkeley and Los Angeles, California.

Nagrodski, A., Raby, G. D., Halser, C. T., Taylor, M. K., and Cooke, S. J. 2012. Fish stranding in freshwater systems: Sources, consequences, and mitigation. Journal of Environmental Management 103, 133-141.

Olson, F.W. 1990. Down Ramping Regime for Power Operations to Minimize Stranding of Salmonid Fry in the Sultan River. Report prepared for Snohomish County Public Utility District No. 1, Everett, WA.

PacifiCorp, 2004. Klamath River Hydroelectric Project - Ramping and Flow Fluctuation Evaluation Study Plan – Section 6. Pacific Corp, Klamath River Hydroelectric Project FERC No. 2082.

Rantz, S.E. 1982. Measurement and computation of stream flow: Volume 1. Measurements of stage and discharge. USGS Water Supply Paper 2175.

Saltveit, S.J., Halleraker, J. H., Arnekleiv, J.V., and Harby, A. 2001. Field experiments on stranding in juvenile Atlantic salmon and brown trout during rapid flow decreases caused by hydropeaking. Regul. Rivers: Res. Mgmt. 17(4-5): 609-622. doi:10.1002/rrr.652.

Trihey, E.W., and D. Wegner. 1981. Field data collection procedures for use with the Habitat Simulation System of the Instream Flow Group, USFWS, Fort Collins, Colorado.

United States Geological Survey (USGS). 2003. Open-File Report 03-383. Bathymetric and Geophysical Surveys of Englebright Lake, Yuba-Nevada Counties, California, 2003.

Vogel, D.A. 2007. A feasibility investigation of reintroduction of anadromous salmonids above Crocker-Huffman Dam on the Merced River. Report prepared for the U.S. Fish and Wildlife Service Anadromous Fish Restoration Program. Natural Resource Scientists, Inc. December 2007. 110 p. plus appendices.

Waddle, T.J., ed. 2001. PHABSIM for Windows: User's Manual and Exercises: Fort Collins, CO, USGS.

Yuba County Water Agency (YCWA). 2003. Lower Yuba River Redd Dewatering and Fry Stranding Monitoring and Evaluation Plan. Prepared by Jones and Stokes, Sacramento, CA.

_____. 2010. Yuba County Water Agency, Pre-Application Document.

Page Left Blank

Technical Memorandum 3-12

New Colgate Powerhouse Ramping

Attachment 3-12A

Pre- and Post-Ramp Down Survey Results

Yuba River Development Project

FERC Project No. 2246

December 2012

List of Tables

Page Left Blank

Snorkel and Walk Observations

Condemned Bar

Page Left Blank

Table 1. June Condemned Bar pre- and post-ramp down snorkel and walk observations.

Date	Location	River Flow (cfs)[1]	Pre- or Post-Ramp Down[2]	Average Observation Time[3] (min)	River Habitat Type	Habitat Location in Channel	River Bank[4]	Species Observed	Species Count	Species Size/Range (mm)	Dominant Substrate[5]	Water Depth (ft)
6/11/2012	Condemned Bar	622	--[6]	210	Pool	Margin	Left	Unknown species	100+	10 - 15	Sand	0.5
6/12/2012	Condemned Bar	3,059	Pre	45	Pool	Margin	Left	Unknown species	200+	10	Large cobble	0.5 - 2.0
6/12/2012	Condemned Bar	3,059	Pre	45	Pool	Margin	Left	Unknown species	50+	30	Sand	2
6/12/2012	Condemned Bar	3,059	Pre	45	Pool	Margin	Left	Rainbow trout	2	40	Small gravel	2
6/12/2012	Condemned Bar	1,561	Post	30	Pool	Margin	Left	Unknown species	200+	10 - 15	Large cobble	0.5 - 2.0
6/12/2012	Condemned Bar	1,561	Post	30	Pool	Margin	Left	Unknown species	20+	30	Small gravel	0.5 - 2.0
6/13/2012	Condemned Bar	1,541	Pre	23	Low gradient riffle	Margin	Left	No fish observed	0	--	--	--
6/13/2012	Condemned Bar	1,541	Pre	20	Pool	Margin	Left	Unknown species	100+	10 - 15	Large cobble	0.5 - 2.0
6/13/2012	Condemned Bar	1,541	Pre	20	Pool	Margin	Left	Unknown species	20+	30	Small gravel	0.5 - 2.0
6/13/2012	Condemned Bar	1,541	Pre	20	Pool	Margin	Left	Rainbow trout	1	40	Small gravel	2
6/13/2012	Condemned Bar	541	Post	25	Pool	Margin	Left	Unknown species	100+	10 - 15	Large cobble	0.5 - 1.0
6/13/2012	Condemned Bar	541	Post	25	Pool	Margin	Left	Unknown species	20	30	Small cobble	0.5 - 1.0
6/13/2012	Condemned Bar	541	Post	25	Pool	Margin	Left	Rainbow trout	1	40	Small cobble	1.0 - 2.0
6/13/2012	Condemned Bar	541	Post	25	Pool	Margin	Left	Rainbow trout	1	70	Small cobble	1.0 - 2.0
6/13/2012	Condemned Bar	541	Post	25	Pool	Margin	Left	Rainbow trout	1	100	Small cobble	1.0 - 2.0

Key:
1 River flow is equal to release from New Colgate Power House plus base flow.
2 Indicates if the observation was performed before (pre-ramp down) or after (post-ramp down) water level change.
3 Average number of minutes spent searching for fish in a given location.
4 Specifies ascending river bank where observation occurred.
5 Dominant substrate present where the observation occurred.
6 Preliminary survey conducted on June 11 was not related to a ramping event and therefore is not considered pre- or post-ramp down.

Table 2. July Condemned Bar pre- and post-ramp down snorkel and walk observations.

Date	Location	River Flow (cfs)[1]	Pre- or Post-Ramp Down[2]	Average or Estimated Observation Time[3] (min)	River Habitat Type	Habitat Location in Channel	River Bank[4]	Species Observed	Species Count	Species Size/Range (mm)	Dominant Substrate[5]	Water Depth (ft)
7/27/2012	Condemned Bar	3,261	Pre	40	Pool	Margin	Left	Unknown species	30	20	Boulder	0.5 - 1
7/27/2012	Condemned Bar	3,261	Pre	40	Run	Mid-channel	Left	Rainbow trout	9	252 - 336	Boulder	0.75
7/27/2012	Condemned Bar	1,599	Post	~40	Pool	Margin	Left	Unknown species	1	10 -20	Boulder	0.5 - 1
7/27/2012	Condemned Bar	1,599	Post	~40	Run	Mid-channel	Left	Rainbow trout	14	252 - 336	Boulder	5 - 10
7/28/2012	Condemned Bar	1,609	Pre	25	Run	Mid-channel	Left	No fish observed	0	--	--	--
7/28/2012	Condemned Bar	1,609	Pre	~40	Pool	Margin	Left	Unknown species	2	20	Boulder	0.5
7/28/2012	Condemned Bar	1,609	Pre	~40	Run	Mid-channel	Left	Rainbow trout	12	170 - 310	Boulder	5 - 10
7/28/2012	Condemned Bar	176	Post	~20	Pool	Margin	Left	No fish observed	0	--	--	--
7/28/2012	Condemned Bar	176	Post	~40	Pool	Margin	Left	Unknown species	20	10 - 20	Sand	0.5 - 1.0
7/28/2012	Condemned Bar	176	Post	~40	Run	Mid-channel	Left	Rainbow trout	18	170 - 310	Boulder	3 - 10

Key:
1 River flow is equal to release from New Colgate Power House plus base flow.
2 Indicates if the observation was performed before (pre-ramp down) or after (post-ramp down) water level change.
3 Average number of minutes spent searching for fish in a given location. A '~' before a value indicates the observation time was estimated based on previous observation times for this location.
4 Specifies ascending river bank where observation occurred.
5 Dominant substrate present where the observation occurred.

Table 3. August Condemned Bar pre- and post-ramp down snorkel and walk observations.

Date	Location	River Flow (cfs)[1]	Pre- or Post-Ramp Down[2]	Average or Estimated Observation Time[3] (min)	River Habitat Type	Habitat Location in Channel	River Bank[4]	Species Observed	Species Count	Species Size/Range (mm)	Dominant Substrate[5]	Water Depth (ft)
8/25/2012	Condemned Bar	3,109	Pre	15	Run	Mid-channel	Left	Rainbow trout	8	170 - 310	Boulder	5 - 10
8/25/2012	Condemned Bar	1,502	Post	~15	Run	Mid-channel	Left	Rainbow trout	12	170 - 310	Boulder	5 - 10
8/30/2012	Condemned Bar	1,509	Pre	15	Pool	Margin	Left	No fish observed	0	--	--	--
8/30/2012	Condemned Bar	1,509	Pre	15	Run	Mid-channel	Left	Rainbow trout	8	170 - 310	Boulder	5 - 10
8/30/2012	Condemned Bar	130	Post	13	Pool	Margin	Left	No fish observed	0	--	--	--
8/30/2012	Condemned Bar	130	Post	20	Run	Mid-channel	Left	Rainbow trout	10	170 - 310	Boulder	5
8/30/2012	Condemned Bar	130	Post	20	Run	Mid-channel	Left	Rainbow trout	2	430 - 505	Boulder	5

Key:
[1] River flow is equal to release from New Colgate Power House plus base flow.
[2] Indicates if the observation was performed before (pre-ramp down) or after (post-ramp down) water level change.
[3] Average number of minutes spent searching for fish in a given location. A '~' before a value indicates the observation time was estimated based on previous observation times for this location.
[4] Specifies ascending river bank where observation occurred.
[5] Dominant substrate present where the observation occurred.

Page Left Blank

Snorkel and Walk Observations

French Bar

Page Left Blank

Table 4. June French Bar pre- and post-ramp down snorkel and walk observations.

Date	Location	River Flow (cfs)[1]	Pre- or Post-Ramp Down[2]	Average Observation Time[3] (min)	River Habitat Type	Habitat Location in Channel	River Bank[4]	Species Observed	Species Count	Species Size/Range (mm)	Dominant Substrate[5]	Water Depth (ft)
6/11/2012	French Bar	622	--[6]	78	Backwater pool	Margin	Right	Unidentified salmonid	1	10 - 15	Small cobble	2
6/11/2012	French Bar	622	--[6]	78	Backwater pool	Margin	Right	Unknown species	6	10 - 15	Small cobble	1.6
6/11/2012	French Bar	622	--[6]	78	Backwater pool	Margin	Right	Unknown species	~250	12 - 18	Small cobble	0.6 - 1.5
6/12/2012	French Bar	3,059	Pre	45	Backwater pool	Margin	Right	Unknown species	50 - 100	10 - 15	Sand	0.5
6/12/2012	French Bar	3,059	Pre	45	Backwater pool	Margin	Right	Unknown species	4	10	Small cobble	3
6/12/2012	French Bar	3,059	Pre	45	Backwater pool	Margin	Right	Unknown species	20	10	Small cobble	0.5
6/12/2012	French Bar	1,561	Post	55	Backwater pool	Margin	Right	Unknown species	30 - 40	8 - 10	Sand	0.6 - 1.5
6/12/2012	French Bar	1,561	Post	55	Backwater pool	Margin	Right	Unknown species	75 - 100	10 - 15	Very small cobble	0.5 - 1.0
6/12/2012	French Bar	1,561	Post	55	Backwater pool	Margin	Right	Unknown species	4	10	Sand	0.5
6/12/2012	French Bar	1,561	Post	55	Backwater pool	Margin	Right	Unknown species	7	15	Small cobble	0.8
6/12/2012	French Bar	1,561	Post	55	Backwater pool	Margin	Right	Unknown species	1	10	Sand	0.2
6/13/2012	French Bar	1,541	Pre	45	Backwater pool	Margin	Right	Unknown species	50 - 100	10 - 15	Sand	0.5
6/13/2012	French Bar	1,541	Pre	45	Backwater pool	Margin	Right	Unknown species	4	10 - 15	Very small cobble	3
6/13/2012	French Bar	1,541	Pre	45	Run	Margin	Right	Unknown species	20	10 - 15	Very small cobble	0.5
6/13/2012	French Bar	541	Post	40	Backwater pool	Margin	Right	Unknown species	6	15 - 20	Sand	0.5
6/13/2012	French Bar	541	Post	40	Backwater pool	Margin	Right	Unknown species	10 - 15	10 - 15	Very small cobble	1
6/13/2012	French Bar	541	Post	40	Backwater pool	Margin	Right	Unknown species	4	10 - 15	Sand	1
6/13/2012	French Bar	541	Post	40	Run	Margin	Right	Unknown species	7	10 - 15	Sand	3
6/13/2012	French Bar	541	Post	40	Run	Margin	Right	Unknown species	1	25	Small cobble	1.5

Table 5. (continued)

Date	Location	River Flow (cfs)[1]	Pre- or Post-Ramp Down[2]	Average Observation Time[3] (min)	River Habitat Type	Habitat Location in Channel	River Bank[4]	Species Observed	Species Count	Species Size/Range (mm)	Dominant Substrate[5]	Water Depth (ft)
6/13/2012	French Bar	541	Post	30	Backwater pool	Margin	Right	Unknown species	5	8 - 10	Sand	0.3
6/13/2012	French Bar	541	Post	30	Side channel	Margin	Left	Unknown species	1	10	Medium gravel	1.5

Key:
[1] River flow is equal to release from New Colgate Power House plus base flow.
[2] Indicates if the observation was performed before (pre-ramp down) or after (post-ramp down) water level change.
[3] Average number of minutes spent searching for fish in a given location.
[4] Specifies ascending river bank where observation occurred.
[5] Dominant substrate present where the observation occurred.
[6] Preliminary survey conducted on June 11 was not related to a ramping event and therefore is not considered pre- or post-ramp down.

Table 6. July French Bar pre- and post-ramp down snorkel and walk observations.

Date	Location	River Flow (cfs)[1]	Pre- or Post-Ramp Down[2]	Average Observation Time[3] (min)	River Habitat Type	Habitat Location in Channel	River Bank[4]	Species Observed	Species Count	Species Size/Range (mm)	Dominant Substrate[5]	Water Depth (ft)
7/27/2012	French Bar	3,261	Pre	36	Backwater pool	Margin	Right	Unknown species	30	12 - 18	Sand	0.3
7/27/2012	French Bar	3,261	Pre	36	Backwater pool	Margin	Right	Unknown species	1	14	Sand	0.8
7/27/2012	French Bar	1,599	Post	92	Backwater pool	Margin	Right	Unknown species	4	15 - 18	Sand	0.5
7/27/2012	French Bar	1,599	Post	92	Backwater pool	Margin	Right	Unknown species	12	10 - 20	Sand	0.5
7/27/2012	French Bar	1,599	Post	92	Backwater pool	Margin	Right	Unknown species	2	10 - 20	Sand	1
7/27/2012	French Bar	1,599	Post	92	Backwater pool	Margin	Right	Unknown species	5	10 - 20	Sand	0.8
7/27/2012	French Bar	1,599	Post	92	Backwater pool	Margin	Right	Unknown species	2	10 - 20	Very small cobble	0.3
7/28/2012	French Bar	1,609	Pre	70	Backwater pool	Margin	Right	Unknown species	2	10 - 15	Sand	0.3
7/28/2012	French Bar	1,609	Pre	70	Backwater pool	Margin	Right	Unknown species	2	10 - 15	Small cobble	0.5
7/28/2012	French Bar	1,609	Pre	70	Backwater pool	Margin	Right	Unknown species	1	20	Small cobble	1
7/28/2012	French Bar	1,609	Pre	70	Backwater pool	Margin	Right	Unknown species	1	10	Small cobble	1

Table 7. (continued)

Date	Location	River Flow (cfs)[1]	Pre- or Post-Ramp Down[2]	Average or Estimated Observation Time[3] (min)	River Habitat Type	Habitat Location in Channel	River Bank[4]	Species Observed	Species Count	Species Size/Range (mm)	Dominant Substrate[5]	Water Depth (ft)
7/28/2012	French Bar	1,609	Pre	70	Backwater pool	Margin	Right	Unknown species	5	10 - 15	Small cobble	2.5
7/28/2012	French Bar	176	Post	59	Run	Margin	Right	No fish observed	0	--	--	--
7/28/2012	French Bar	176	Post	49	Backwater pool	Margin	Right	Unknown species	30	15 - 22	Small cobble	0.8
7/28/2012	French Bar	176	Post	49	Backwater pool	Margin	Right	Unknown species	5	20 - 22	Small cobble	1
7/28/2012	French Bar	176	Post	49	Backwater pool	Margin	Right	Unknown species	2	18	Small cobble	0.5
7/28/2012	French Bar	176	Post	49	Low gradient riffle	Margin	Right	Unidentified sculpin	1	70	Small cobble	1
7/28/2012	French Bar	176	Post	49	Low gradient riffle	Margin	Right	Unidentified sculpin	1	40	Small cobble	0.8
7/28/2012	French Bar	176	Post	10	Side Channel	Margin	Left	No fish observed	0	--	--	--

Key:
[1] River flow is equal to release from New Colgate Power House plus base flow.
[2] Indicates if the observation was performed before (pre-ramp down) or after (post-ramp down) water level change.
[3] Average number of minutes spent searching for fish in a given location.
[4] Specifies ascending river bank where observation occurred.
[5] Dominant substrate present where the observation occurred.

Table 8. August French Bar pre- and post-ramp down snorkel and walk observations.

Date	Location	River Flow (cfs)[1]	Pre- or Post-Ramp Down[2]	Average Observation Time[3] (min)	River Habitat Type	Habitat Location in Channel	River Bank[4]	Species Observed	Species Count	Species Size/Range (mm)	Dominant Substrate[5]	Water Depth (ft)
8/25/2012	French Bar	3,109	Pre	55	Run	Margin	Right	No fish observed	0	--	--	--
8/25/2012	French Bar	1,502	Post	49	Low gradient riffle	Margin	Right	Green sunfish	1	150	Very small cobble	1
8/25/2012	French Bar	1,502	Post	49	Low gradient riffle	Margin	Right	Green sunfish	1	175	Very small cobble	1.5

Table 9. (continued)

Date	Location	River Flow (cfs)[1]	Pre- or Post-Ramp Down[2]	Average Observation Time[3] (min)	River Habitat Type	Habitat Location in Channel	River Bank[4]	Species Observed	Species Count	Species Size/Range (mm)	Dominant Substrate[5]	Water Depth (ft)
8/25/2012	French Bar	1,502	Post	49	Low gradient riffle	Margin	Right	Green sunfish	1	140	Very small cobble	1
8/25/2012	French Bar	1,502	Post	49	Backwater pool	Margin	Right	Unknown species	1	10	Sand	0.4
8/30/2012	French Bar	1,509	Pre	46	Backwater pool	Margin	Right	No fish observed	0	--	--	--
8/30/2012	French Bar	1,509	Pre	46	Low gradient riffle	Margin	Right	No fish observed	0	--	--	--
8/30/2012	French Bar	130	Post	50	Backwater pool	Margin	Right	No fish observed	0	--	--	--
8/30/2012	French Bar	130	Post	50	Low gradient riffle	Margin	Left	No fish observed	0	--	--	--
8/30/2012	French Bar	130	Post	50	Low gradient riffle	Margin	Left	No fish observed	0	--	--	--

Key:
[1] River flow is equal to release from New Colgate Power House plus base flow.
[2] Indicates if the observation was performed before (pre-ramp down) or after (post-ramp down) water level change.
[3] Average number of minutes spent searching for fish in a given location.
[4] Specifies ascending river bank where observation occurred.
[5] Dominant substrate present where the observation occurred.

Technical Memorandum 3-12

New Colgate Powerhouse Ramping

Attachment 3-12B

Stranding Survey Results

Yuba River Development Project

FERC Project No. 2246

December 2012

List of Tables

Table No. **Description** **Page No.**

Page Left Blank

Stranding Survey Results

Condemned Bar

Page Left Blank

Table 1. June Condemned Bar Stranding Survey Results.

Date	Location	River Flow Change (cfs)	Walking Observation Pass #	Average Observation Time[1] (min)	Observation Habitat Location[2]	Species Observed	Count	Size/Range (mm)	Stranding Location UTM Coordinates	Map Zone[3]	Distance to Main Channel[4] (ft)	Dominant Substrate[5]	Residual Water Depth (ft)
6/12/2012	Condemned Bar	3,059→1,561	1	20	Margin	No fish observed	0	--	--	--	--	--	--
6/12/2012	Condemned Bar	3,059→1,561	2	25	Margin	No fish observed	0	--	--	--	--	--	--
6/12/2012	Condemned Bar	3,059→1,561	3	25	Margin	No fish observed	0	--	--	--	--	--	--
6/12/2012	Condemned Bar	3,059→1,561	4	15	Margin	No fish observed	0	--	--	--	--	--	--
6/12/2012	Condemned Bar	3,059→1,561	5	15	Margin	No fish observed	0	--	--	--	--	--	--
6/13/2012	Condemned Bar	1,541→541	1	18	Margin	No fish observed	0	--	--	--	--	--	--
6/13/2012	Condemned Bar	1,541→541	2	11	Margin	No fish observed	0	--	--	--	--	--	--
6/13/2012	Condemned Bar	1,541→541	3	15	Margin	No fish observed	0	--	--	--	--	--	--
6/13/2012	Condemned Bar	1,541→541	4	11	Bar	No fish observed	0	--	--	--	--	--	--
6/13/2012	Condemned Bar	1,541→541	6	18	Pool	Unknown species	2	10 - 15	--	A	2	Sand	0.0 (dry)
6/13/2012	Condemned Bar	1,541→541	7	28	Pool	Unknown species	4	10 - 15	--	A	3	Large cobble	0.2
6/13/2012	Condemned Bar	1,541→541	7	28	Margin	Rainbow trout	1	40	--	A	5	Medium cobble	0.0 (dry)

Key:
[1] Average number of minutes spent searching for stranded fish in a given location.
[2] Specifies the part of the river channel in which the observation occurred.
[3] Refers to the stranding zone mapped in Figure 2.2-1 where the observation occurred.
[4] Indicates how far away from the main channel the observation occurred.
[5] Dominant substrate present where observation occurred.

Table 2. July Condemned Bar Stranding Survey Results.

Date	Location	River Flow Change (cfs)	Walking Observation Pass #	Average Observation Time[1] (min)	Observation Habitat Location[2]	Species Observed	Count	Size/Range (mm)	Stranding Location UTM Coordinates	Map Zone[3]	Distance to Main Channel[4] (ft)	Dominant Substrate[5]	Residual Water Depth (ft)
7/27/2012	Condemned Bar	3,261→1,599	1	20	Margin	Unknown species	1	20	4354879/ 655458	A	2	Sand	0.0 (dry)
7/27/2012	Condemned Bar	3,261→1,599	2	~25	Margin	No fish observed	0	--	--	--	--	--	--

Table 3. (continued)

Date	Location	River Flow Change (cfs)	Walking Observation Pass #	Average Observation Time[1] (min)	Observation Habitat Location[2]	Species Observed	Count	Size/Range (mm)	Stranding Location UTM Coordinates	Map Zone[3]	Distance to Main Channel[4] (ft)	Dominant Substrate[5]	Residual Water Depth (ft)
7/28/2012	Condemned Bar	1,609→176	1	~25	Margin	No fish observed	0	--	--	--	--	--	--
7/28/2012	Condemned Bar	1,609→176	2	15	Margin	No fish observed	0	--	--	--	--	--	--
7/28/2012	Condemned Bar	1,609→176	3	25	Margin	No fish observed	0	--	--	--	--	--	--

Key:
1 Average number of minutes spent searching for stranded fish in a given location.
2 Specifies the part of the river channel in which the observation occurred.
3 Refers to the stranding zone mapped in Figure 2.2-1 where the observation occurred.
4 Indicates how far away from the main channel the observation occurred.
5 Dominant substrate present where observation occurred.

Table 4. August Condemned Bar Stranding Survey Results.

Date	Location	River Flow Change (cfs)	Walking Observation Pass #	Average Observation Time[1] (min)	Observation Habitat Location[2]	Species Observed	Count	Size/Range (mm)	Stranding Location UTM Coordinates	Map Zone[3]	Distance to Main Channel[4] (ft)	Dominant Substrate[5]	Residual Water Depth (ft)
8/25/2012	Condemned Bar	3,109→1,502	1	18	Margin	No fish observed	0	--	--	--	--	--	--
8/25/2012	Condemned Bar	3,109→1,502	2	15	Margin	No fish observed	0	--	--	--	--	--	--
8/30/2012	Condemned Bar	1,509→130	1	10	Margin	No fish observed	0	--	--	--	--	--	--
8/30/2012	Condemned Bar	1,509→130	2	9	Margin	No fish observed	0	--	--	--	--	--	--
8/30/2012	Condemned Bar	1,509→130	3	12	Margin	No fish observed	0	--	--	--	--	--	--
8/30/2012	Condemned Bar	1,509→130	4	~10	Margin	No fish observed	0	--	--	--	--	--	--
8/30/2012	Condemned Bar	1,509→130	5	30	Margin	No fish observed	0	--	--	--	--	--	--
8/30/2012	Condemned Bar	1,509→130	6	10	Margin	Unknown species	1	15	4354883/ 655453	A	5	Medium cobble	0.2

Key:
1 Average number of minutes spent searching for stranded fish in a given location.
2 Specifies the part of the river channel in which the observation occurred.
3 Refers to the stranding zone mapped in Figure 2.2-1 where the observation occurred.
4 Indicates how far away from the main channel the observation occurred.
5 Dominant substrate present where observation occurred.

Stranding Survey Results

French Bar

Page Left Blank

Table 5. June French Bar Stranding Survey Results.

Date	Location	River Flow Change (cfs)	Walking Observation Pass #	Average Observation Time[1] (min)	Observation Habitat Location[2]	Species Observed	Count	Size/Range (mm)	Stranding Location UTM Coordinates	Map Zone[3]	Distance to Main Channel[4] (ft)	Dominant Substrate[5]	Residual Water Depth (ft)
6/12/2012	French Bar	3,059→1,561	1	10	Backwater Margin	No fish observed	0	--	--	--	--	--	--
6/12/2012	French Bar	3,059→1,561	2	9	Backwater pool	No fish observed	0	--	--	--	--	--	--
6/13/2012	French Bar	1,541→541	1	10	Backwater Margin	No fish observed	0	--	--	--	--	--	--
6/13/2012	French Bar	1,541→541	2	12	Backwater Margin	No fish observed	0	--	--	--	--	--	--
6/13/2012	French Bar	1,541→541	3	15	Backwater Margin	No fish observed	0	--	--	--	--	--	--
6/13/2012	French Bar	1,541→541	4	11	Backwater Margin	No fish observed	0	--	--	--	--	--	--
6/13/2012	French Bar	1,541→541	5	10	Backwater pool	Unknown species	6	10 - 12	4353574/ 654754	C	7 - 10	Sand	0.3

Key:
1 Average number of minutes spent searching for stranded fish in a given location.
2 Specifies the part of the river channel in which the observation occurred.
3 Refers to the stranding zone mapped in Figure 2.2-1 where the observation occurred.
4 Indicates how far away from the main channel the observation occurred.
5 Dominant substrate present where observation occurred.

Table 6. July French Bar Stranding Survey Results.

Date	Location	River Flow Change (cfs)	Walking Observation Pass #	Average Observation Time[1] (min)	Observation Habitat Location[2]	Species Observed	Count	Size/Range (mm)	Stranding Location UTM Coordinates	Map Zone[3]	Distance to Main Channel[4] (ft)	Dominant Substrate[5]	Residual Water Depth (ft)
7/27/2012	French Bar	3,261→1599	1	~10	Backwater pool	No fish observed	0	--	--	--	--	--	--
7/27/2012	French Bar	3,261→1599	2	~15	Backwater pool	No fish observed	0	--	--	--	--	--	--
7/27/2012	French Bar	3,261→1599	3	~10	Margin	No fish observed	0	--	--	--	--	--	--
7/28/2012	French Bar	1,609→176	1	~15	Backwater pool	No fish observed	0	--	--	--	--	--	--
7/28/2012	French Bar	1,609→176	2	~15	Backwater pool	No fish observed	0	--	--	--	--	--	--
7/28/2012	French Bar	1,609→176	3	~15	Backwater pool	No fish observed	0	--	--	--	--	--	--

Table 7. (continued)

Date	Location	River Flow Change (cfs)	Walking Observation Pass #	Average Observation Time[1] (min)	Observation Habitat Location[2]	Species Observed	Count	Size/Range (mm)	Stranding Location UTM Coordinates	Map Zone[3]	Distance to Main Channel[4] (ft)	Dominant Substrate[5]	Residual Water Depth (ft)
7/28/2012	French Bar	1,609→176	4	~15	Margin	No fish observed	0	--	--	--	--	--	--

Key:
[1] Average number of minutes spent searching for stranded fish in a given location.
[2] Specifies the part of the river channel in which the observation occurred.
[3] Refers to the stranding zone mapped in Figure 2.2-1 where the observation occurred.
[4] Indicates how far away from the main channel the observation occurred.
[5] Dominant substrate present where observation occurred.

Table 8. August French Bar Stranding Survey Results.

Date	Location	River Flow Change (cfs)	Walking Observation Pass #	Average Observation Time[1] (min)	Observation Habitat Location[2]	Species Observed	Count	Size/Range (mm)	Stranding Location UTM Coordinates	Map Zone[3]	Distance to Main Channel[4] (ft)	Dominant Substrate[5]	Residual Water Depth (ft)
8/25/2012	French Bar	3,109→1,502	1	6	Backwater pool	No fish observed	0	--	--	--	--	--	--
8/25/2012	French Bar	3,109→1,502	2	11	Backwater pool	No fish observed	0	--	--	--	--	--	--
8/25/2012	French Bar	3,109→1,502	3	11	Backwater pool	No fish observed	0	--	--	--	--	--	--
8/25/2012	French Bar	3,109→1,502	4	15	Backwater pool	No fish observed	0	--	--	--	--	--	--
8/25/2012	French Bar	3,109→1,502	5	12	Backwater pool	No fish observed	0	--	--	--	--	--	--
8/25/2012	French Bar	3,109→1,502	6	~15	Backwater pool	No fish observed	0	--	--	--	--	--	--
8/30/2012	French Bar	1,509→130	1	5	Backwater pool	No fish observed	0	--	--	--	--	--	--
8/30/2012	French Bar	1,509→130	2	19	Backwater pool	No fish observed	0	--	--	--	--	--	--
8/30/2012	French Bar	1,509→130	3	5	Backwater pool	Unknown species	1	10	4353638/ 654767	C	8	Sand	1.0
8/30/2012	French Bar	1,509→130	4	17	Backwater pool	No fish observed	0	--	--	--	--	--	--

Key:
[1] Average number of minutes spent searching for stranded fish in a given location.
[2] Specifies the part of the river channel in which the observation occurred.
[3] Refers to the stranding zone mapped in Figure 2.2-1 where the observation occurred.
[4] Indicates how far away from the main channel the observation occurred.
[5] Dominant substrate present where observation occurred.

Technical Memorandum 3-12

New Colgate Powerhouse Ramping

Attachment 3-12C

Stranding Survey Photos

Yuba River Development Project

FERC Project No. 2246

December 2012

Table of Contents

Section No.	Description	Page No.

List of Figures

Figure No.	Description	Page No.

List of Figures (continued)

Figure No. **Description** **Page No.**

List of Figures (continued)

List of Figures (continued)

List of Figures (continued)

Figure No. **Description** **Page No.**

List of Figures (continued)

List of Figures (continued)

List of Figures (continued)

Figure No. Description Page No.

List of Figures (continued)

Figure No. Description Page No.

Page Left Blank

1.0 Introduction

Following are photos taken over the course of the New Colgate Power House Ramping and Stranding Study. Some of the photos were taken to show stranded fish and to illustrate what types of habitats are more prone to stranding. Many other photos were shot to show how the habitats present at each ramping transect change with varying water levels. Some of the photos have one or more colored flags present. As is explained in each photo caption, these flags show where the water level was at a higher flow than the flow seen in the photo. There are also a few photos taken looking upstream and downstream from the top or bottom of each study site at different flows. These photos are included to provide a more general look at how the river's conditions change with differing flows.

Page Left Blank

2.0 June

Page Left Blank

Figure 1. Transect R1 – Right bank tail pin looking toward left bank at 3,059 cfs.

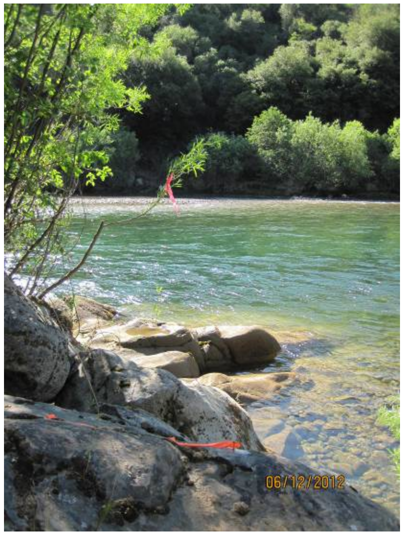

Figure 2. Transect R1 – Right bank tail pin looking toward left bank at 1,561 cfs.

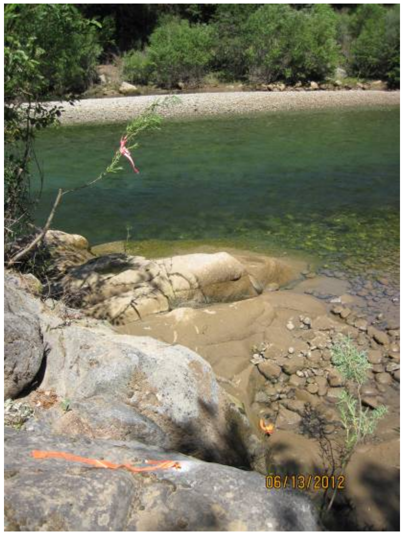

Figure 3. Transect R1 – Right bank tail pin looking toward left bank at 541 cfs.

Figure 4. Transect R1 – Right bank water's edge looking toward right bank tail pin at 3,059 cfs.

Figure 5. Transect R1 – Right bank water's edge looking toward right bank tail pin at 1,561 cfs.

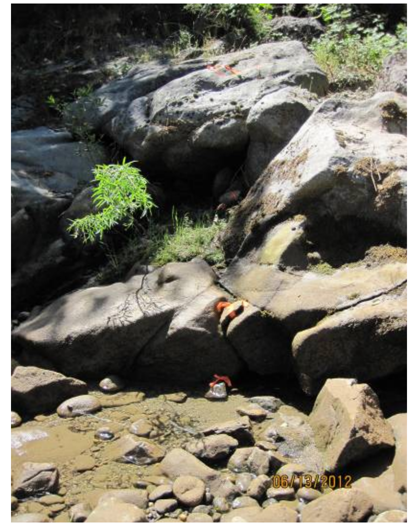

Figure 6. Transect R1 – Right bank water's edge looking toward right bank tail pin at 541 cfs.

Figure 7. Transect R1 – Location and site characteristics of stranding observation of multiple individuals (unidentified sp.), Stranding Zone C at 541 cfs.

Figure 8. Transect R1 – Right bank looking downstream to transect showing stranded fish locations (orange flags) in backwater habitat (Stranding Zone C) at 541 cfs.

Figure 9. Transect R1 – Close up stranding observation of an unidentified sp., Stranding Zone C. Red circle indicates location of larval fish.

Figure 10. Transect R1 – Looking downstream at mid-channel point bar at 1,541 cfs.

Figure 11. Transect R1 – Looking downstream at mid-channel point bar at 541 cfs.

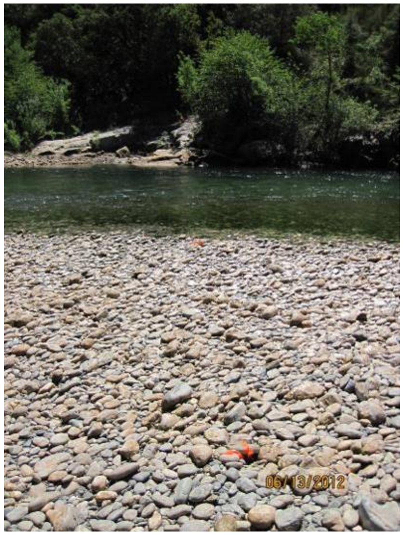

Figure 12. Transect R1 -- On middle of point bar looking toward right bank with flags showing water levels at 1,541 cfs & 541 cfs (currently).

Figure 13. Transect R1 -- On middle of point bar looking toward left bank with flags showing water levels at 1,541 cfs & 541 cfs (currently).

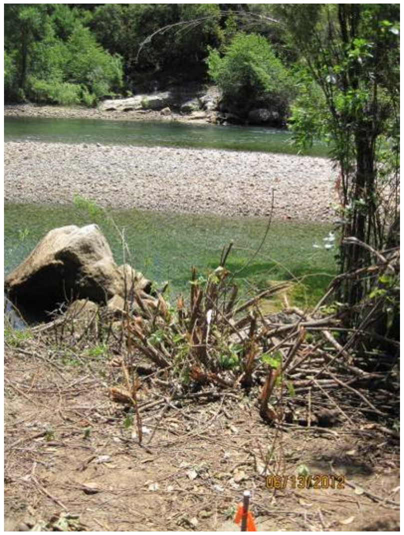

Figure 14. Transect R1 – Left bank head pin looking toward right bank showing exposed point bar at 541 cfs.

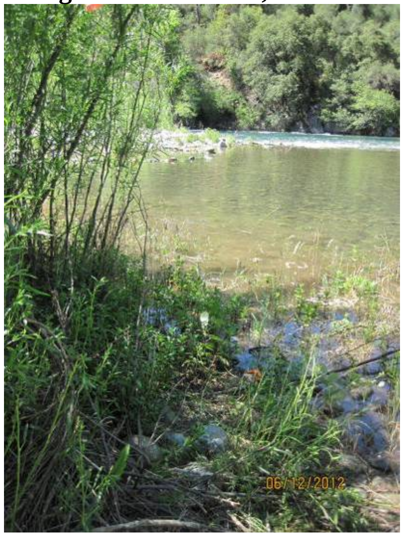

Figure 15. Transect R2 – Right bank water's edge looking to left bank at 3,059 cfs.

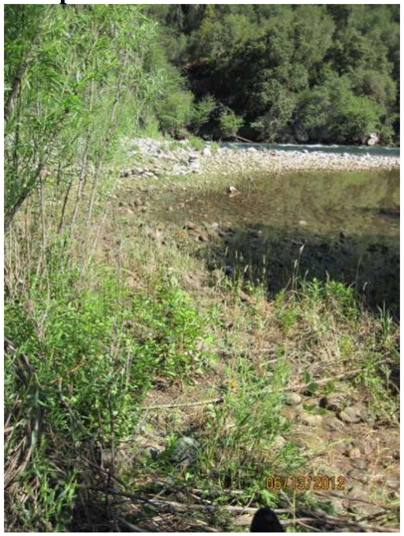

Figure 16. Transect R2 – Right bank looking to left bank at 1,541 cfs.

Figure 17. Transect R2 – Right bank looking to left bank at 541 cfs.

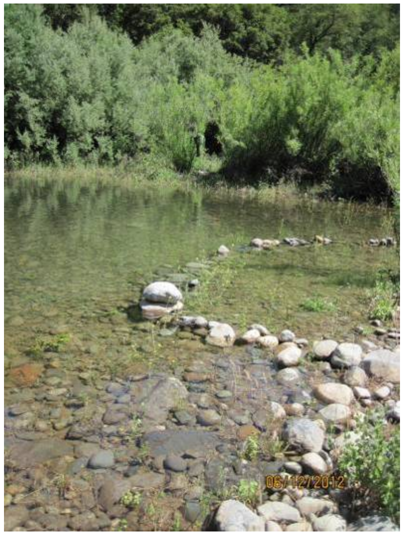

Figure 18. Transect R2 – From mid-channel looking across backwater pool habitat toward right bank at 3,059 cfs.

Figure 19. Transect R2 – From mid-channel looking across backwater pool habitat toward right bank at 1,561 cfs.

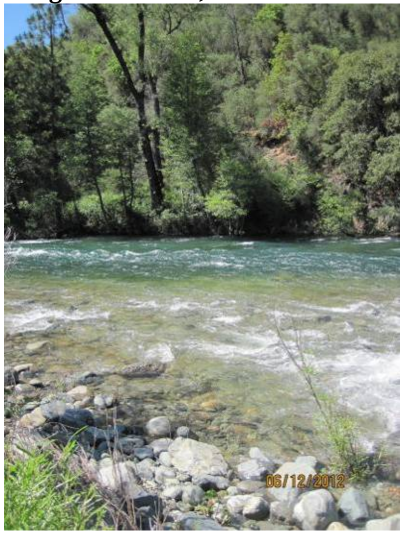

Figure 20. Transect R2 – From mid-channel bar looking across main channel toward left bank at 3,059 cfs.

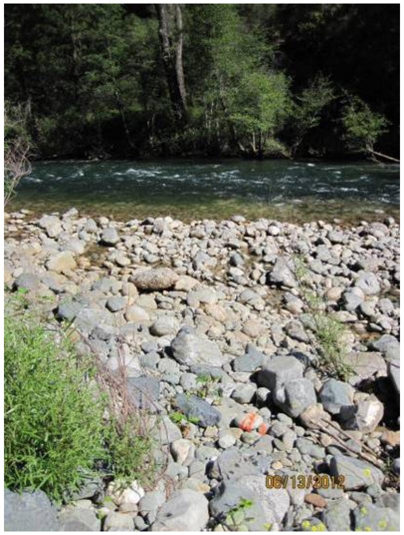

Figure 21. Transect R2 – From mid-channel bar looking across main channel toward left bank at 1,541 cfs.

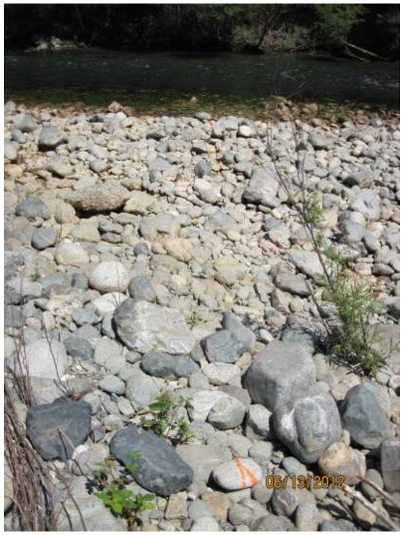

Figure 22. Transect R2 – From mid-channel bar looking across main channel toward left bank at 541 cfs.

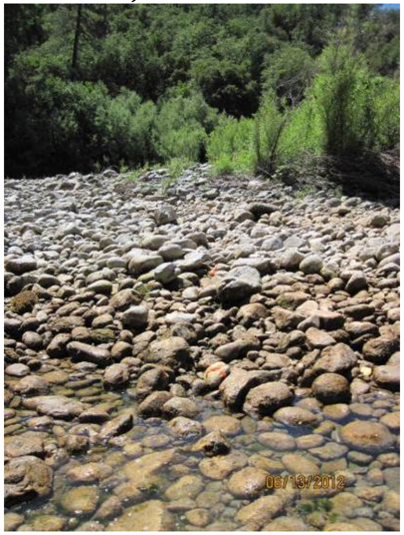

Figure 23. Transect R2 –Right bank water's edge of main channel with flags showing water levels at 541 cfs (currently) & 1,541 cfs (middle of photo) & 3,059 cfs (background).

Figure 24. Transect R3 -- Right bank looking across channel toward left bank at 3,059 cfs.

Figure 25. Transect R3 -- Right bank looking toward left bank at 1,561 cfs.

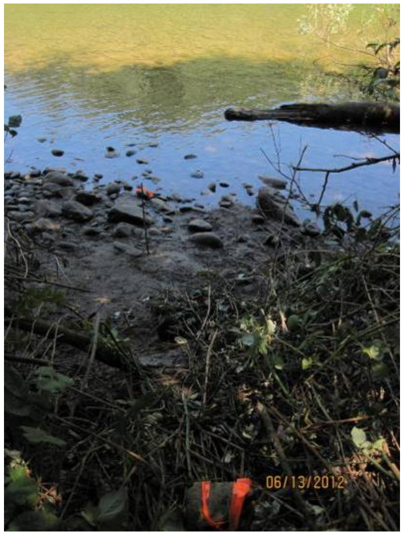

Figure 26. Transect R3 -- Right bank water's edge looking across channel toward left bank at 1,541 cfs.

Figure 27. Transect R3 -- Right bank waters edge looking toward right bank at 3,059 cfs.

Figure 28. Transect R3 -- Right bank waters edge looking toward right bank at 1,561 cfs.

Figure 29. Transect R3 -- Right bank waters edge looking toward right bank at 541 cfs.

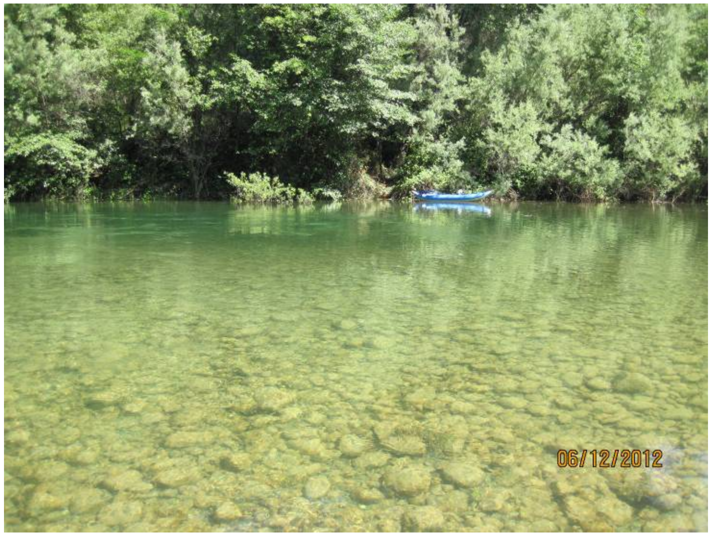

Figure 30. Transect R3 -- From mid-channel looking toward right bank at 3,059 cfs.

Figure 31. Transect R3 -- From mid-channel looking toward right bank at 1,541 cfs.

Figure 32. Transect R3 -- From mid-channel bar looking toward right bank at 541 cfs.

Figure 33. Transect R3 -- From mid-channel looking toward left bank at 3,059 cfs.

Figure 34. Transect R3 -- From mid-channel looking toward left bank at 1,541 cfs.

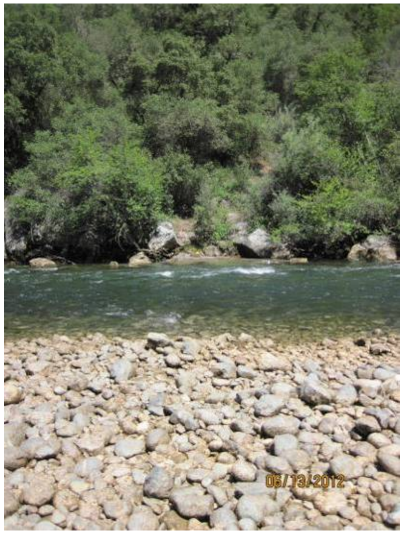

Figure 35. Transect R3 -- From mid-channel bar looking toward left bank at 541 cfs.

Figure 36. From right bank gravel bar upstream of Transect R4 looking downstream at whole channel at 1,561 cfs.

Figure 37. Transect R4 – Right bank looking upstream at whole channel at 1,561 cfs.

Figure 38. Transect R4 -- Left bank looking toward top of gravel bar above transect at 3,059 cfs.

Figure 39. Transect R4 -- Left bank looking toward top of gravel bar above transect at 1,561 cfs.

Figure 40. Transect R4 -- Left bank looking toward bottom of gravel bar (inundated) at 3,059 cfs.

Figure 41. Transect R4 -- Left bank looking toward bottom of gravel bar (inundated) at 1,561 cfs.

Figure 42. Transect R4 – Right bank looking downstream at gravel bar with flags showing water levels at 3,059 cfs & 1,561 cfs & current water level at 541 cfs.

Figure 43. Transect R4 – Right bank looking downstream at transect and possible stranding habitat at 541 cfs.

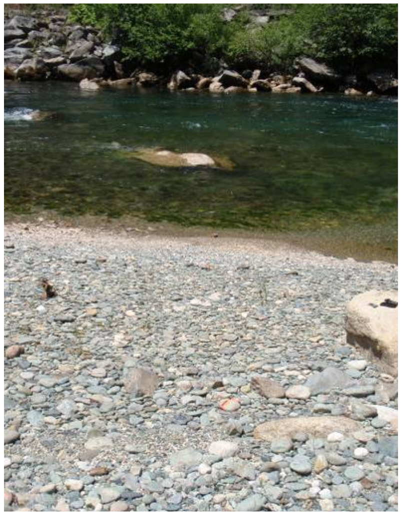

Figure 44. Gravel bar above Transect R4 – Right bank looking to left bank with flags showing water levels at 3,059 cfs & 1,561 cfs & current water level at 541 cfs.

Figure 45. Pool under boulder showing stranding location and site characteristics of stranding observation (incidental sighting of unidentified sp.), Stranding Zone B.

Figure 46. Pool under boulder showing stranding location and site characteristics of stranding observation (incidental sighting of unidentified sp.), Stranding Zone B.

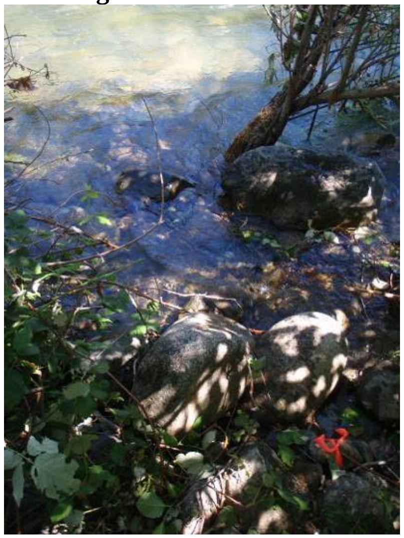

Figure 47. Transect R5 – Left bank water's edge at 3,059 cfs.

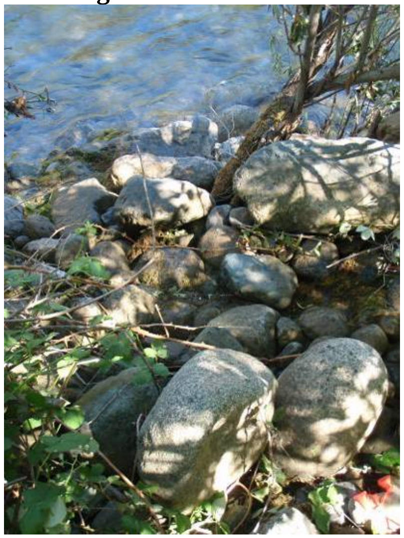

Figure 48. Transect R5 – Left bank water's edge at 1,561cfs.

Figure 49. Transect R5 – Left bank water's edge facing left bank with flags showing water levels at 1,561 cfs (currently) & at 3,059 cfs.

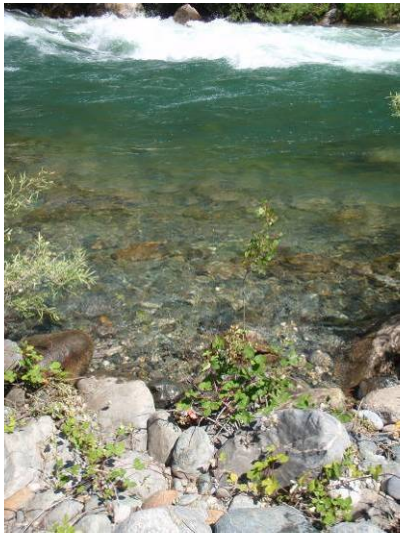

Figure 50. Transect R6 – Left bank toward right bank at 3,059 cfs.

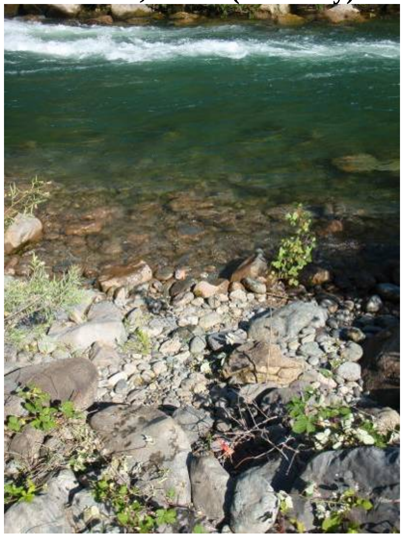

Figure 51. Transect R6 – Left bank toward right bank at 1,561 cfs.

Figure 52. Transect R6 – Left bank toward right bank with flags showing water levels at 3,059 cfs & 1,561 cfs & 541 cfs (currently).

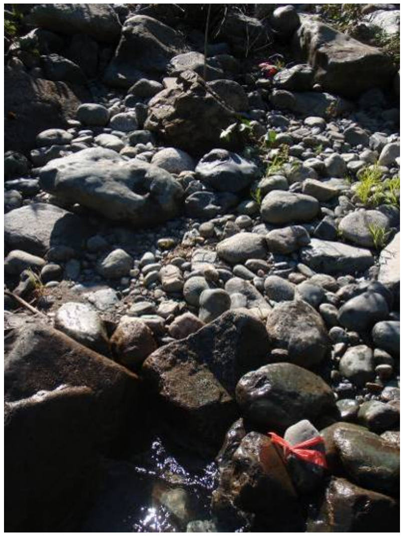

Figure 53. Transect R6 – Facing toward left bank with flags showing water levels at 1,561 cfs (currently) & 3,059 cfs.

Figure 54. Transect R6 – Left bank showing exposed substrate with water level drop from 1,561 cfs to 541 cfs (currently).

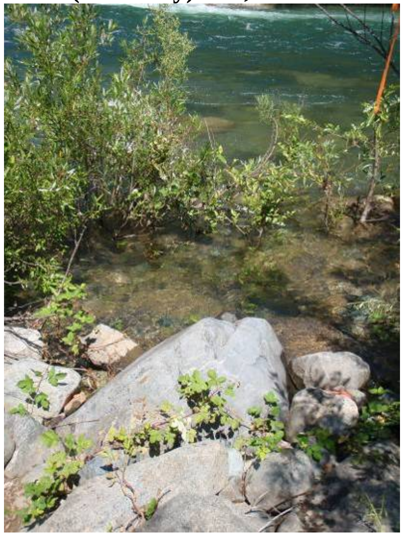

Figure 55. Transect R7 – Left bank water's edge looking toward right bank at 3,059 cfs.

Figure 56. Transect R7 – Left bank water's edge looking toward right bank at 1,561 cfs.

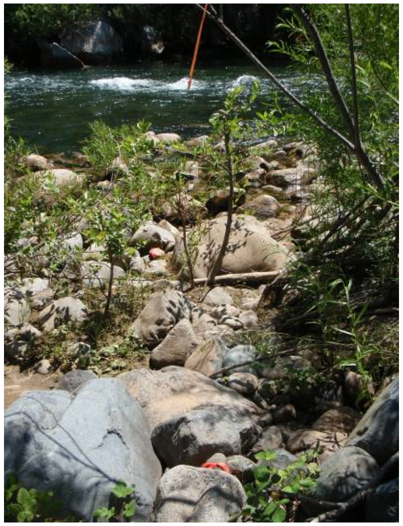

Figure 57. Transect R7 – Left bank water's edge looking toward right bank at 541 cfs.

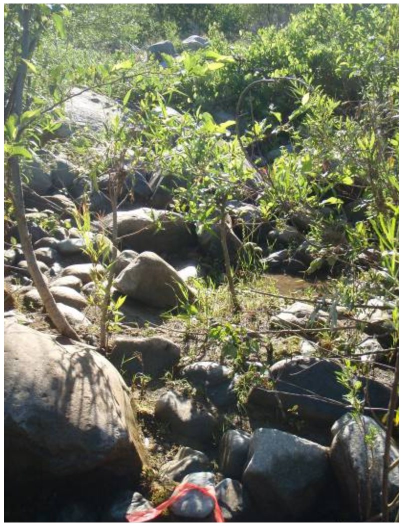

Figure 58. Transect R7 – Left bank water's edge facing toward left bank with flags showing water levels at 1,561 cfs & 541 cfs.

Figure 59. Upstream of Transect R7 – Location and site characteristics of stranding observation (unidentified sp.) near Dobbins Creek, Stranding Zone A.

Figure 60. Upstream of Transect R7 – Stranded rainbow trout observation near Dobbins Creek, Stranding Zone A.

Figure 61. Upstream of Transect R7 – Stranding observation of two unidentified fish near Dobbins Creek, Stranding Zone A. Red circles indicate locations of larval fish.

Figure 62. Upstream of Transect R7 – Stranding observation of unidentified sp. near Dobbins Creek, Stranding Zone A. Red circle indicates location of larval fish.

Figure 63. Upstream of Transect R7 – Stranding observation of one unidentified sp. on moist sand and silt near Dobbins Creek, Stranding Zone A. Red circle indicates location of larval fish.

3.0 July

Page Left Blank

Figure 64. Transect R1 – Looking downstream at whole channel at 3,261 cfs.

Figure 65. Transect R1 – Looking downstream at whole channel at 1,599 cfs.

Figure 66. Transect R1 – Looking downstream at whole channel at 176 cfs.

Figure 67. Transect R1 – Looking upstream at whole channel at 3,261 cfs.

Figure 68. Transect R1 – Looking upstream at whole channel at 1,599 cfs.

Figure 69. Looking upstream at whole channel at 176 cfs.

Figure 70. Transect R1 –Right bank looking to left bank at 3,261 cfs.

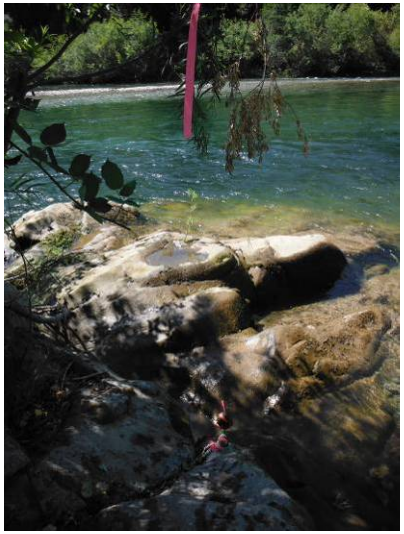

Figure 71. Transect R1 –Right bank looking to left bank at 1,599 cfs.

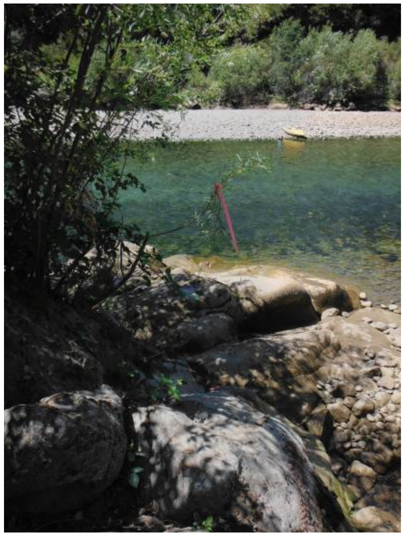

Figure 72. Transect R1 –Right bank looking to left bank at 176 cfs.

Figure 73. Transect R1 – Right bank looking upstream showing backwater stranding habitat at 3,261 cfs.

Figure 74. Transect R1 – Right bank looking upstream showing backwater stranding habitat at 1,599 cfs.

Figure 75. Transect R1 – Right bank looking upstream showing backwater stranding habitat at 176 cfs.

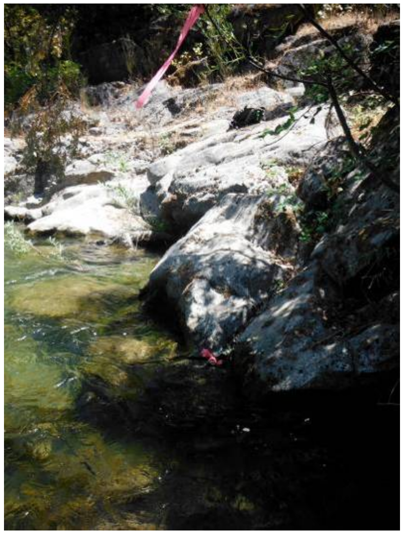

Figure 76. Transect R1 – Right bank water's edge facing toward right bank at 3,261 cfs.

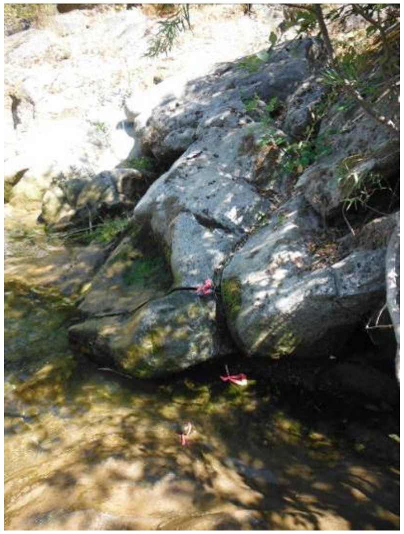

Figure 77. Transect R1 – Right bank water's edge facing toward right bank at 1,599 cfs.

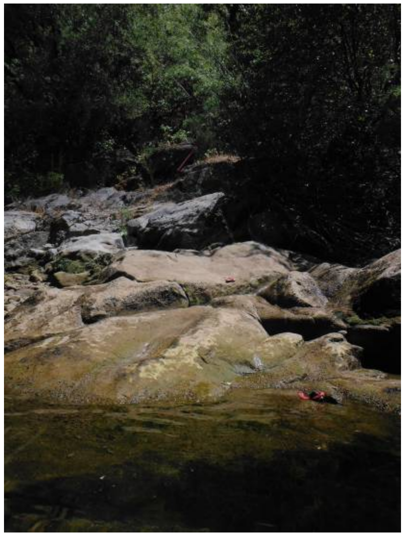

Figure 78. Transect R1 – Right bank water's edge facing toward right bank at 176 cfs.

Figure 79. Transect R1 – Left bank of main channel looking to right bank at 176 cfs.

Figure 80. Transect R1 – On exposed point bar looking toward left bank showing backwater channel at 176 cfs.

Figure 81. Transect R1 – Near left bank looking upstream at backwater channel disconnected from main channel at 176 cfs.

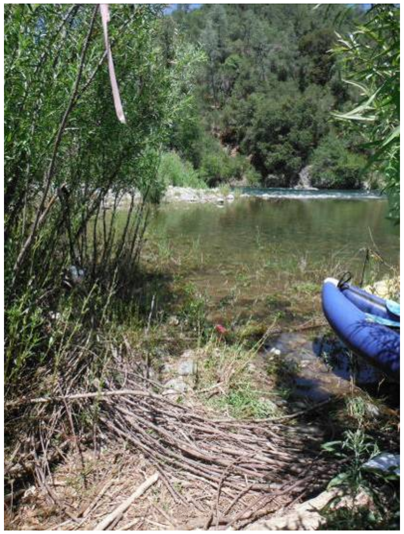

Figure 82. Transect R2 – Right bank looking across backwater pool toward left bank at 3,261 cfs.

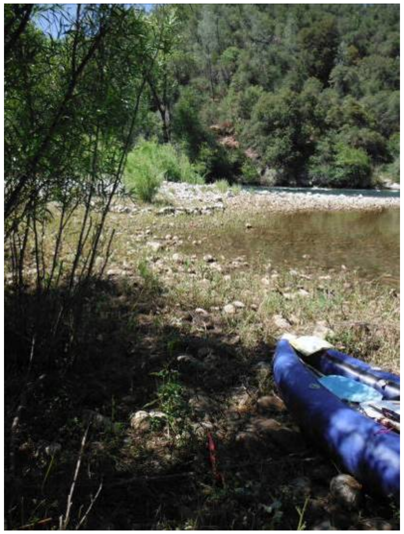

Figure 83. Transect R2 – Right bank looking across backwater pool toward left bank at 1,599 cfs.

Figure 84. Transect R2 – Right bank looking across backwater pool (which is dry on transect) at 176 cfs.

Figure 85. Transect R2 – Looking upstream at backwater pool habitat at 3,261 cfs.

Figure 86. Transect R2 – Looking upstream at backwater pool habitat at 1,599 cfs.

Figure 87. Transect R2 – Looking upstream at backwater pool habitat at 176 cfs.

Figure 88. Transect R2 – On mid-channel bar looking across backwater pool toward right bank at 3,261 cfs.

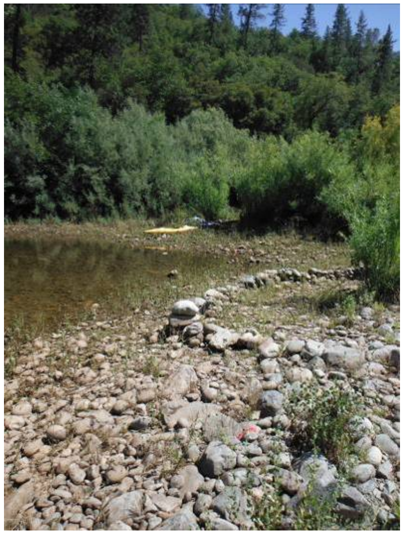

Figure 89. Transect R2 – On mid-channel bar looking across backwater pool toward right bank at 1,599 cfs.

Figure 90. Transect R2 – On mid-channel bar looking across dry backwater pool toward right bank at 176 cfs.

Figure 91. Transect R2 – On mid-channel bar looking toward left bank at 3,261 cfs.

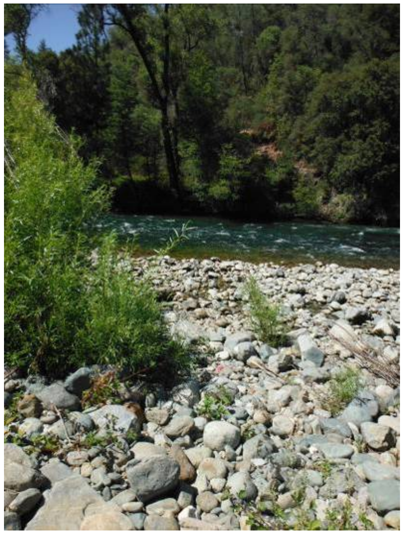

Figure 92. Transect R2 – On mid-channel bar looking toward left bank at 1,599 cfs.

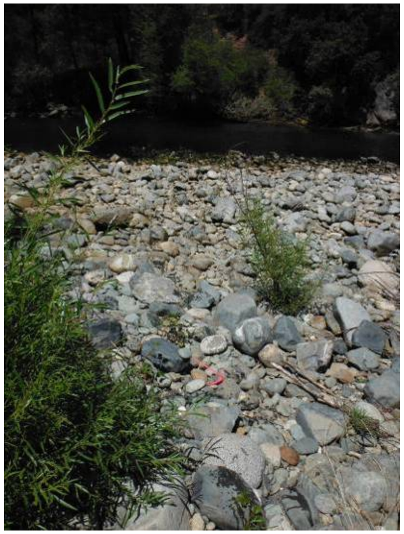

Figure 93. Transect R2 – On mid-channel bar looking toward left bank at 176 cfs.

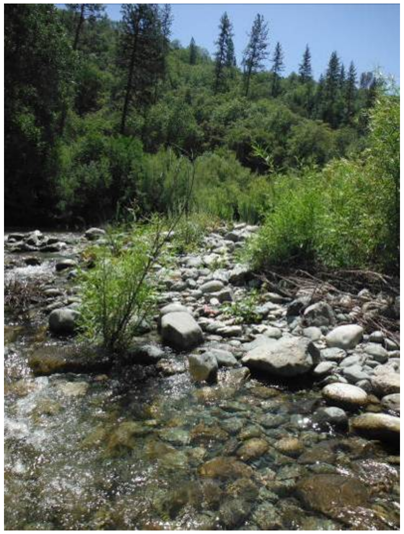

Figure 94. Transect R2 – Right bank water's edge of main channel looking toward right bank at 3,261 cfs.

Figure 95. Transect R2 – Right bank water's edge of main channel looking toward right bank at 1,599 cfs.

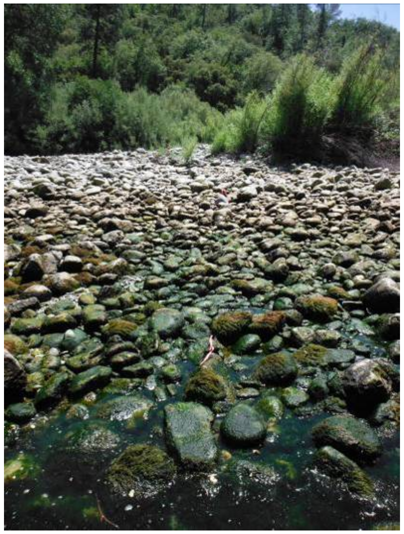

Figure 96. Transect R2 -- Right bank water's edge of main channel looking toward right bank at 176 cfs.

Figure 97. Transect R3 -- Right bank looking across channel toward left bank at 3,261cfs.

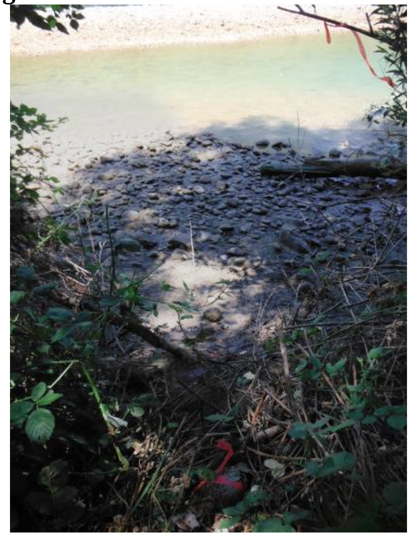

Figure 98. Transect R3 -- Right bank looking across channel toward mid-channel bar with flags showing water levels at 3,261 cfs & 1,599 cfs & current water level at 176 cfs.

Figure 99. Transect R3 -- Right bank waters edge looking toward right bank at 3,261 cfs.

Figure 100. Transect R3 -- Right bank waters edge looking toward right bank at 1,599 cfs.

Figure 101. Transect R3 – Right bank water's edge looking toward right bank showing water levels at 176 cfs (currently) & 1,599 cfs & 3,261 cfs.

Figure 102. Transect R3 -- From mid-channel looking across backwater pool toward right bank at 3,261 cfs.

Figure 103. Transect R3 -- From mid-channel looking across backwater pool toward right bank at 1,599 cfs.

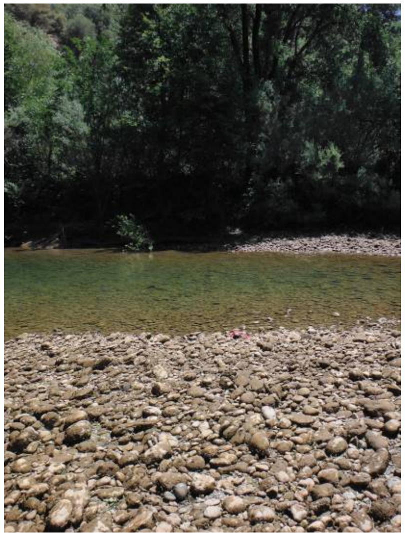

Figure 104. Transect R3 -- From mid-channel bar looking across backwater pool toward right bank at 176 cfs.

Figure 105. Transect R3 -- From mid-channel looking across main channel toward left bank at 3,261 cfs.

Figure 106. Transect R3 -- From mid-channel bar looking across main channel toward left bank at 1,599 cfs.

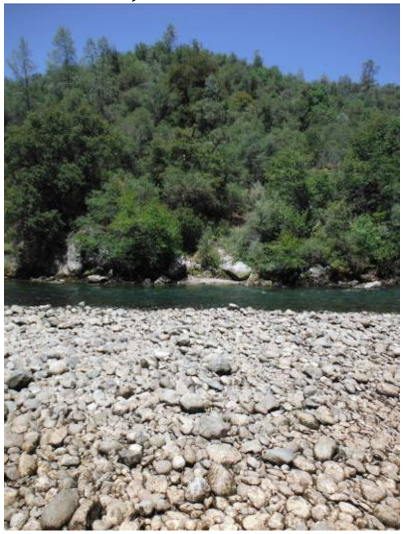

Figure 107. Transect R3 -- From mid-channel bar looking across main channel toward left bank at 176 cfs.

Figure 108. Transect R3 – Looking downstream at backwater pool habitat at 3,261 cfs.

Figure 109. Transect R3 – Looking downstream at backwater pool habitat at 1,599 cfs.

Figure 110. Transect R3 – Looking downstream at backwater pool habitat at 176 cfs.

Figure 111. Transect R3 – Looking downstream at main channel at 3,261 cfs.

Figure 112. Transect R3 – Looking downstream at main channel at 1,599 cfs.

Figure 113. Transect R3 – Looking downstream at main channel at 176 cfs.

Figure 114. Transect R3 – Looking upstream at whole channel at 3,261 cfs.

Figure 115. Transect R3 – Looking upstream at whole channel at 1,599 cfs.

Figure 116. Transect R3 – Looking upstream at whole channel at 176 cfs.

Figure 117. Transect R4 – Right bank looking downstream from transect at 1,599 cfs.

Figure 118. Transect R4 – Right bank looking upstream from transect at 1,599 cfs.

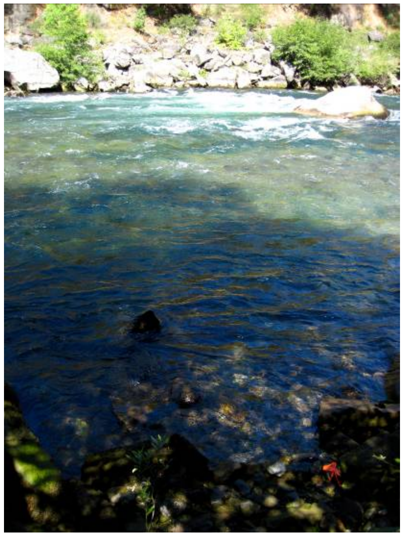

Figure 119. Transect R4 – Right bank to left bank at 1,599 cfs.

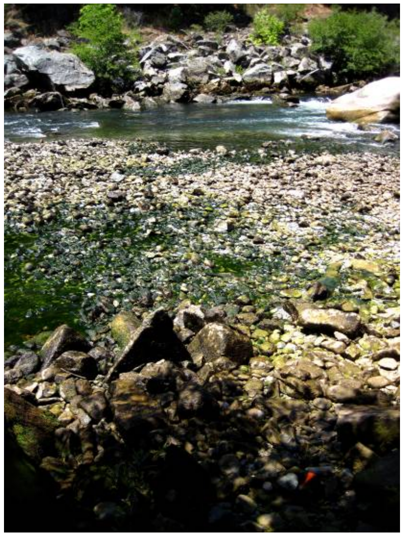

Figure 120. Transect R4 – Right bank to left bank at 176 cfs.

Figure 121. Transect R4 – Right bank water's edge facing right bank showing exposed substrate at 176 cfs.

Figure 122. Transect R4 – Right bank looking upstream to right bank and channel at 176 cfs.

Figure 123. Transect R4 – Right bank looking upstream to left bank and channel at 176 cfs.

Figure 124. Transect R5 – Looking upstream from transect at whole channel at 176 cfs.

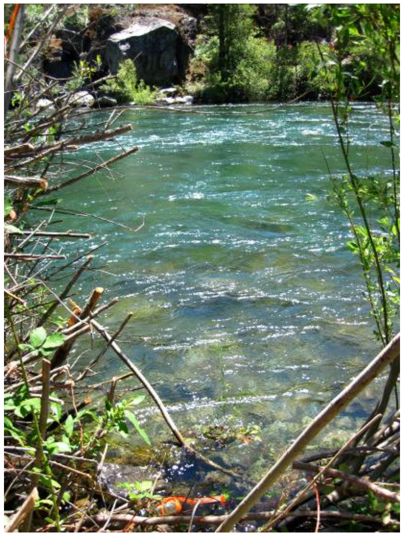

Figure 125. Transect R5 – Left bank to right bank at 3,261 cfs.

Figure 126. Transect R5 – Left bank to right bank at 1,599 cfs.

Figure 127. Transect R5 – Left bank to right bank at 176 cfs.

Figure 128. Transect R5 – Left bank water's edge with flagged rocks showing water levels at 3,261 cfs & 1,599 cfs (currently)

Figure 129. Transect R5 – Left bank looking upstream from transect at 176 cfs.

Figure 130. Transect R5 – Left bank water's edge facing left bank with flags showing water levels at 1,599 cfs (currently) & 3,261 cfs.

Figure 131. Transect R5 – Left bank water's edge facing left bank with flags showing water levels at 176 cfs (currently) & 1,599 cfs & 3,261 cfs.

Figure 132. Transect R6 – Left bank looking upstream from below transect to whole channel at 3,261 cfs.

Figure 133. Transect R6 – Left bank looking upstream from below transect to whole channel at 1,599 cfs.

Figure 134. Transect R6 – Left bank looking upstream from transect to whole channel at 176 cfs.

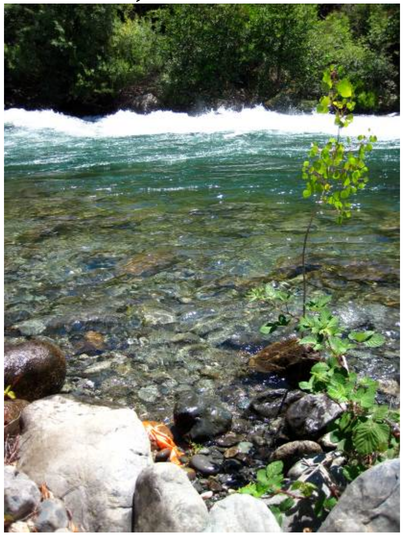

Figure 135. Transect R6 – Left bank to right bank at 3,261 cfs.

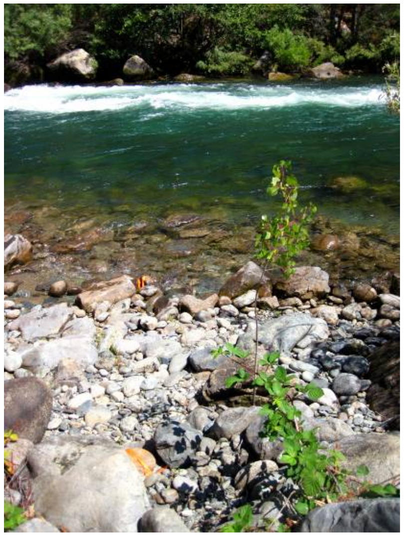

Figure 136. Transect R6 – Left bank to right bank at 1,599 cfs.

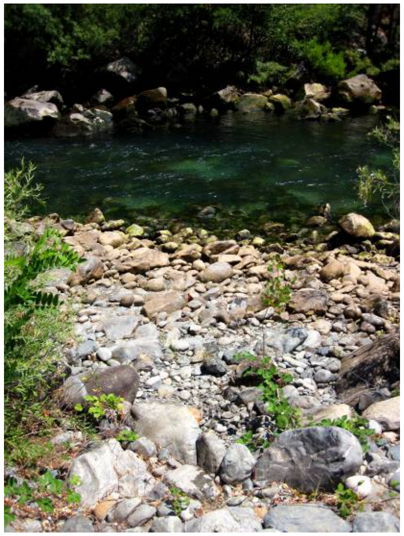

Figure 137. Transect R6 – Left bank to right bank at 176 cfs.

Figure 138. Transect R6 – Left bank water's edge facing left bank with flags showing water levels at 1,599 cfs (currently) & 3,261 cfs.

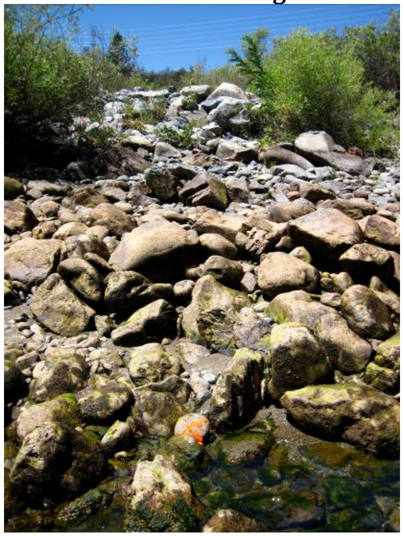

Figure 139. Transect R6 – Left bank water's edge facing left bank with flags showing water levels at 176 cfs (currently) & 1,599 cfs & 3,261 cfs.

Figure 140. Transect R6 – Left bank looking upstream to transect with flags showing water levels at 3,261 cfs & 1,599 cfs & 176 cfs (currently)

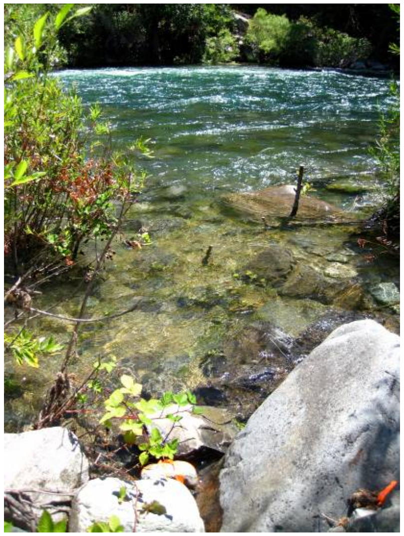

Figure 141. Transect R7 – Left bank looking to right bank at 3,261 cfs.

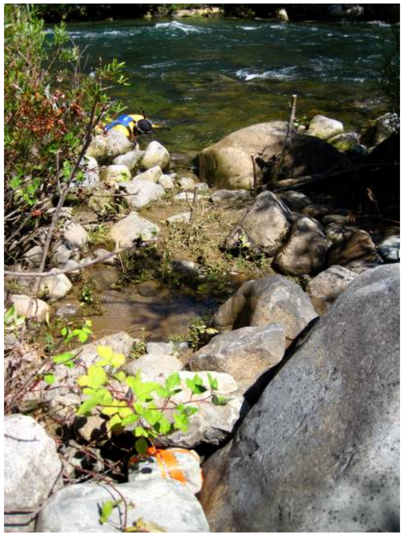

Figure 142. Transect R7 – Left bank looking to right bank at 1,599cfs.

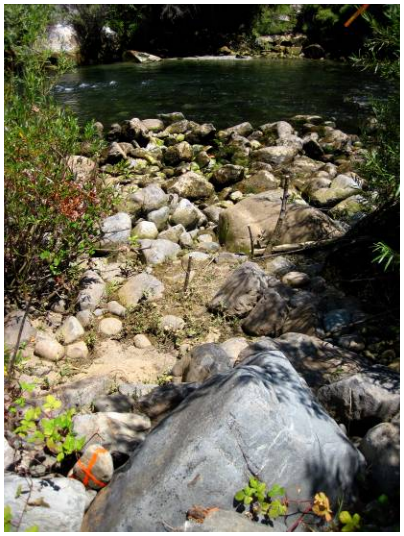

Figure 143. Transect R7 – Left bank looking to right bank at 176 cfs.

Figure 144. Transect R7 – Left bank water's edge facing left bank with flag showing water level at 1,599 cfs (currently).

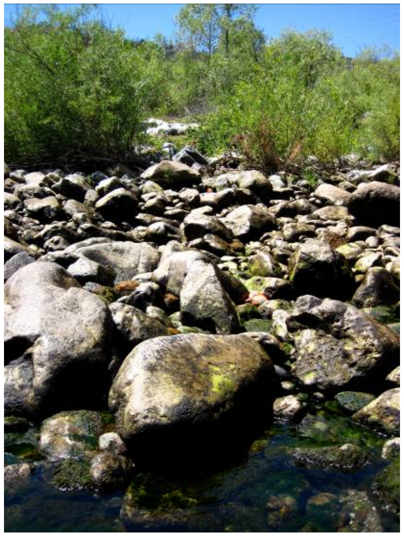

Figure 145. Transect R7 – Left bank water's edge facing left bank with flags showing water level at 176 cfs (currently) & 1,599 cfs.

Figure 146. Transect R7 – Upstream of transect on left bank looking upstream to whole channel at 176 cfs.

4.0 August

Page Left Blank

Figure 147. Transect R1 – Right bank looking downstream to whole channel at 1,502 cfs.

Figure 148. Transect R1 – Right bank looking upstream to whole channel at 1,502 cfs.

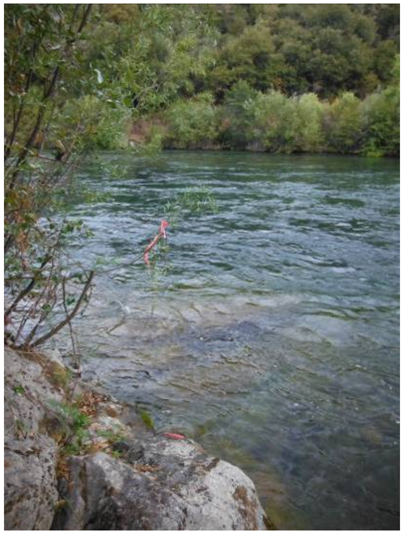

Figure 149. Transect R1 – Right bank looking to left bank at 3,109 cfs.

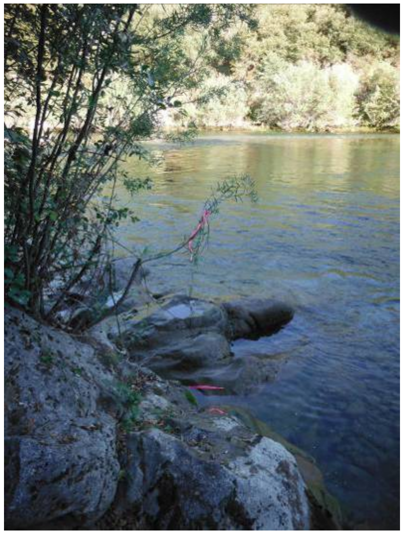

Figure 150. Transect R1 – Right bank looking to left bank at 1,502 cfs.

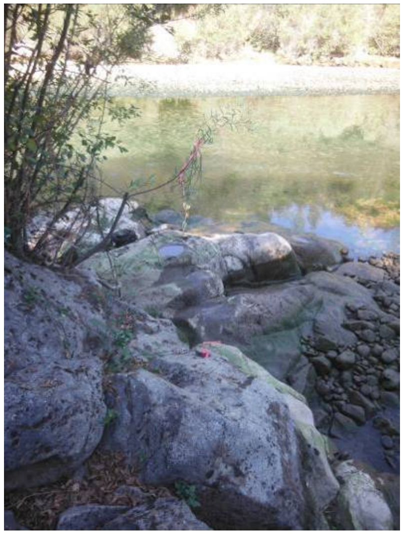

Figure 151. Transect R1 – Right bank looking to left bank at 130 cfs.

Figure 152. Transect R1 – Looking down at pocket of water on transect at 3,109 cfs.

Figure 153. Transect R1 – Looking down at pocket of water (now dry) on transect at 1,502 cfs.

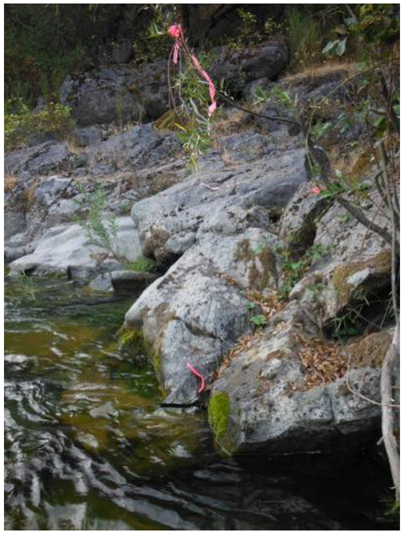

Figure 154. Transect R1 – Right bank water's edge facing right bank at 3,109 cfs.

Figure 155. Transect R1 – Right bank water's edge facing right bank at 1,502 cfs.

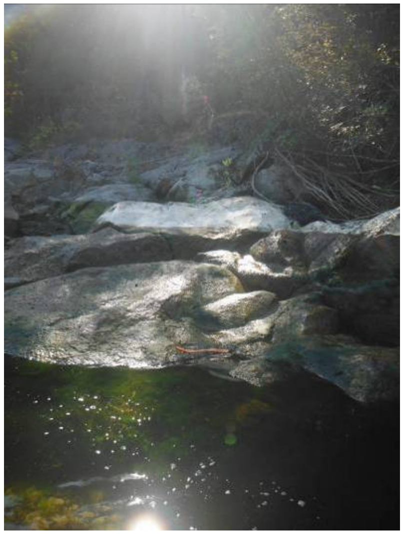

Figure 156. Transect R1 – Right bank water's edge facing right bank at 130 cfs.

Figure 157. Transect R1 – Right bank looking upstream to backwater pool habitat at 3,109 cfs.

Figure 158. Transect R1 – Right bank looking upstream to location of stranding observation of one unidentified sp. (near yellow bag), Stranding Zone C.

Figure 159. Upstream of Transect R1 – Up close view of characteristic stranding habitat, Stranding Zone C.

Figure 160. Transect R1 – Near left bank looking downstream at point bar at 1,502 cfs.

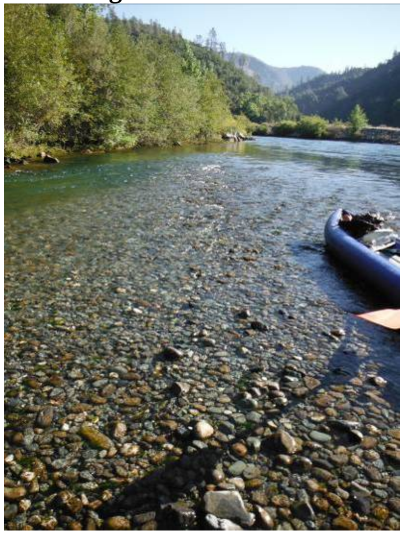

Figure 161. Transect R1 – On point bar near left bank looking upstream at 1,502 cfs.

Figure 162. Transect R2 – Right bank looking across backwater pool to left bank at 3,109 cfs.

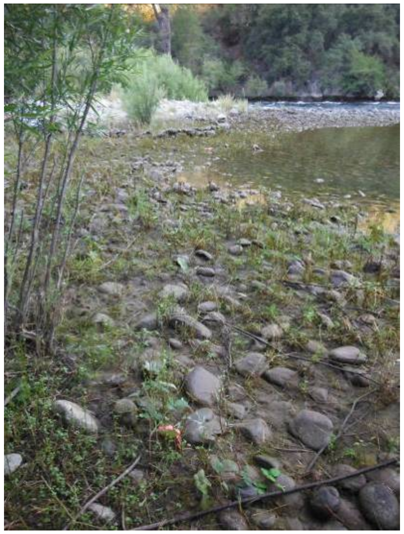

Figure 163. Transect R2 – Right bank looking across backwater pool to left bank at 1,502 cfs.

Figure 164. Transect R2 – Looking upstream to backwater pool at 3,109 cfs.

Figure 165. Transect R2 – Looking upstream to backwater pool at 1,502 cfs.

Figure 166. Transect R2 – Looking upstream to backwater pool at 130 cfs.

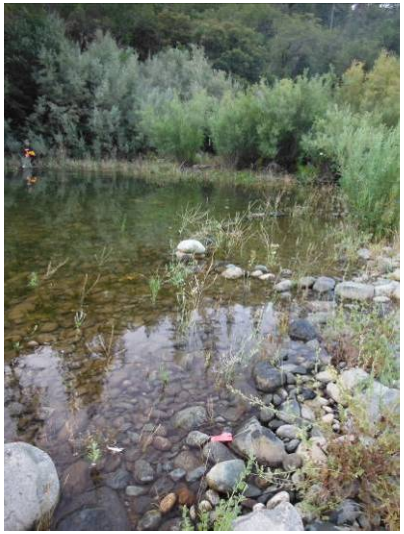

Figure 167. Transect R2 – Mid-channel bar looking across backwater pool toward right bank at 3,109 cfs.

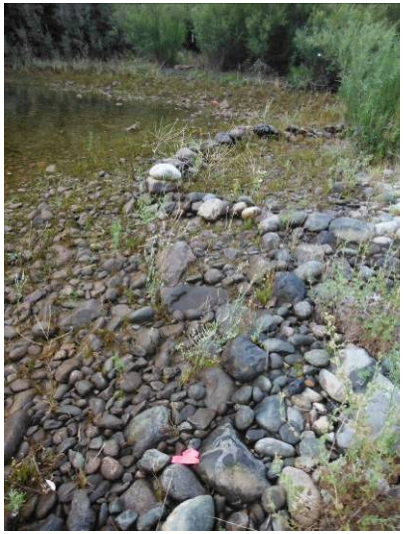

Figure 168. Transect R2 – Mid-channel bar looking across backwater pool toward right bank at 1,502 cfs.

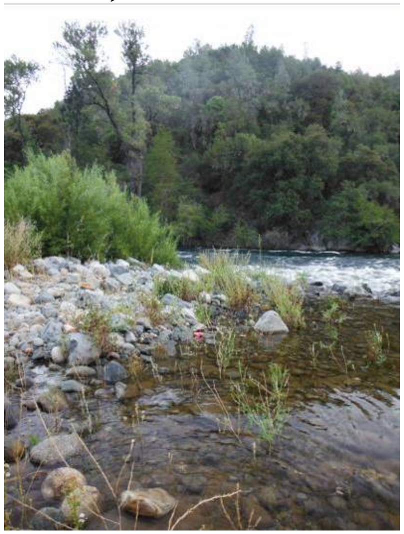

Figure 169. Transect R2 – Mid-channel bar at 3,109 cfs.

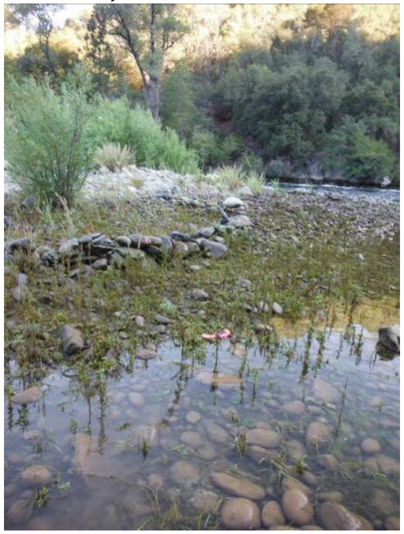

Figure 170. Transect R2 – Mid-channel bar at 1,502 cfs.

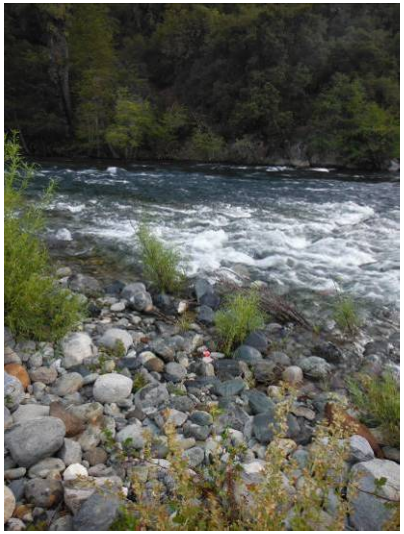

Figure 171. Transect R2 – Mid-channel bar looking toward left bank at 3,109 cfs.

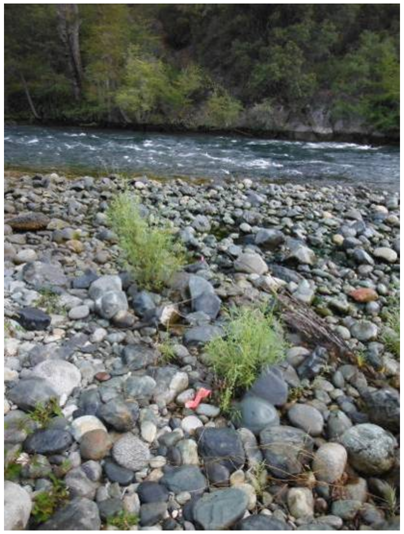

Figure 172. Transect R2 – Mid-channel bar looking toward left bank at 1,502 cfs.

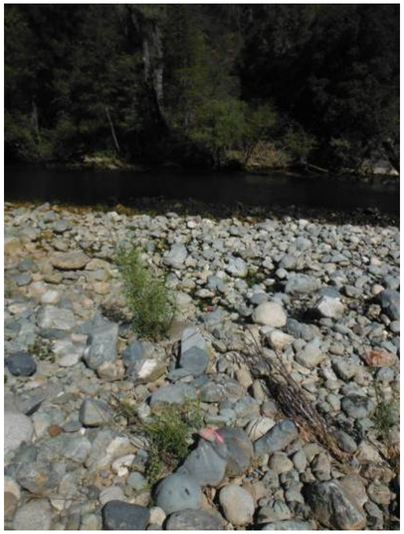

Figure 173. Transect R2 – Mid-channel bar looking toward left bank at 130 cfs.

Figure 174. Transect R2 – Right bank water's edge of main channel looking toward right bank and mid channel bar at 3,109 cfs.

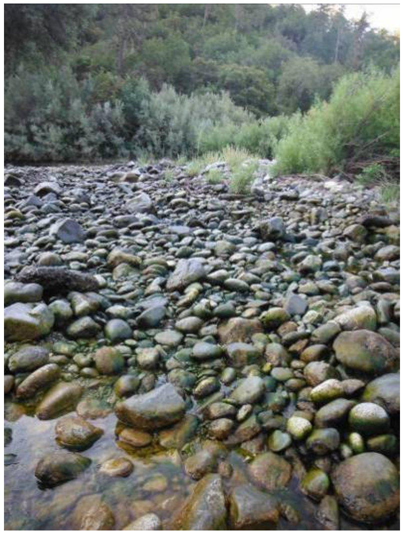

Figure 175. Transect R2 – Right bank water's edge of main channel looking toward right bank and mid channel bar at 1,502 cfs.

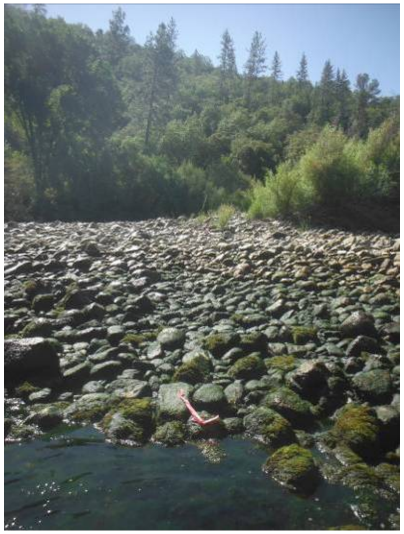

Figure 176. Transect R2 – Right bank water's edge of main channel looking toward right bank and mid channel bar with flags showing water levels at 130 cfs (currently) & 1,502 cfs & 3,109 cfs.

Figure 177. Transect R2 – On mid-channel bar looking upstream to whole channel at 1,502 cfs.

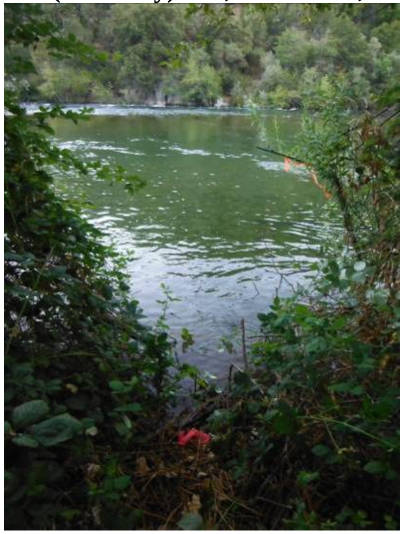

Figure 178. Transect R3 – Right bank to left bank at 3,109 cfs.

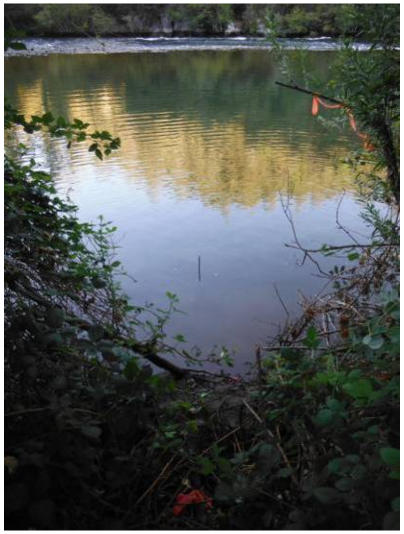

Figure 179. Transect R3 – Right bank to left bank at 1,502 cfs.

Figure 180. Transect R3 – Right bank to left bank at 130 cfs.

Figure 181. Transect R3 – Right bank water's edge facing right bank at 3,109 cfs.

Figure 182. Transect R3 – Right bank water's edge facing right bank at 1,502 cfs.

Figure 183. Transect R3 – Right bank water's edge facing right bank at 130 cfs.

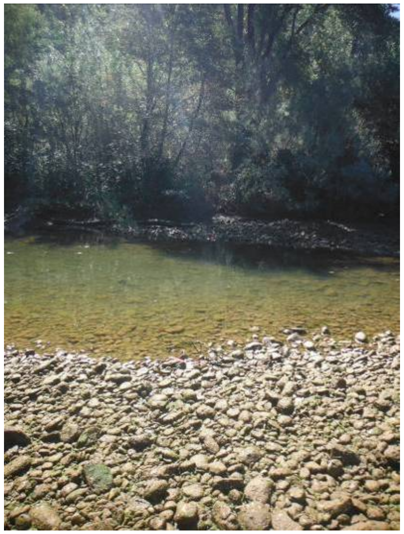

Figure 184. Transect R3 – On mid-channel bar looking across backwater pool toward right bank at 130 cfs.

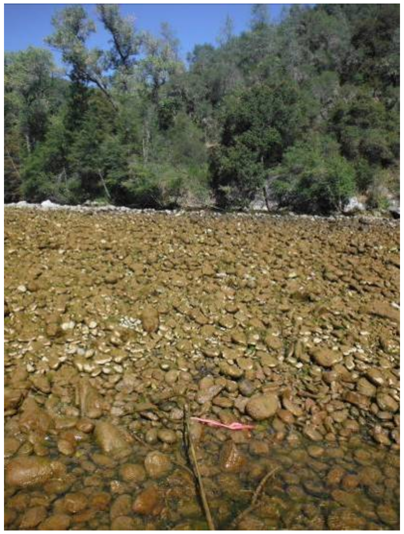

Figure 185. Transect R3 – Looking across mid-channel bar toward left bank showing exposed substrate at 130 cfs.

Figure 186. Transect R4 – Right bank looking downstream from transect to whole channel showing exposed substrate at 130 cfs.

Figure 187. Transect R4 – Right bank looking upstream from transect to right bank and channel showing exposed substrate at 130 cfs.

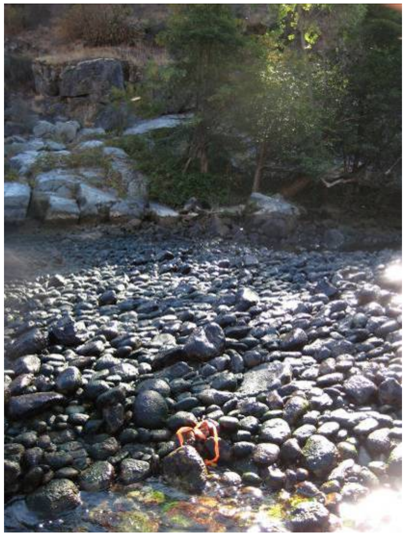

Figure 188. Transect R4 – Right bank water's edge facing toward right bank showing exposed substrate at 130 cfs.

Figure 189. Upstream of Transect R4 – Incidental sighting of stranded rainbow trout near Dobbins Creek in November, Stranding Zone A.

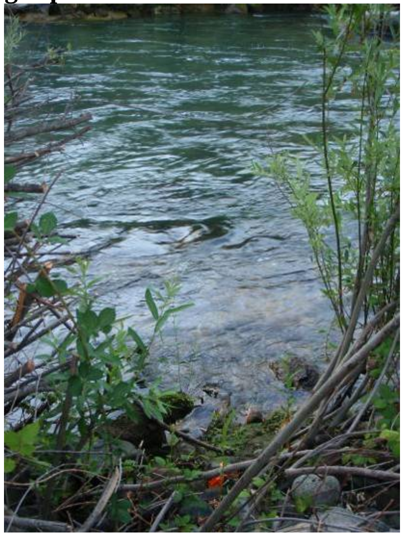

Figure 190. Transect R5 – Left bank toward right bank with flags showing water levels at 3,109 cfs & 1,502 cfs (currently).

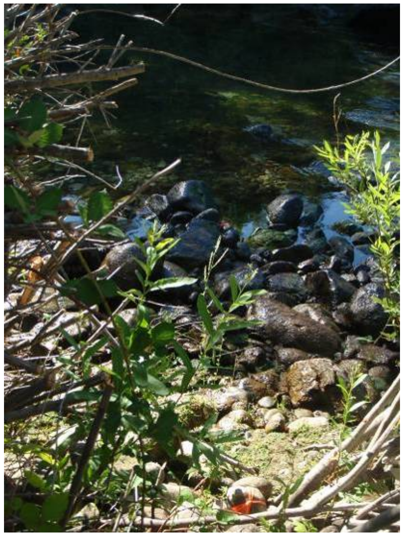

Figure 191. Transect R5 – Left bank toward right bank with flags showing water levels at 3,109 cfs & 1,502 cfs & 130 cfs (currently).

Figure 192. Transect R5 – Left bank looking downstream from transect to whole channel at 1,502 cfs.

Figure 193. Transect R5 – Left bank looking downstream from transect to whole channel at 130 cfs.

Figure 194. Transect R5 – Left bank looking upstream from transect to whole channel at 1,502 cfs.

Figure 195. Transect R5 – Left bank looking upstream from transect to whole channel at 130 cfs.

Figure 196. Transect R6 – Left bank toward right bank with flags showing water levels at 3,109 cfs & 1,502 cfs (currently).

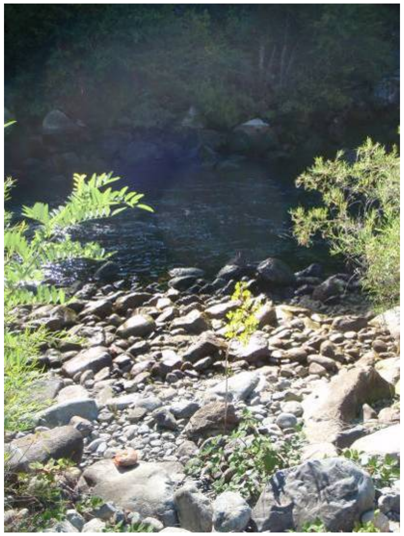

Figure 197. Transect R6 – Left bank toward right bank with flags showing water levels at 3,109 cfs & 1,502 cfs & 130 cfs (currently).

Figure 198. Transect R7 – Left bank looking toward left bank with flag showing water level at 3,109 cfs & current water level at 1,502 cfs.

Technical Memorandum 3-12

New Colgate Powerhouse Ramping

Attachment 3-12D

Hydraulic Calibration Report

Yuba River Development Project

FERC Project No. 2246

December 2012

Table of Contents

Section No. **Description** **Page No.**

List of Figures

Figure No. **Description** **Page No.**

List of Tables

Table No. **Description** **Page No.**

Page Left Blank

ATTACHMENT 3-12D

YUBA RIVER NEW COLGATE POWERHOUSE REACH DRAFT HYDRAULIC CALIBRATION RESULTS

1.0 Model Used

The hydraulic model developed for the site was calibrated in the HYDSIM routine of RHABSIM 3.0. Hydraulic modeling procedures appropriate to the study site and level of data collection were used for modeling water surface elevations and velocities across each transect.

1.1 Files

The following file is associated with the hydraulic model for this study reach:

DSNCPHR.RHB

2.0 Modeling Methods

Hydraulic modeling procedures appropriate to the study site and level of data collection were used for modeling water surface elevations and velocities across each of the 21 cross sections comprising the study reach. Twenty of the 21 transets were selected for PHABSIM. Six of the twenty plus one additional transect were selected to be used as part of Study 3.12 – *New Colgate Powerhouse Ramping* for a total of 7 transects. Transects used in both the PHABSIM and Ramping analyses are denoted using the following labeling structure: Transect (T) 1-20 (R1-7). For example: T-18 (R7).

2.1 Water Surface Elevations (WSE)

For water surface elevations, these procedures included: the development of stage/discharge rating curves using log-log regression (IFG4); Manning's formula (MANSQ); and/or step backwater models (WSP); direct comparison of results; and selection of the most appropriate and accurate method. Log-log and MANSQ were run for each transect, with MANSQ set as the default modeling method. If individual transects did not calibrate sufficiently well using MANSQ, based on general guidelines of maximum Beta (0.5), and/or professional judgment, then log/log or WSP was selected. The WSP model was used where suitable sections of the study site were surveyed to a common datum and a reliable rating curve at the downstream control or transect was available. For transects that the WSP model was calibrated, results were compared to results from Log/Log and MANSQ. WSP was generally preferred in pools or where uphill flow between transects was predicted by either Log/Log or MANSQ. Data file construction, calibration, and simulation followed standard procedures and guidelines outlined in the PHABSIM Reference Manual Version II, Instream Flow Information Paper No.26 (Milhous, R.T., M.A. Updike, and D.M. Schneider 1989) and PHABSIM for Windows: User's Manual and Exercises (Waddle 2001).

2.2 Modeling Guidelines

PHABSIM modeling guidelines considered for the New Colgate Powerhouse Reach were as follows:

1. The beta value (a measure of the change in channel roughness with changes in streamflow) must be between 2.0 and 4.5;
2. The mean error in calculated versus given discharges must be less than 10%;
3. There must be no more than a 25% difference for any calculated versus given discharge; and
4. There must be no more than a 0.1-foot difference between measured and simulated water surface elevations (WSE)s.

- To determine whether the MANSQ model accurately predicts measured values, the second through fourth of the above criteria must be met, and the beta value parameter used by MANSQ must be within the range of 0.0 to 0.5. The first IFG4 criterion is not applicable to MANSQ.
- To determine accuracy of predictions of the WSP model, modeled water surfaces are compared to field measured (observed) values across all measured flows. Ideally, agreement between observed and simulated WSEs is within ±0.01 to 0.02 ft. Manning's n values for all transects must be reasonable, be based on handbook values (Chow 1959) or a combination of handbook values, site specific considerations and professional judgement. Longitudinal profiles should be evaluated for realism and compared to IFG4 and MANSQ results.

3.0 <u>Habitat Summary for New Colgate Powerhouse Reach</u>

A hydraulic model was developed for the 20 instream flow transects, plus 1 additional ramping transect, for a total of 21 transects on the New Colgate Powerhouse Reach on the Yuba River upstream of Englebright Reservoir. Meso-habitats represented in this reach are presented in Table 3.0-. Final PHABSIM transect locations are presented in Figure 3.0-1, and the transects selected for Study 3.12 are presented in Figure 3.0-2.

Table 3.0-1. Target transects for primary habitats in the Mainstem Yuba River Colgate Powerhouse Reach (RM 32.55 to 33.9).

Habitat	# Selected Mesohabitats Instream Flow (Ramping)
Low gradient riffles	1
Runs/Step-Runs	4
Pools	11 (1)
Rapid	4
TOTAL	21

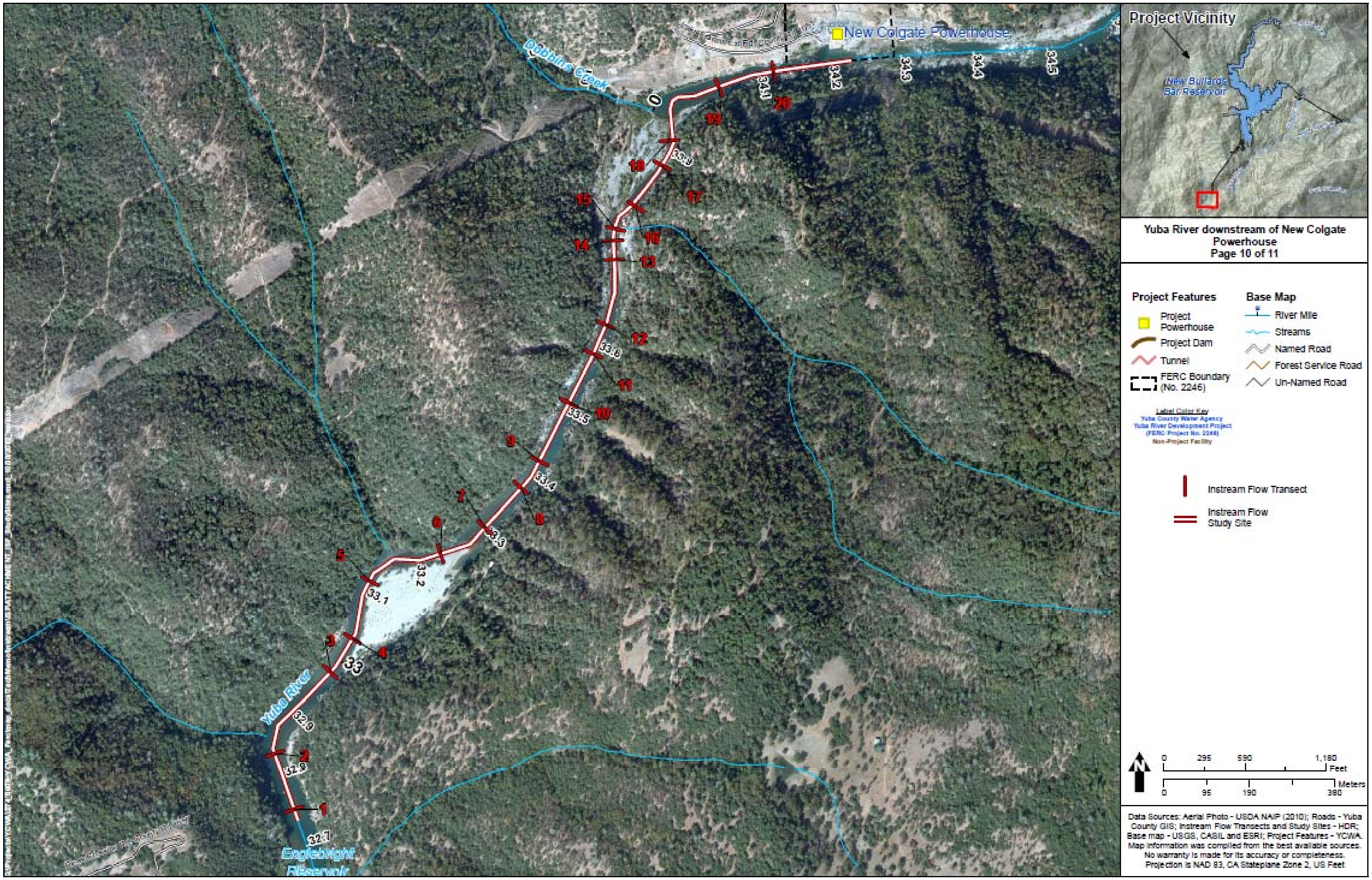

Figure 3.0-1. PHABSIM transects in the New Colgate Powerhouse Reach.

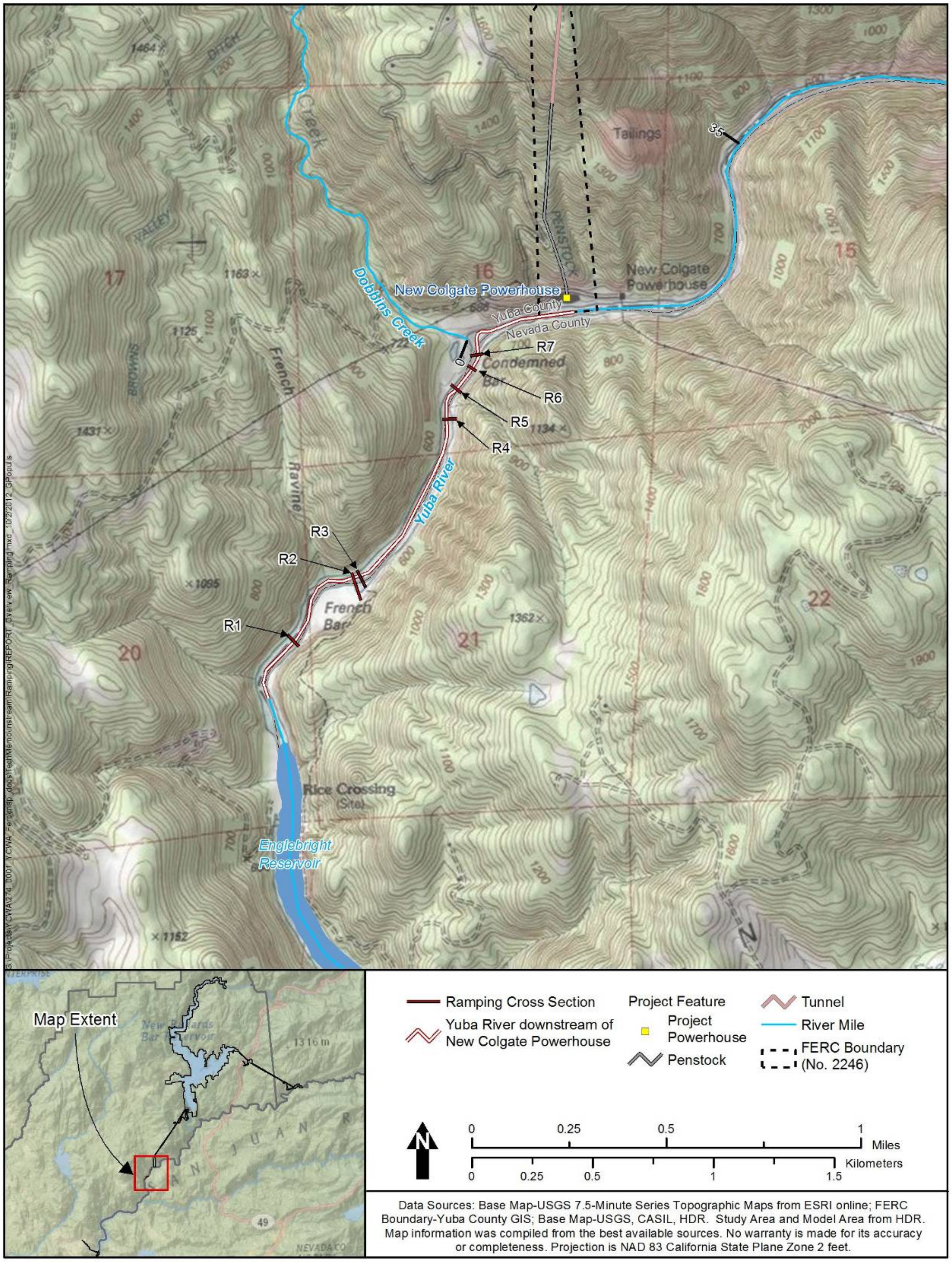

Figure 3.0-2. Overview map of the New Colgate Powerhouse reach showing the locations of ramping transects for Study 3.12, *New Colgate Powerhouse Ramping.*

4.0 Calibration Summary for New Colgate Powerhouse Reach

Stage/discharge regressions were developed using four main channel calibration discharges: 3749 cubic feet per second (cfs), 1529 cfs 640 cfs and 253 cfs. For each transect, one velocity calibration set was collected at one of the four flows. The flow at which velocity data was collected depended on safety considerations or significant turbulence/air entrainment which restricts the use of ADCP in deeper water. Table 5.1- summarizes modeling statistics for each transect and modeling method, while Table C-1, in Appendix C, summarize the given calibration stage and the modeled stages for each flow, at each transect, using all modeling methods used on a given transect.

4.1 Cross Section Adjustments

Standard practice for water surface adjustments is to select the average, left bank or right bank WSE collected in the field. One limitation of 1D hydraulic flow models is that a single water surface must be used for the entirety of each transect at a given flow. Because of this limitation, when a transect exhibits more than one significantly different water surface, RHABSIM will over- or under predict depths depending on what water surface elevation is used. An unintended consequence of this limitation is that for each station where modeled depths are greater or less than the observed depth, the model will adjust the velocity at that station down or up, to match the measured discharge.

Therefore, in order to create the most realistic representation of wetted area and water depths, two transects with multiple WSE differences had part of their bed shifted. The right side of Transect T-06 (R2) and T-R3 were lowered.

Also, at the simulated 2.5 times the High-High flow discharge, two transects, T-11 and T-12 had water surfaces slightly higher than the measured topography. Additional stations, based on the nearby slope, were added to increase the bank height on these two transect to prevent overbank flow at the highest simulated flow. Cross sectional profiles with measured water surface elevations have been included in Appendix A. Detailed notes describing overbank conditions at each transect and the addition of topographic stations have been included in Appendix B.

5.0 Calibration Details for New Colgate Powerhouse Reach

5.1 Water Surface Elevations

The New Colgate Powerhouse reach model was calibrated using four stage/discharge calibration data sets: 3749 cfs, 1529 cfs, 640 cfs, and 253 cfs. All transects in the study site were calibrated using both Log/Log and MANSQ and four groups of transects were modeled using WSP. These groups generally represented pool and run dominated sections of the reach. For model calibration, water surface elevations were selected within the range of field collected data only. All model calculated discharges based on field measured velocities, were within 10% of the best estimate of discharge. Both MANSQ and Log/Log percent mean error[1] and Beta (β) values can be seen in Table 5.1-1 below. No mean error values are available for the WSP routine in RHABSIM. A list of key findings is provided below.

- 4 groups of transects were modeled using WSP. These groups generally represented pool and run dominated sections of the reach.
  - T-01 to T-04
  - T-07 to T-10
  - T-16 (R5) to T-17 (R6)
  - T-19 to T-20
- WSP was selected on T-01 to T-04, T07 to T10, T-16 (R5) to T-17 (R6), and T-19 to T-20, with log/log stage elevations entered for the most downstream transect of each group.
- MANSQ was selected as the primary calibration method on T-05 and T-14, based on the modeling guidelines outlined above.
- All Log/Log betas were between 2.0 and 4.5, except for T-07, T-08, T-09 and T-10.
  - T-07 had Log/Log beta of 1.85, but had a much lower mean error than MANSQ, so was used for calibrating Step-Backwater on T-07 through T-10.
- All transects but one had MANSQ betas inside the range of 0.0 to 5.0
  - T-07's beta = -0.286. A negative beta value is typically indicative of a riffle with high gradient
- 18 out of 21 MANSQ mean errors were less than 10%, and the only transects selected for MANSQ, T-05 and T-14, the errors were less than 3.8%.
- Both MANSQ and Log/Log mean errors can be seen in Table 5.1-. No mean error values are available for the WSP routine. Refer to Table C-1 and C-2 in the Appendix for a comparison of measured versus modeled water surface elevations..

Table 5.1-1. Percent Mean Error for Stage/Discharge Relationships[1].

	T-20	T-19	T-18 (R7)	T-17 (R6)	T-16 (R5)	T-15	T-14	T-13 (R4)	T-12	T-11	T-10
Log/Log	5.538	5.273	1.679	1.042	5.143	2.584	1.136	1.257	2.537	1.606	5.225
MANSQ	8.508	7.811	2.576	4.977	6.312	4.791	3.214	6.736	4.876	12.611	7.185
MANSQ BETA	0.563	0.572	0.081	0.313	0.322	0.398	0.371	0.256	0.193	0.133	0.426
	T-09	**T-08**	**T-07**	**T-R3**	**T-06 (R2)**	**T-05**	**T-04**	**T-03 (R1)**	**T-02**	**T-01**	
Log/Log	4.623	5.036	5.103	3.692	10.710	3.407	5.660	3.852	1.096	1.435	
MANSQ	6.405	6.602	29.719	4.631	14.631	3.137	1.968	6.207	7.038	4.991	
MANSQ BETA	0.425	0.330	-0.286	0.174	0.294	0.471	0.3721	0.102	0.489	0.357	

1 Mean error not available for the WSP routine in RHABSIM.

1 Percent mean error is defined as: an evaluation of the average difference between the predicted water surface elevations and the observed water surface elevations measured in the field.

5.2 Velocity Calibration Summary

The RHABSIM model used the "one-velocity" method, as any given transect only has one velocity set. All transect velocity measurements in the reach downstream of New Colgate Powerhouse, were collected at the highest target flow possible for that transect. Limiting physical parameters included deep swift water to deep to safely wade or deep water with entrained air which limited ADCP data collection. No velocity data were collected on Transect R3 because velocity data collection occurred only during the implementation of Study 3.10. Therefore, to predict transect velocities over the range of simulated flows, the depth-calibration method in RHABSIM was used. This procedure applies a uniform roughness coefficient to each cell across the cross section to achieve the user supplied discharge. The calibration procedure then entails manual adjustment of the roughness coefficients to create an appropriate velocity distribution across the channel, based on field knowledge and professional judgment. Since Transect R3 was placed in the same channel type and mesohabitat as Transect 6 (R2), 91 feet upstream, the velocity distribution profile for Transect R3 was based on the profile from Transect 6 (R2).

5.3 Target Discharge and Field Discharge

Average daily discharge calculated from all field measurements are summarized below in Table 5.3-1.

Table 5.3-1. Target and measured flows for the New Colgate Powerhouse Reach.

	LF	MF	HF	HHF
Target Discharge (cfs)	100	600	1570	3260
Field Measured Discharge (cfs)	253	640	1529	3749

Discharge, like water surface elevation, is used to calibrate stage/discharge relationships in the PHABSIM hydraulic models. Modeled discharges used in the Log/Log and MANSQ routines were modified slightly from best estimates to improve model calibration. Discharge selections were within the range of flows observed during data collection if the average discharge for the day was not used.

6.0 References

Chow, V.T. 1959. Open channel hydraulics. McGraw-Hill Publishing Co., New York.

Milhous, R. T., M. A. Updike, and D. M. Schneider. 1989. PHABSIM Reference Manual Version II, Instream Flow Information Paper No. 26. U.S. Fish and Wildlife Service (USFWS) Biological Report 89(16).

Waddle, T. J. (ed.) 2001. PHABSIM for Windows: User's Manual and Exercises. United.States. Geological Survey (USGS) Open-File Report 2001-340.

Page Left Blank

Attachment 3-12D

Hydraulic Calibration Report

Appendix A

New Colgate Powerhouse Reach Cross Sectional Profiles and Photos

Yuba River Development Project

FERC Project No. 2246

December 2012

List of Figures

List of Figures (continued)

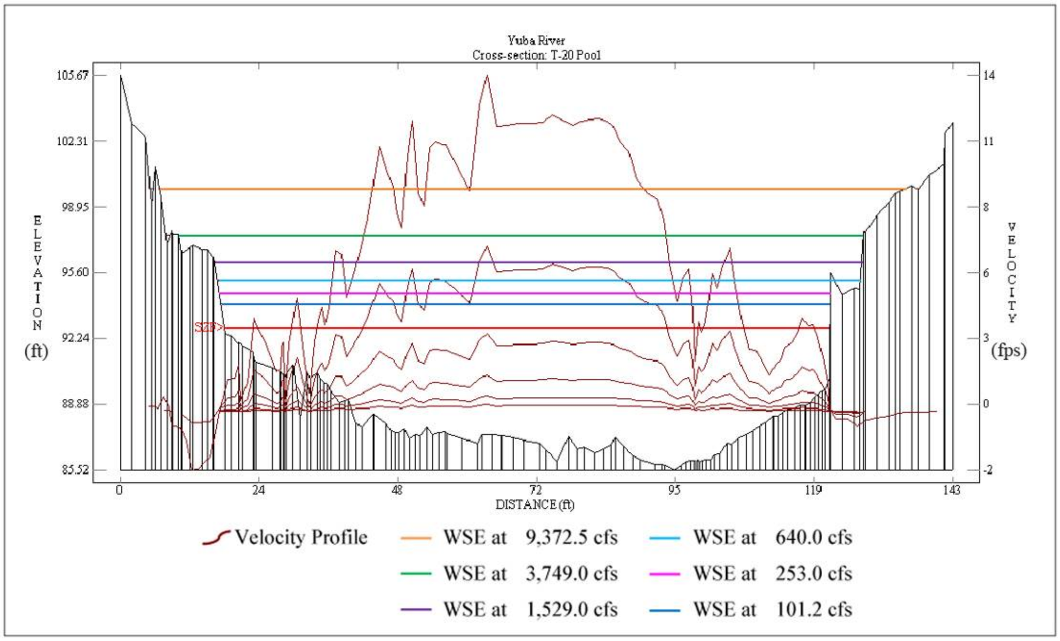

Figure A-1. Transect 20 (Pool).

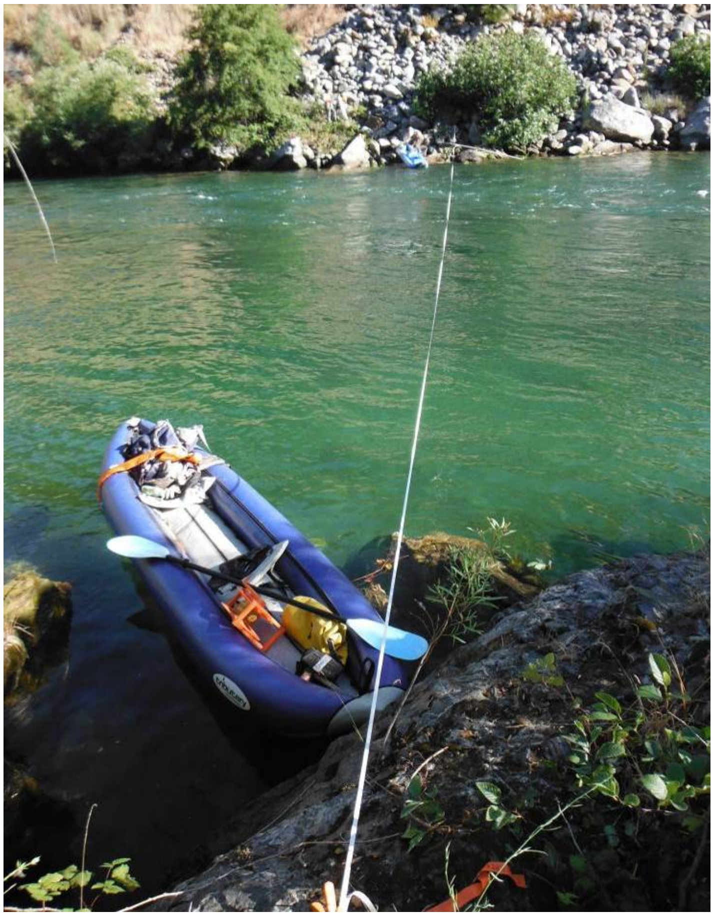

Figure A-2. Transect 20, right bank to left bank at High Flow (1529 cfs).

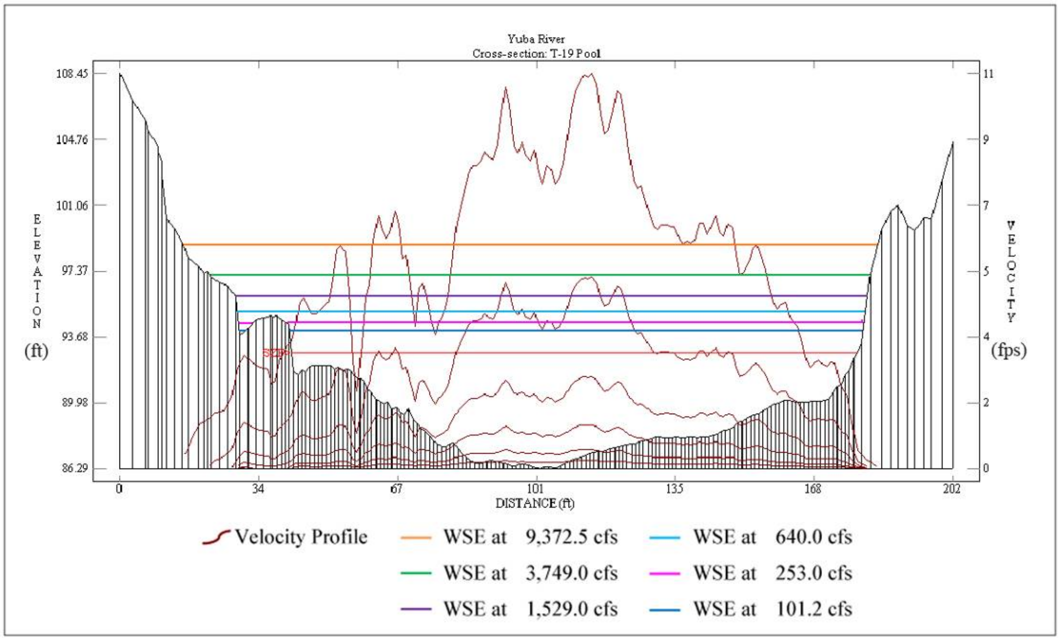

Figure A-3. Transect 19 (Pool).

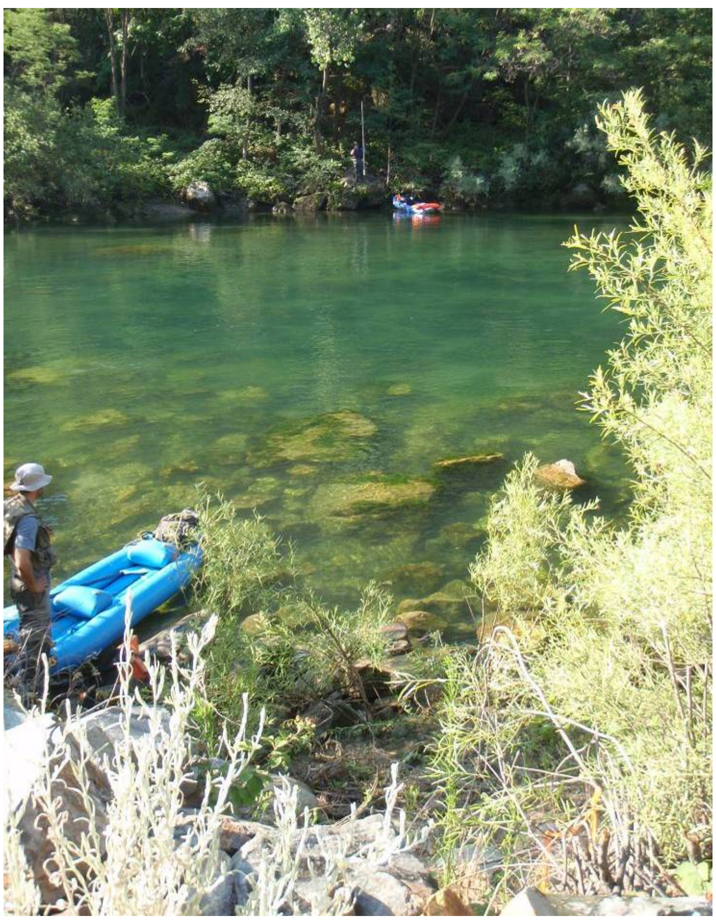

Figure A-4. Transect 19, looking right bank to left bank at Mid Flow (640 cfs).

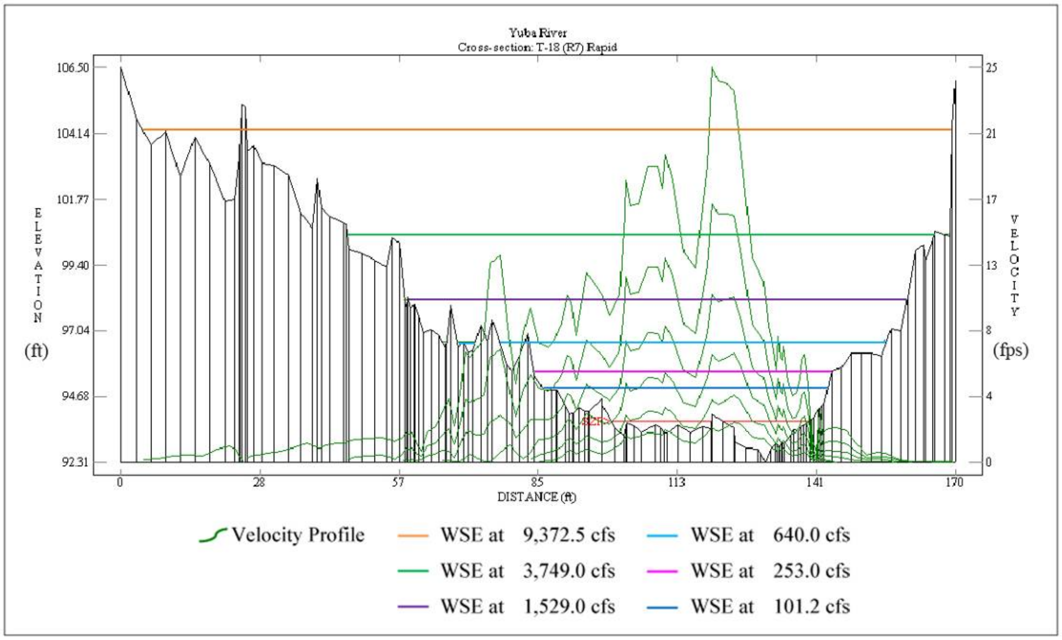

Figure A-5. Transect 18 (R7) (Rapid)

Figure A-6. Transect 18 (R7)), looking left bank to right bank at High Flow (~1500 cfs).

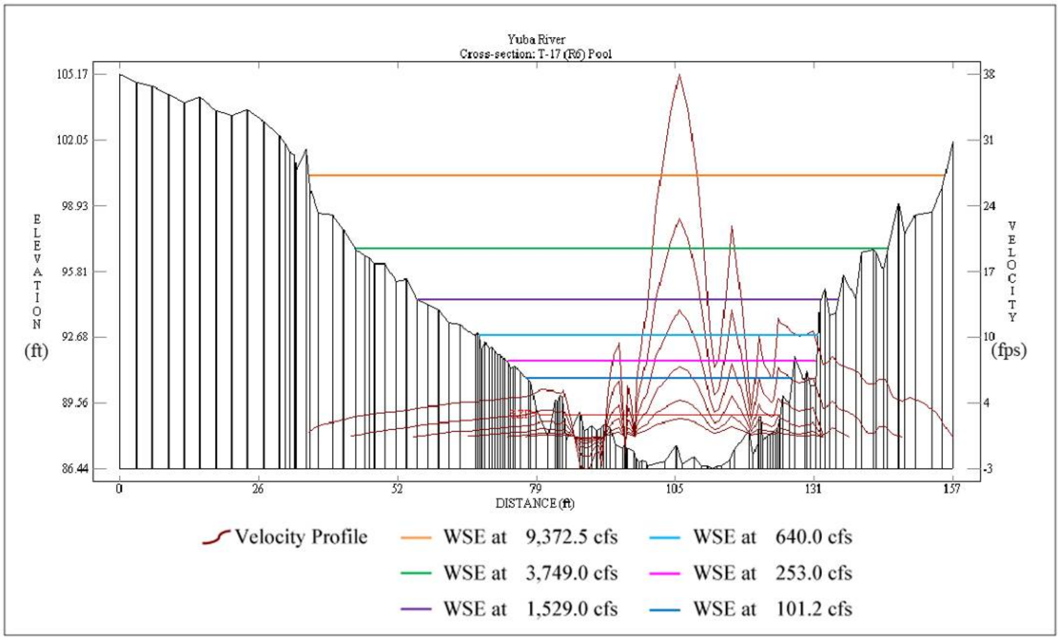

Figure A-7. Transect 17 (R6) (Pool)

Figure A-8. Transect 17 (R6), looking from right to left at High Flow (~1,500 cfs)

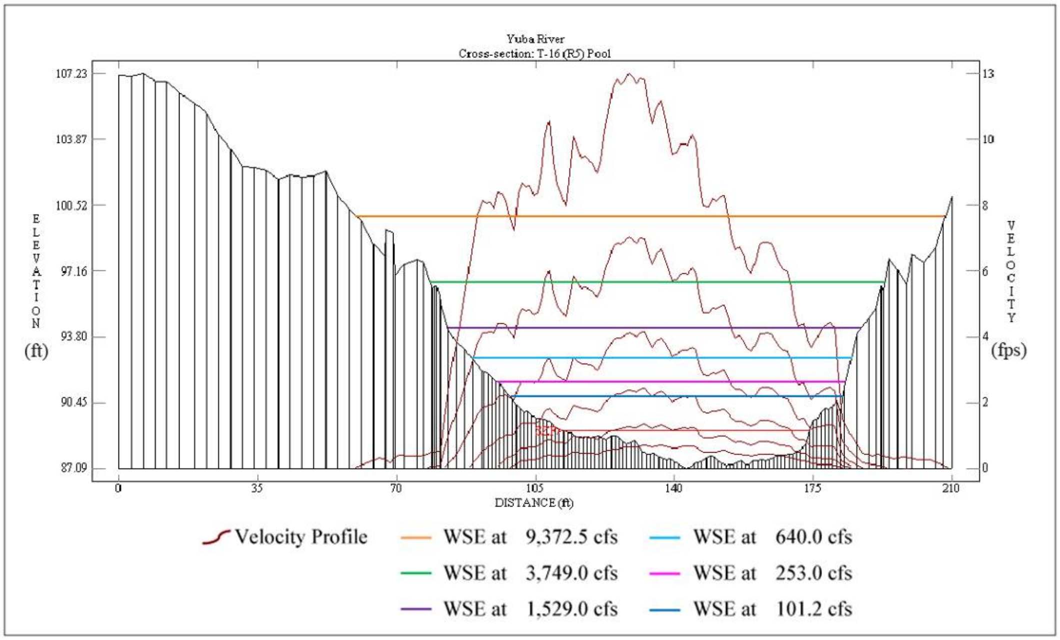

Figure A-9. Transect 16 (R5) (Pool)

Figure A-10. Transect 16 (R5), looking from left bank towards right bank at Low Flow (253 cfs)

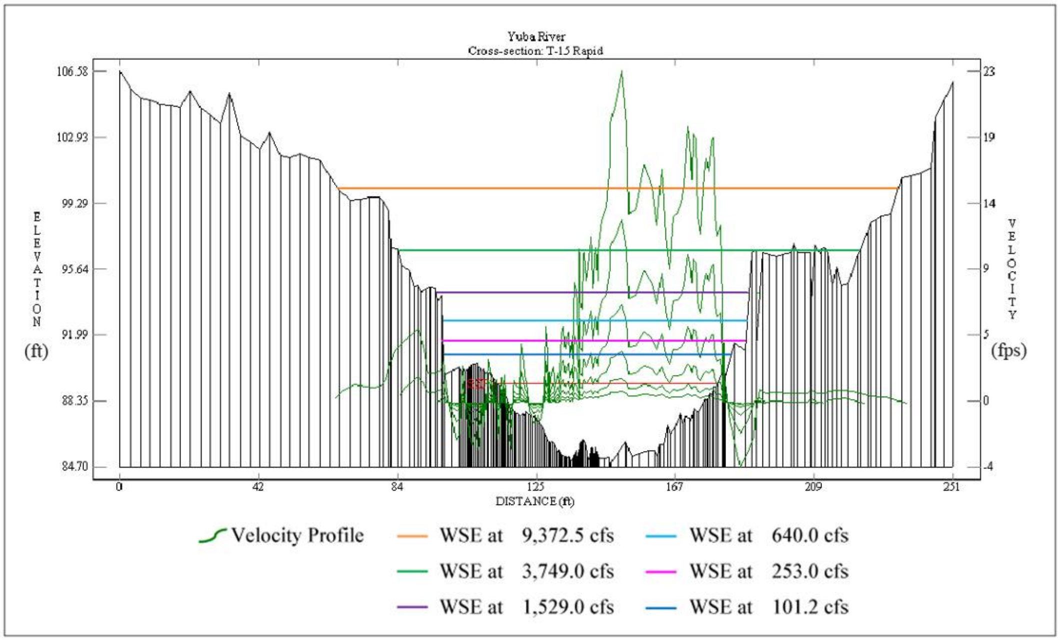

Figure A-11. Transect 15 (Rapid)

Figure A-12. Transect 15, looking from left bank towards right bank at High Flow (1529 cfs)

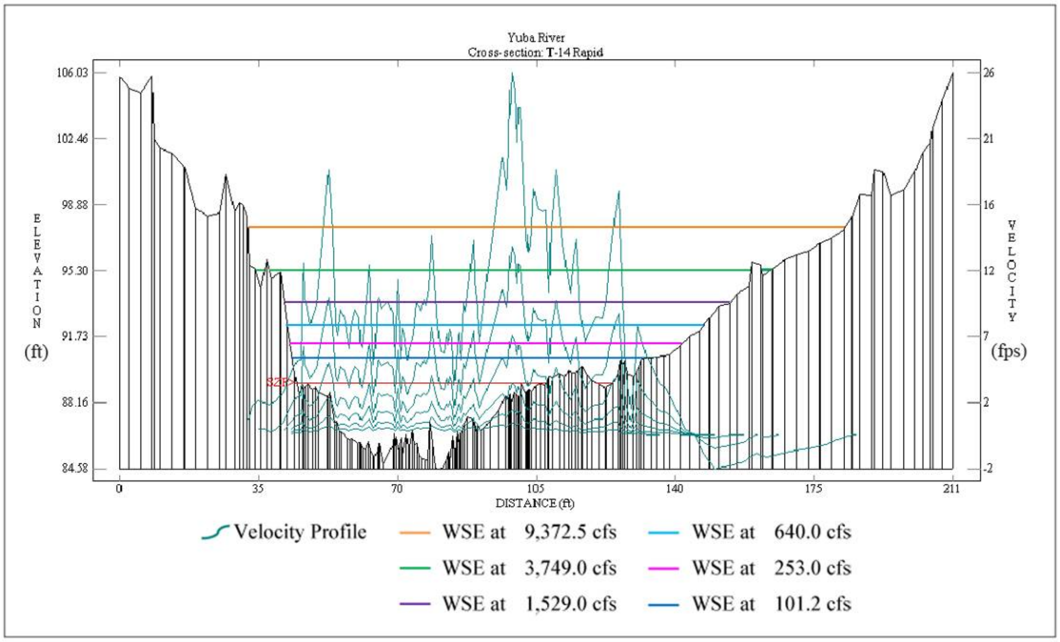

Figure A-13. Transect 14 (Rapid)

Figure A-14. Transect 14, looking from left bank towards right bank at High Flow (1529 cfs)

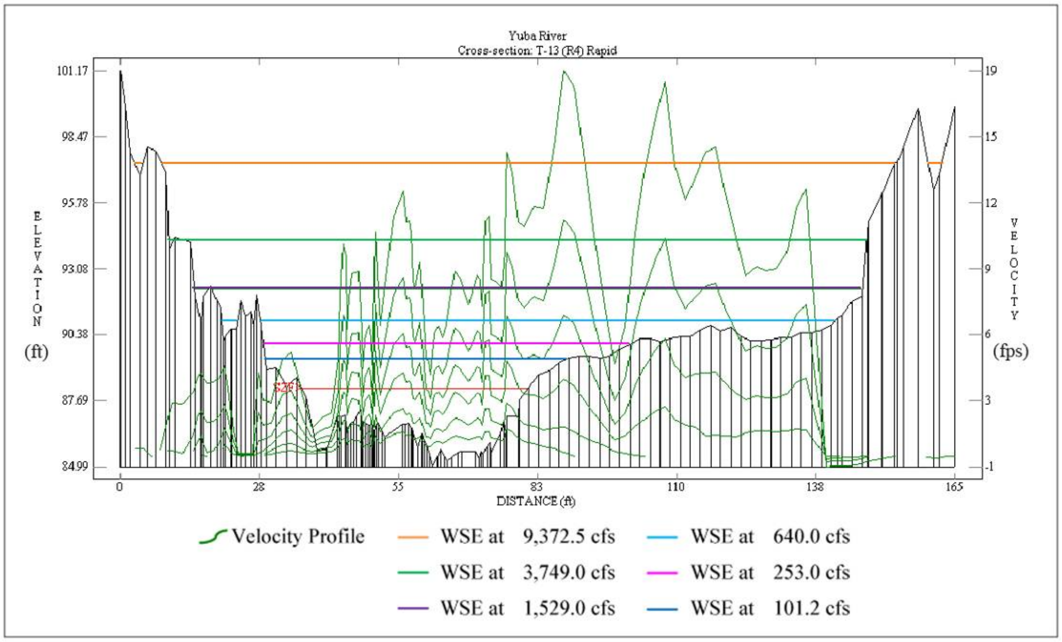

Figure A-15. Transect 13 (R4) (Rapid)

Figure A-16. Transect 13 Right, looking from left bank to right bank at High Flow (1529 cfs)

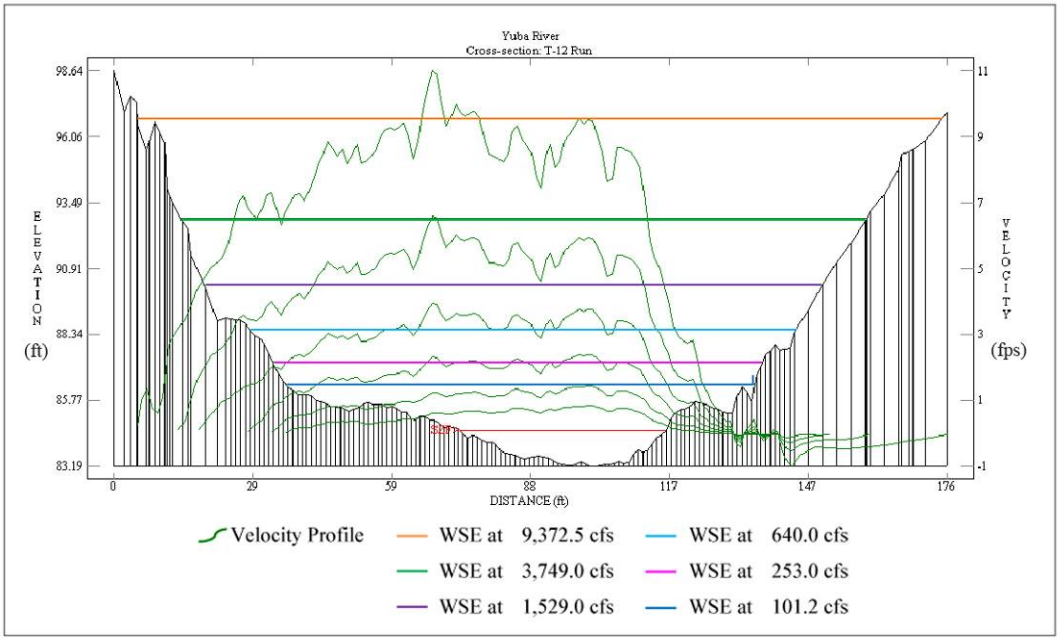

Figure A-17. Transect 12 (Run)

Figure A-18. Transect 12, looking from left bank towards right bank at Low Flow (253 cfs)

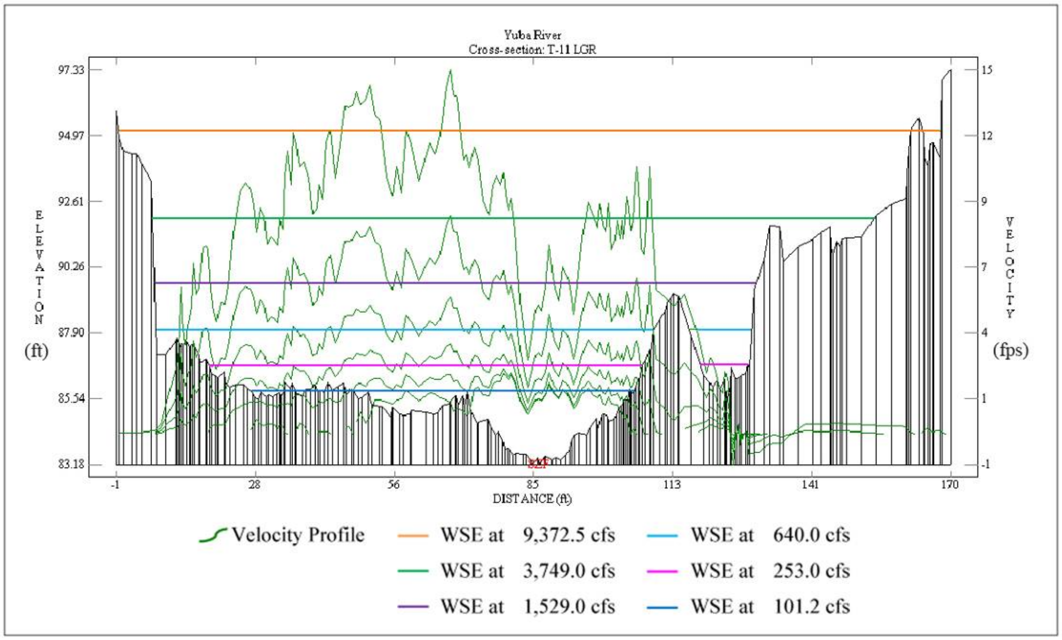

Figure A-19. Transect 11 (Low gradient riffle)

Figure A-20. Transect 11, looking from left bank towards right bank at Low Flow (253 cfs)

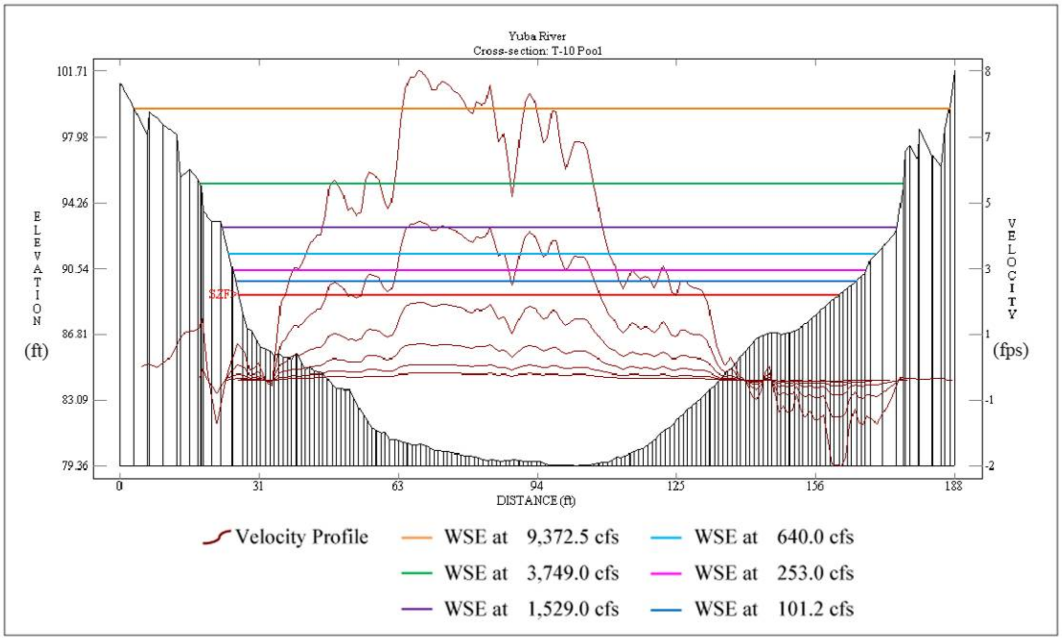

Figure A-21. Transect 10 (Pool)

Figure A-22. Transect 10, looking from downstream right bank at Low Flow (253 cfs)

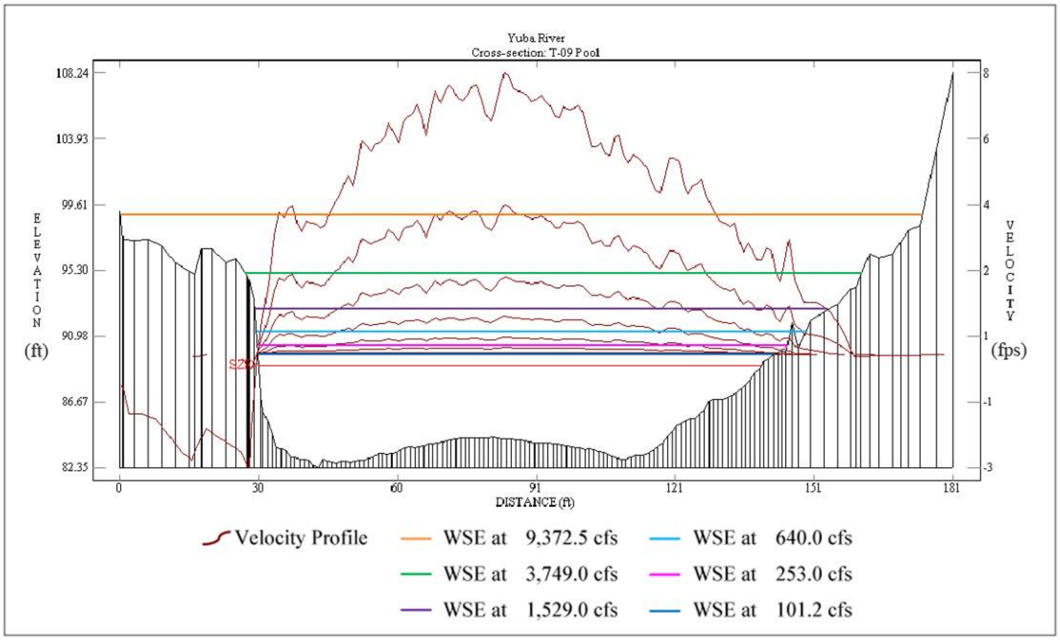

Figure A-23. Transect 09 (Pool)

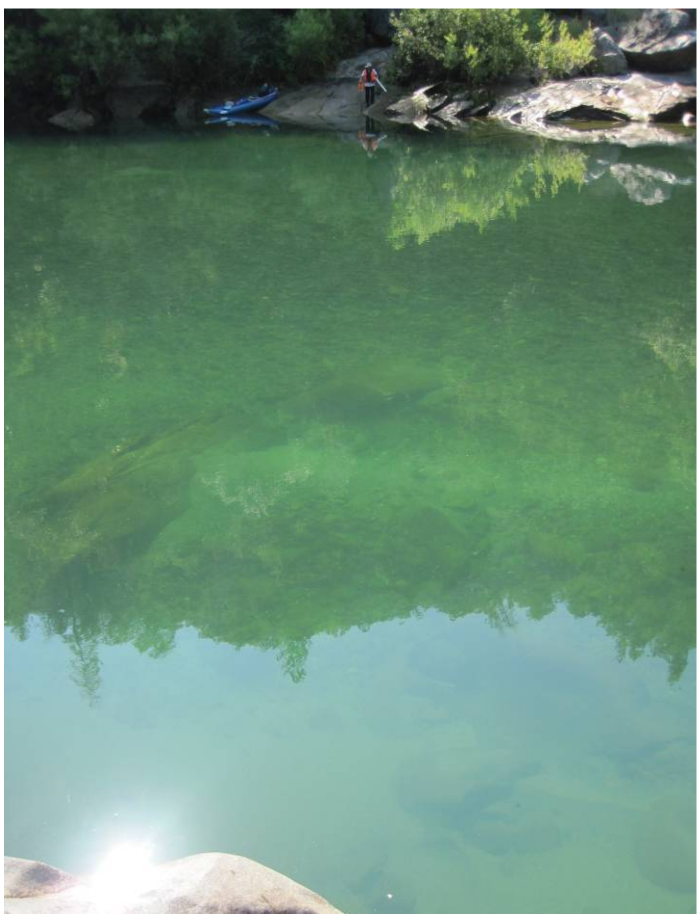

Figure A-24. Transect 09, looking from left bank towards right bank at Mid Flow (640 cfs)

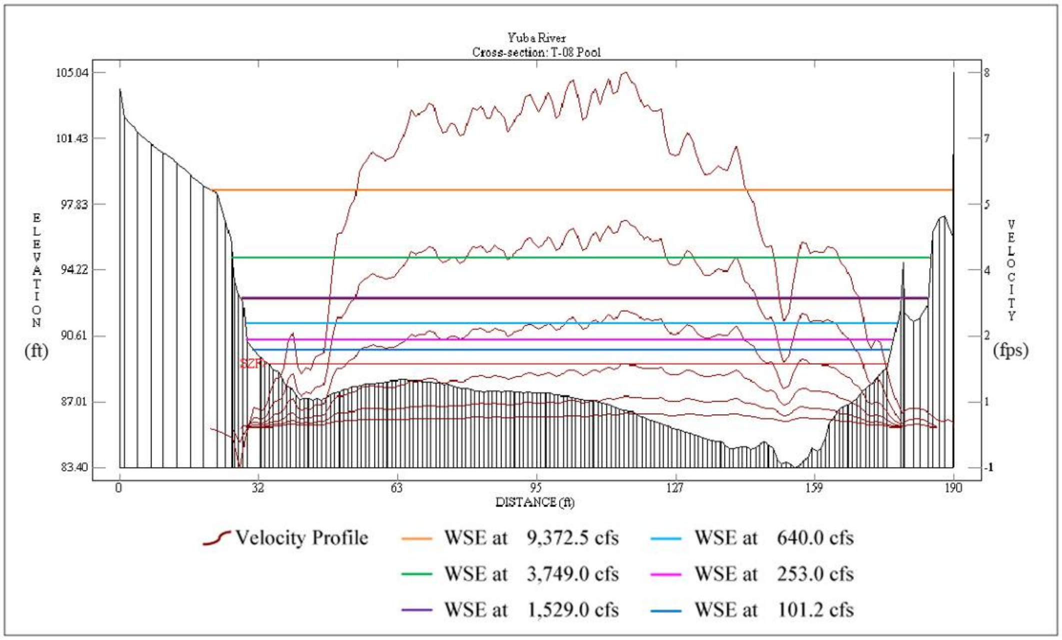

Figure A-25. Transect 08 (Pool)

Figure A-26. Transect 08, looking from left bank towards right bank at Low Flow (253 cfs)

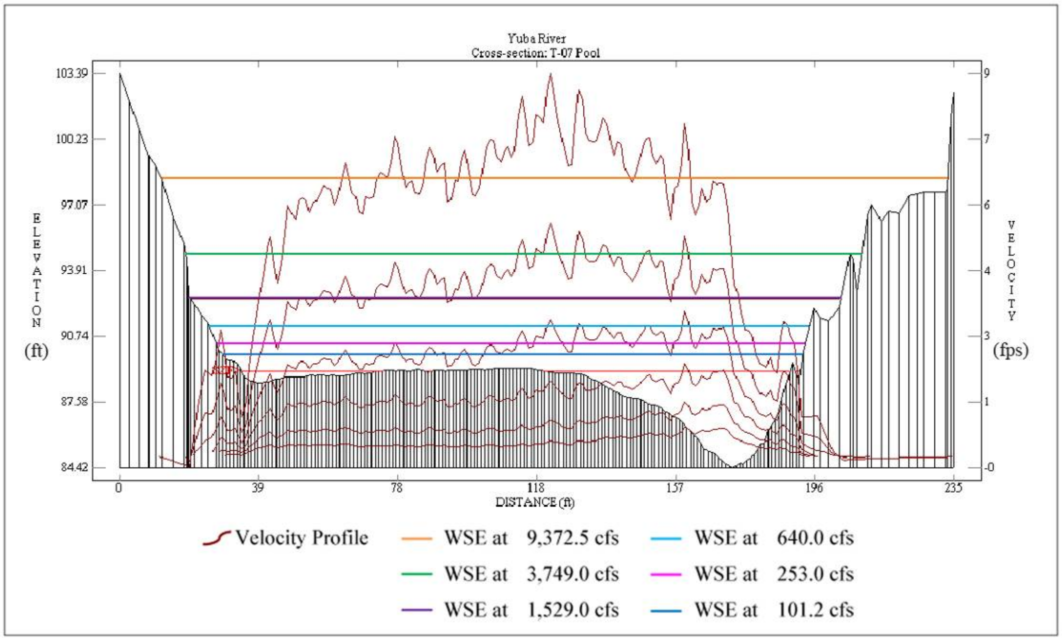

Figure A-27. Transect 07 (Pool)

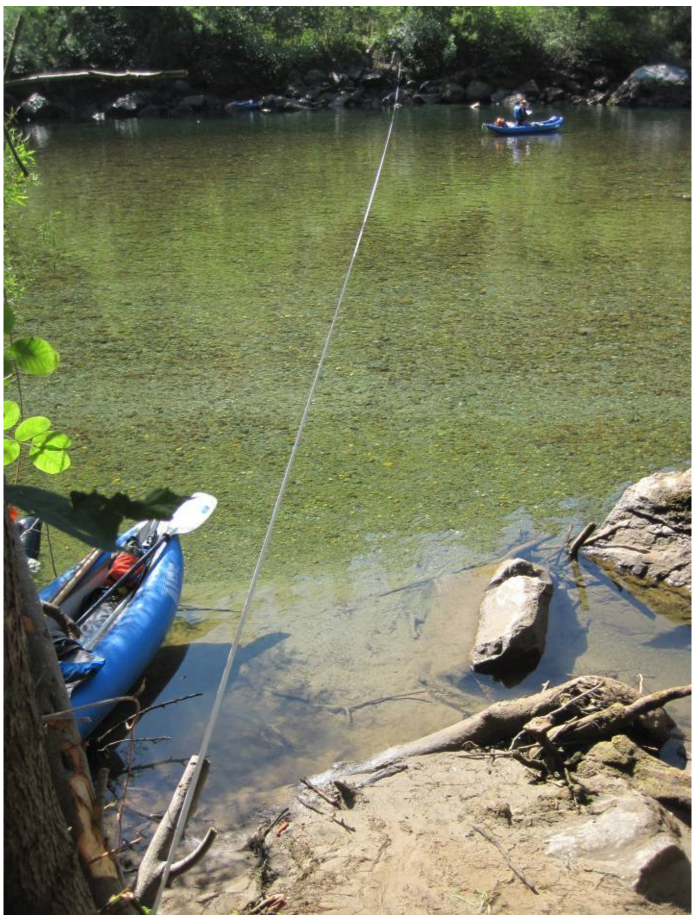

Figure A-28. Transect 07, looking from left bank towards right bank at Low Flow (253 cfs)

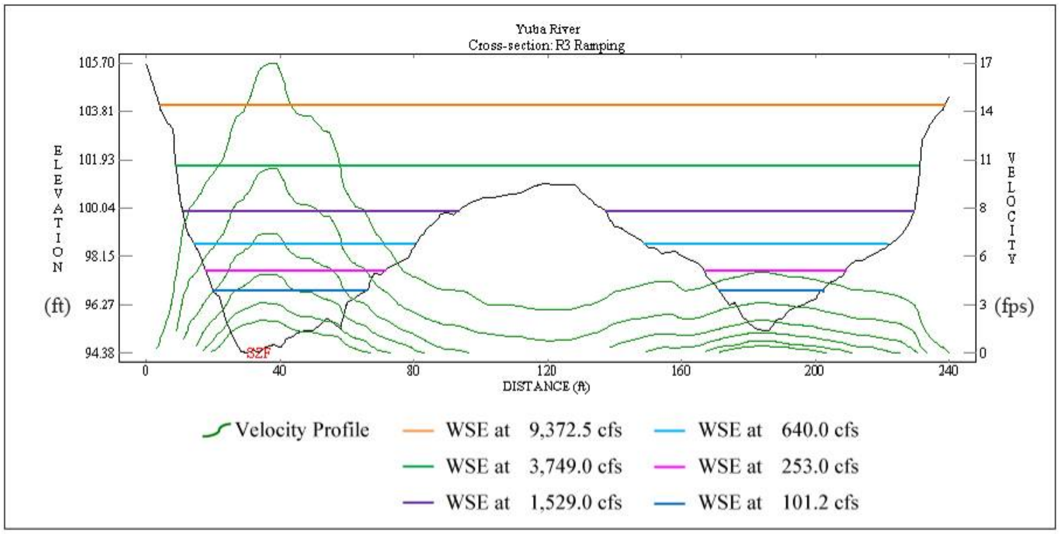

Figure A-29. Transect R3 (Run)

Figure A-30. Transect R3, looking from right bank to left bank at High-High Flow (~3200 cfs)

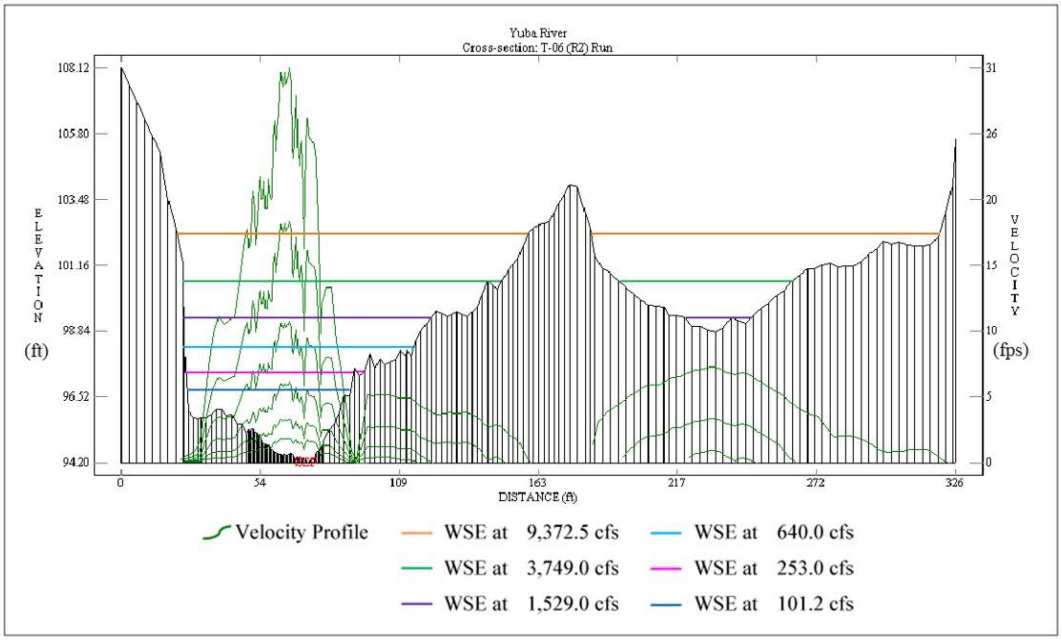

Figure A-31. Transect 06 (R2) (Run)

Figure A-32. Transect 06 (R2),looking from right bank towards left bank at High Flow (1529 cfs)

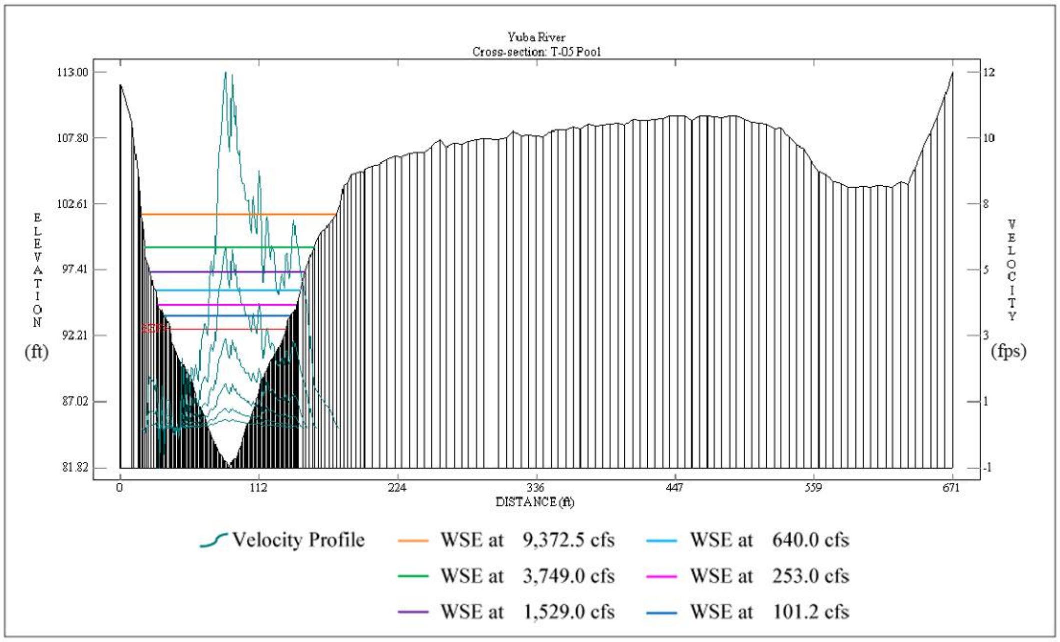

Figure A-33. Transect 05 (Pool)

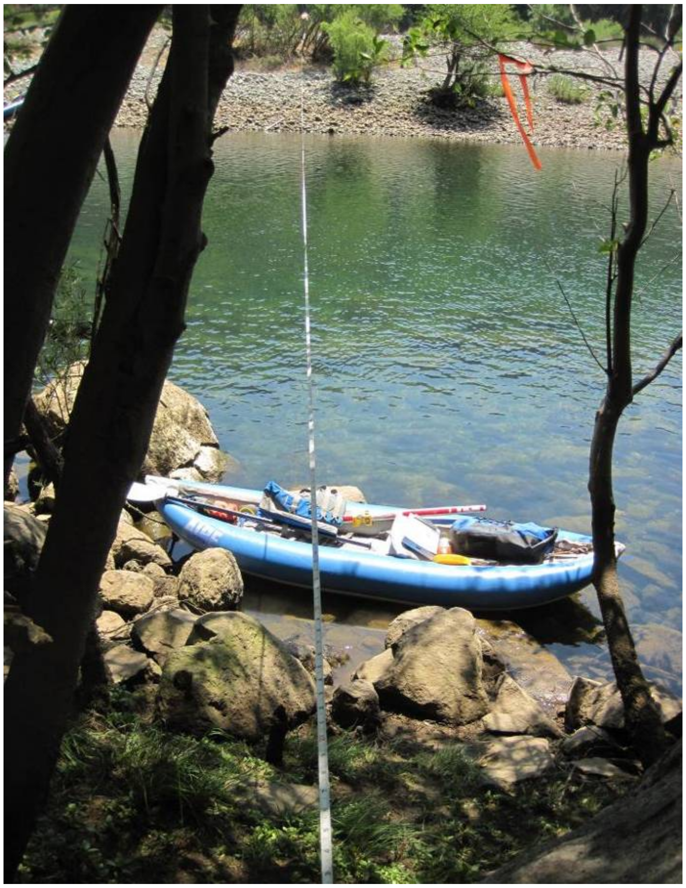

Figure A-34. Transect 05, looking from left bank towards right bank at Low Flow (253 cfs)

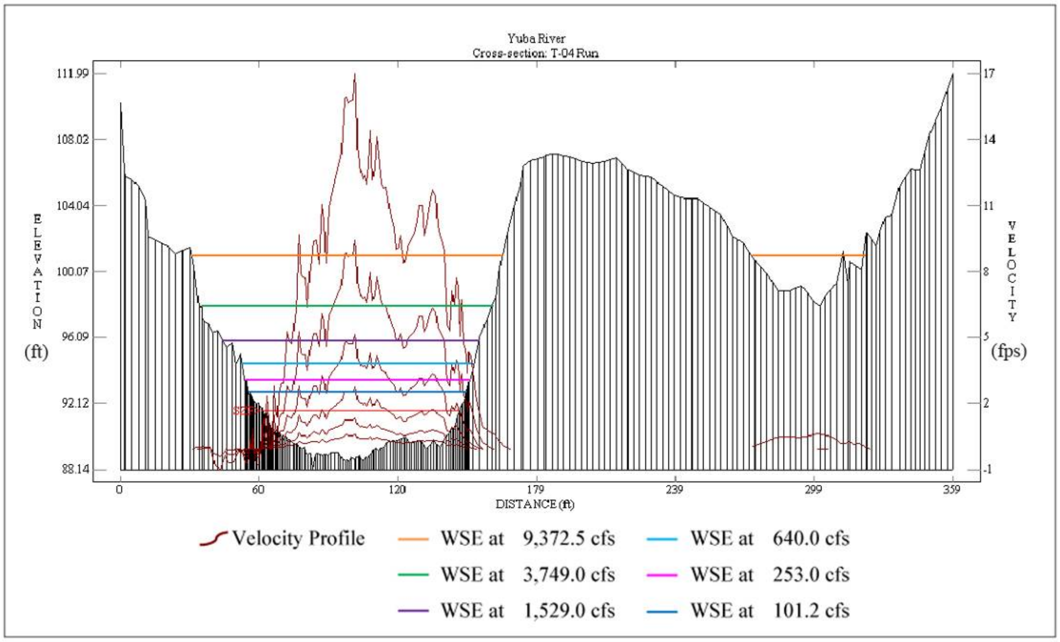

Figure A-35. Transect 04 (Run)

Figure A-36. Transect 04, looking from left bank to right bank at Low Flow (253 cfs)

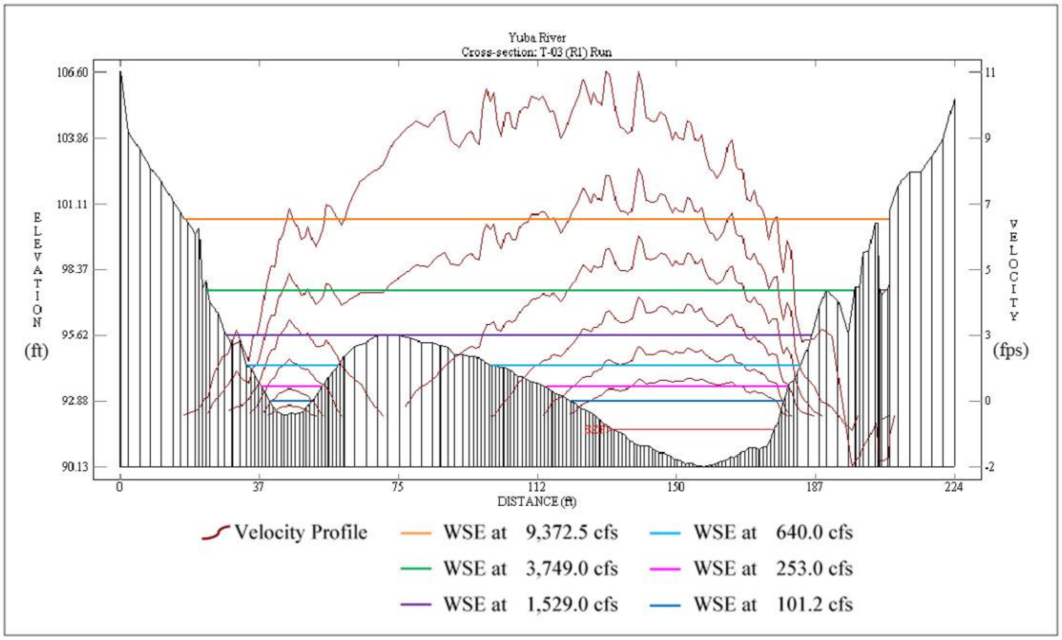

Figure A-37. Transect 03 (R1) (Run)

Figure A-38. Transect 03, looking from left bank to right bank at Low Flow (253 cfs)

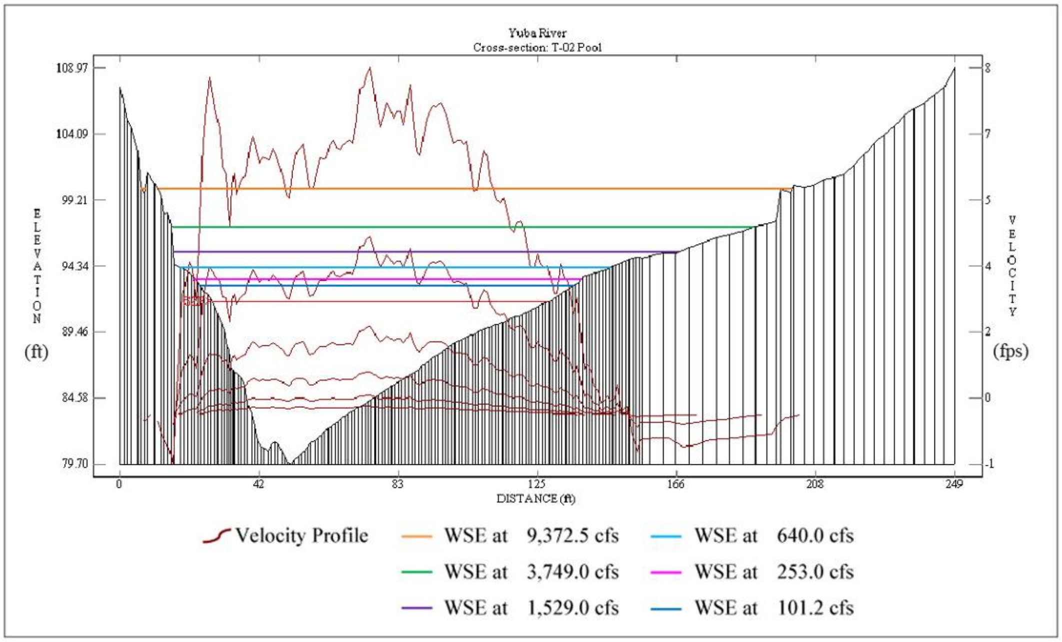

Figure A-39. Transect 02 (Pool)

Figure A-40. Transect 02, looking from left bank towards right bank at Low Flow (253 cfs)

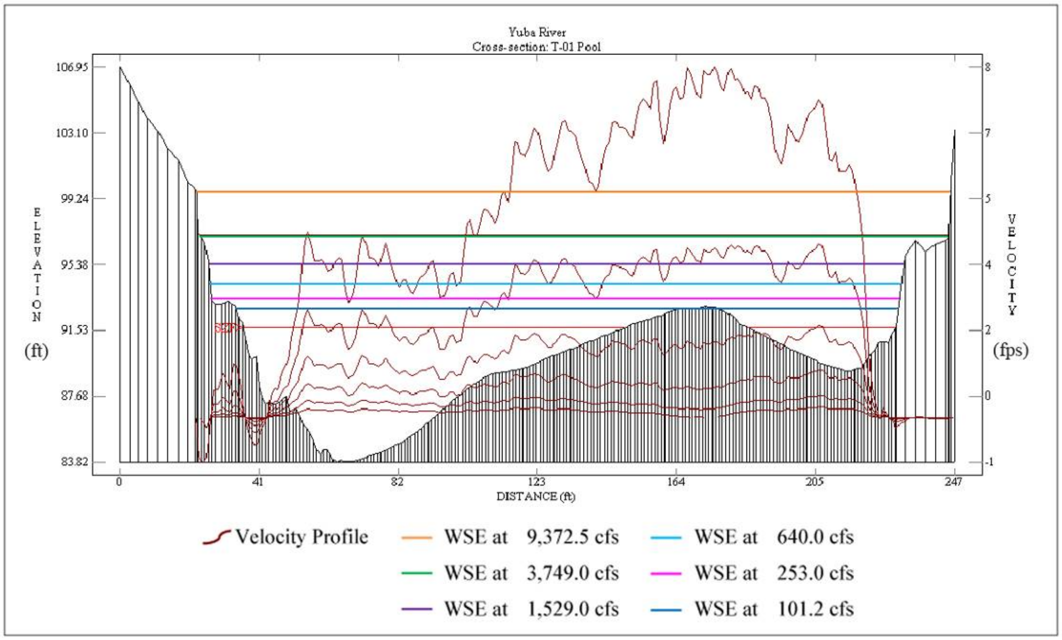

Figure A-41. Transect 01 (Pool)

Figure A-42. Transect 01, looking from left bank towards right bank at Low Flow (253 cfs)

Page Left Blank

Attachment 3-12D

Hydraulic Calibration Report

Appendix B

New Colgate Powerhouse Reach
Cross Section Adjustments

Yuba River Development Project

FERC Project No. 2246

December 2012

T-01

- Station 39.0 and 42.0, borrowed adjacent N values to release flow through cell at other simulation flows.

T-02

- No changes.

T-03 (R1)

- No changes.

T-04

- Adjusted SZF to 91.69 based knowledge of the transect and professional judgment of model accuracy.

T-05

- Stations 142.5-152.5: Adjusted roughness, based on nearby cells, to dampen a velocity spike

T-06 (R2)

- Stations 0.0 to 26.0 and 95.0 to end: Adjusted roughnesses, based on nearby cells, to decrease velocity troughs.
- Conducted a bedshift on the right side of the channel so a consistent water surface elevation for the entire transect would generate appropriate depths.

T-R3

- Removed farthest right point of profile data to prevent overbank flow at 2.5*[High-High Flow] discharge.
- Conducted a bedshift on the right side of the channel so a consistent water surface elevation for the entire transect would generate appropriate depths.
- N values across the transect were adjusted to bring velocities more in line with Transect T-06 (R2). Initial N values were uniform across the channel due to an absence of velocity measurements for the model to use to adjust the roughness.

T-07

- No changes.

T-08

- No changes.

T-09

- No changes.

T-10

- No changes.

T-11

- Extended left bank 0.5’ to prevent overbank flow at 2.5*[High-High Flow] discharge.

T-12

- Extended left bank 4.5’ to prevent overbank flow at 2.5*[High-High Flow] discharge.

T-13 (R4)

- Raised SZF from 87.37 to 88.20 to increase residual depth, based on knowledge of the transect and professional judgment.
- Stations 26.0-27.0: Adjusted roughness to remove unrealistic negative velocities.
- Stations 120.8-122.8: Adjusted roughness to remove unrealistic velocity trough.

T-14

- Stations 129.64-130.54: Made roughness values positive to remove unrealistic negative velocity spike

T-15

- Raised SZF from 88.99 to 89.30, based on knowledge of the transect and professional judgment, to improve model accuracy and performance.
- Stations 95.50- 97.50: Adjusted roughness to decrease velocity spike
- Station 102.65: Adjusted roughness to decrease velocity trough.
- Stations 102.00, 104.76, 105.09, 105.27, and 107.28: Adjusted roughness to dampen negative velocity spikes.

T-16 (R5)

- No changes.

T-17 (R6)

- Stations 86.66-88.17: Adjusted roughness to dampen negative velocity spike.
- Stations104.95-106.06 and 114.90-118.60: Adjusted roughness to dampen velocity spikes.

T-18 (R7)

- Stations 118.16-122.32: Adjusted roughness to dampen velocity spike.

T-19

- No changes.

T-20

- An incomplete velocity set was collected, so parts of this transect were only depth calibrated.

Attachment 3-12D

Hydraulic Calibration Report

Appendix C

New Colgate Powerhouse Reach
Water Surface Elevation Comparison Tables

Yuba River Development Project
FERC Project No. 2246

December 2012

List of Tables

Page Left Blank

Table C-1. Measured and Modeled WSEs.

Modeling Methods and Water Surface Elevations - New Colgate Powerhouse Reach														
Transect	**01**				**Transect**	**02**				**Transect**	**03 (R1)**			
Q	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**
253	**93.4**	93.39	93.24	93.39	**253**	**93.4**	93.39	93.24	93.39	**253**	**93.41**	93.4	93.3	93.46
640	**94.19**	94.22	94.19	94.22	**640**	**94.22**	94.24	94.21	94.24	**640**	**94.25**	94.3	94.35	94.36
1529	**95.39**	95.37	95.38	95.37	**1529**	**95.44**	95.43	95.53	95.42	**1529**	**95.7**	95.59	95.69	95.6
3749	**97.1**	97.1	97.09	97.1	**3749**	**97.25**	97.24	97.24	97.25	**3749**	**97.5**	97.57	97.49	97.5
Transect	**04**				**Transect**	**05**				**Transect**	**06 (R2)**			
Q	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**
253	**93.47**	93.47	93.44	93.52	**253**	**94.66**	94.64	94.42	--	**253**	**97.5**	97.41	97.24	--
640	**94.6**	94.59	94.61	94.53	**640**	**95.72**	95.77	95.72	--	**640**	**98.21**	98.27	98.2	--
1529	**96.02**	96.01	96.05	95.92	**1529**	**97.26**	97.22	97.25	--	**1529**	**99.07**	99.27	99.37	--
3749	**97.97**	97.98	97.96	97.97	**3749**	**99.24**	99.25	99.23	--	**3749**	**100.75**	100.57	100.74	--
Transect	**R3**				**Transect**	**07**				**Transect**	**08**			
Q	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**
253	**97.62**	97.57	97.57	--	**253**	**90.36**	90.38	90.36	90.38	**253**	**90.46**	90.43	90.45	90.4
640	**98.53**	98.63	98.64	--	**640**	**91.23**	91.23	90.86	91.23	**640**	**91.27**	91.36	91.45	91.29
1529	**99.95**	99.93	99.94	--	**1529**	**92.73**	92.54	92.02	92.54	**1529**	**92.83**	92.69	92.78	92.65
3749	**101.72**	101.69	101.71	--	**3749**	**94.49**	94.7	94.47	94.7	**3749**	**94.71**	94.79	94.69	94.9
Transect	**09**				**Transect**	**10**				**Transect**	**11**			
Q	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**
253	**90.42**	90.42	90.42	90.41	**253**	**90.44**	90.43	90.43	90.41	**253**	**86.72**	86.74	86.81	--
640	**91.27**	91.32	91.44	91.32	**640**	**91.3**	91.37	91.51	91.35	**640**	**88.05**	88.04	87.95	--
1529	**92.9**	92.72	92.85	92.73	**1529**	**93.05**	92.85	93.01	92.83	**1529**	**89.74**	89.69	89.5	--
3749	**94.9**	95.06	94.89	95.08	**3749**	**95.2**	95.36	95.19	95.37	**3749**	**91.92**	91.98	91.9	--
Transect	**12**				**Transect**	**13 (R4)**				**Transect**	**14**			
Q	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**
253	**87.24**	87.26	87.26	--	**253**	**89.97**	89.98	89.78	--	**253**	**91.46**	91.45	91.37	--
640	**88.56**	88.54	88.55	--	**640**	**91.03**	91	91.02	--	**640**	**92.35**	92.38	92.36	--
1529	**90.37**	90.28	90.3	--	**1529**	**92.32**	92.31	92.36	--	**1529**	**93.61**	93.59	93.6	--
3749	**92.78**	92.89	92.86	--	**3749**	**94.14**	94.16	94.13	--	**3749**	**95.33**	95.33	95.32	--
Transect	**15**				**Transect**	**16 (R5)**				**Transect**	**17 (R6)**			
Q	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**
253	**91.67**	91.67	91.66	--	**253**	**91.48**	91.53	91.54	91.53	**253**	**91.63**	91.63	91.48	91.59
640	**92.81**	92.84	92.89	--	**640**	**92.77**	92.69	92.76	92.69	**640**	**92.81**	92.82	92.8	92.82
1529	**94.5**	94.39	94.42	--	**1529**	**94.36**	94.25	94.34	94.25	**1529**	**94.47**	94.42	94.48	94.48
3749	**96.56**	96.65	96.55	--	**3749**	**96.4**	96.57	96.55	96.57	**3749**	**96.75**	96.78	96.73	96.89
Transect	**18 (R7)**				**Transect**	**19**				**Transect**	**20**			
Q	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**
253	**95.61**	95.62	95.61	--	**253**	**94.53**	94.5	94.34	94.5	**253**	**94.51**	94.47	94.32	94.5
640	**96.65**	96.65	96.72	--	**640**	**95.11**	95.15	95.11	95.15	**640**	**95.14**	95.19	95.13	95.18
1529	**98.22**	98.15	98.21	--	**1529**	**95.94**	96	96.03	96	**1529**	**96.06**	96.13	96.17	96.1
3749	**100.44**	100.51	100.43	--	**3749**	**97.26**	97.18	97.25	97.18	**3749**	**97.59**	97.5	97.58	97.52

Table C-2. Differences Between Measured and Modeled WSEs.

Differences Between Measured and Modeled WSEs														
Transect	**01**				**Transect**	**02**				**Transect**	**03 (R1)**			
Q	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**
253	**93.4**	-0.01	-0.16	-0.01	**253**	**93.4**	-0.01	-0.16	-0.01	**253**	**93.41**	-0.01	-0.11	0.05
640	**94.19**	0.03	0.00	0.03	**640**	**94.22**	0.02	-0.01	0.02	**640**	**94.25**	0.05	0.10	0.11
1529	**95.39**	-0.02	-0.01	-0.02	**1529**	**95.44**	-0.01	0.09	-0.02	**1529**	**95.7**	-0.11	-0.01	-0.10
3749	**97.1**	0.00	-0.01	0.00	**3749**	**97.25**	-0.01	-0.01	0.00	**3749**	**97.5**	0.07	-0.01	0.00
Transect	**04**				**Transect**	**05**				**Transect**	**06 (R2)**			
Q	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**
253	**93.47**	0.00	-0.03	0.05	**253**	**94.66**	-0.02	-0.24	--	**253**	**97.5**	-0.09	-0.26	--
640	**94.6**	-0.01	0.01	-0.07	**640**	**95.72**	0.05	0.00	--	**640**	**98.21**	0.06	-0.01	--
1529	**96.02**	-0.01	0.03	-0.10	**1529**	**97.26**	-0.04	-0.01	--	**1529**	**99.07**	0.20	0.30	--
3749	**97.97**	0.01	-0.01	0.00	**3749**	**99.24**	0.01	-0.01	--	**3749**	**100.75**	-0.18	-0.01	--
Transect	**R3**				**Transect**	**07**				**Transect**	**08**			
Q	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**
253	**97.62**	-0.05	-0.05	--	**253**	**90.36**	0.02	0.00	0.02	**253**	**90.46**	-0.03	-0.01	-0.06
640	**98.53**	0.10	0.11	--	**640**	**91.23**	0.00	-0.37	0.00	**640**	**91.27**	0.09	0.18	0.02
1529	**99.95**	-0.02	-0.01	--	**1529**	**92.73**	-0.19	-0.71	-0.19	**1529**	**92.83**	-0.14	-0.05	-0.18
3749	**101.72**	-0.03	-0.01	--	**3749**	**94.49**	0.21	-0.02	0.21	**3749**	**94.71**	0.08	-0.02	0.19
Transect	**09**				**Transect**	**10**				**Transect**	**11**			
Q	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**
253	**90.42**	0.00	0.00	-0.01	**253**	**90.44**	-0.01	-0.01	-0.03	**253**	**86.72**	0.02	0.09	--
640	**91.27**	0.05	0.17	0.05	**640**	**91.3**	0.07	0.21	0.05	**640**	**88.05**	-0.01	-0.10	--
1529	**92.9**	-0.18	-0.05	-0.17	**1529**	**93.05**	-0.20	-0.04	-0.22	**1529**	**89.74**	-0.05	-0.24	--
3749	**94.9**	0.16	-0.01	0.18	**3749**	**95.2**	0.16	-0.01	0.17	**3749**	**91.92**	0.06	-0.02	--
Transect	**12**				**Transect**	**13 (R4)**				**Transect**	**14**			
Q	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**
253	**87.24**	0.02	0.02	--	**253**	**89.97**	0.01	-0.19	--	**253**	**91.46**	-0.01	-0.09	--
640	**88.56**	-0.02	-0.01	--	**640**	**91.03**	-0.03	-0.01	--	**640**	**92.35**	0.03	0.01	--
1529	**90.37**	-0.09	-0.07	--	**1529**	**92.32**	-0.01	0.04	--	**1529**	**93.61**	-0.02	-0.01	--
3749	**92.78**	0.11	0.08	--	**3749**	**94.14**	0.02	-0.01	--	**3749**	**95.33**	0.00	-0.01	--
Transect	**15**				**Transect**	**16 (R5)**				**Transect**	**17 (R6)**			
Q	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**
253	**91.67**	0.00	-0.01	--	**253**	**91.48**	0.05	0.06	0.05	**253**	**91.63**	0.00	-0.15	-0.04
640	**92.81**	0.03	0.08	--	**640**	**92.77**	-0.08	-0.01	-0.08	**640**	**92.81**	0.01	-0.01	0.01
1529	**94.5**	-0.11	-0.08	--	**1529**	**94.36**	-0.11	-0.02	-0.11	**1529**	**94.47**	-0.05	0.01	0.01
3749	**96.56**	0.09	-0.01	--	**3749**	**96.4**	0.17	0.15	0.17	**3749**	**96.75**	0.03	-0.02	0.14
Transect	**18 (R7)**				**Transect**	**19**				**Transect**	**20**			
Q	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**WSP**
253	**95.61**	0.01	0.00	--	**253**	**94.53**	-0.03	-0.19	-0.03	**253**	**94.51**	-0.04	-0.19	-0.01
640	**96.65**	0.00	0.07	--	**640**	**95.11**	0.04	0.00	0.04	**640**	**95.14**	0.05	-0.01	0.04
1529	**98.22**	-0.07	-0.01	--	**1529**	**95.94**	0.06	0.09	0.06	**1529**	**96.06**	0.07	0.11	0.04
3749	**100.44**	0.07	-0.01	--	**3749**	**97.26**	-0.08	-0.01	-0.08	**3749**	**97.59**	-0.09	-0.01	-0.07

Technical Memorandum 3-12

New Colgate Powerhouse Ramping

Attachment 3-12E

Ramping Wedge Tables

Yuba River Development Project

FERC Project No. 2246

December 2012

List of Tables

Table No. **Description** **Page No.**

List of Tables (continued)

Table No. Description Page No.

List of Tables (continued)

Table No. **Description** **Page No.**

Page Left Blank

Magnitude Change in Wetted Perimeter

Page Left Blank

Tables 1—7 show the magnitude change in wetted perimeter from a starting discharge to an ending discharge. Magnitude change in wetted perimeter is calculated based on the difference between starting wetted perimeter and ending wetted perimeter. The table shows starting discharges in descending order along the table's left column and ending discharges in descending order from left to right along the top row.

Table 1. Transect R1: Magnitude change in wetted perimeter as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Wetted Perimeter (ft)	Ending discharge (cfs), Ending Wetted Perimeter (ft), and Magnitude Change in Wetted Perimeter																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		192.05	189.54	188.08	186.80	184.96	179.86	174.20	171.29	168.09	165.36	162.53	152.91	146.65	132.48	125.64	114.60	107.76	102.01	96.89	90.73	82.67	78.67	74.13	69.94
6,500	192.05	0.00	2.51	3.97	5.25	7.09	12.19	17.85	20.76	23.96	26.69	29.52	39.14	45.40	59.57	66.41	77.45	84.29	90.04	95.16	101.32	109.38	113.38	117.92	122.11
6,000	189.54	--	0.00	1.46	2.74	4.58	9.68	15.34	18.25	21.45	24.18	27.01	36.63	42.89	57.06	63.90	74.94	81.78	87.53	92.65	98.81	106.87	110.87	115.41	119.60
5,400	188.08	--	--	0.00	1.28	3.12	8.22	13.88	16.79	19.99	22.72	25.55	35.17	41.43	55.60	62.44	73.48	80.32	86.07	91.19	97.35	105.41	109.41	113.95	118.14
4,900	186.80	--	--	--	0.00	1.84	6.94	12.60	15.51	18.71	21.44	24.27	33.89	40.15	54.32	61.16	72.20	79.04	84.79	89.91	96.07	104.13	108.13	112.67	116.86
4,300	184.96	--	--	--	--	0.00	5.10	10.76	13.67	16.87	19.60	22.43	32.05	38.31	52.48	59.32	70.36	77.20	82.95	88.07	94.23	102.29	106.29	110.83	115.02
3,749	179.86	--	--	--	--	--	0.00	5.66	8.57	11.77	14.50	17.33	26.95	33.21	47.38	54.22	65.26	72.10	77.85	82.97	89.13	97.19	101.19	105.73	109.92
3,300	174.20	--	--	--	--	--	--	0.00	2.91	6.11	8.84	11.67	21.29	27.55	41.72	48.56	59.60	66.44	72.19	77.31	83.47	91.53	95.53	100.07	104.26
2,950	171.29	--	--	--	--	--	--	--	0.00	3.20	5.93	8.76	18.38	24.64	38.81	45.65	56.69	63.53	69.28	74.40	80.56	88.62	92.62	97.16	101.35
2,600	168.09	--	--	--	--	--	--	--	--	0.00	2.73	5.56	15.18	21.44	35.61	42.45	53.49	60.33	66.08	71.20	77.36	85.42	89.42	93.96	98.15
2,250	165.36	--	--	--	--	--	--	--	--	--	0.00	2.83	12.45	18.71	32.88	39.72	50.76	57.60	63.35	68.47	74.63	82.69	86.69	91.23	95.42
1,900	162.53	--	--	--	--	--	--	--	--	--	--	0.00	9.62	15.88	30.05	36.89	47.93	54.77	60.52	65.64	71.80	79.86	83.86	88.40	92.59
1,529	152.91	--	--	--	--	--	--	--	--	--	--	--	0.00	6.26	20.43	27.27	38.31	45.15	50.90	56.02	62.18	70.24	74.24	78.78	82.97
1,400	146.65	--	--	--	--	--	--	--	--	--	--	--	--	0.00	14.17	21.01	32.05	38.89	44.64	49.76	55.92	63.98	67.98	72.52	76.71
1,200	132.48	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	6.84	17.88	24.72	30.47	35.59	41.75	49.81	53.81	58.35	62.54
1,000	125.64	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	11.04	17.88	23.63	28.75	34.91	42.97	46.97	51.51	55.70
800	114.60	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	6.84	12.59	17.71	23.87	31.93	35.93	40.47	44.66
640	107.76	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	5.75	10.87	17.03	25.09	29.09	33.63	37.82
550	102.01	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	5.12	11.28	19.34	23.34	27.88	32.07
450	96.89	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	6.16	14.22	18.22	22.76	26.95
350	90.73	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	8.06	12.06	16.60	20.79
253	82.67	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	4.00	8.54	12.73
200	78.67	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	4.54	8.73
150	74.13	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	4.19
101	69.94	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00

Table 2. Transect R2: Magnitude change in wetted perimeter as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Wetted Perimeter (ft)	Ending discharge (cfs), Ending Wetted Perimeter (ft), and Magnitude Change in Wetted Perimeter																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		244.94	240.99	232.22	212.19	203.86	195.72	186.31	179.64	173.42	166.53	152.97	123.85	115.75	105.48	94.94	93.04	92.04	90.29	83.73	75.24	69.84	66.51	65.77	64.85
6,500	244.94	0.00	3.95	12.72	32.75	41.08	49.22	58.63	65.30	71.52	78.41	91.97	121.09	129.19	139.46	150.00	151.90	152.90	154.65	161.21	169.70	175.10	178.43	179.17	180.09
6,000	240.99	--	0.00	8.77	28.80	37.13	45.27	54.68	61.35	67.57	74.46	88.02	117.14	125.24	135.51	146.05	147.95	148.95	150.70	157.26	165.75	171.15	174.48	175.22	176.14
5,400	232.22	--	--	0.00	20.03	28.36	36.50	45.91	52.58	58.80	65.69	79.25	108.37	116.47	126.74	137.28	139.18	140.18	141.93	148.49	156.98	162.38	165.71	166.45	167.37
4,900	212.19	--	--	--	0.00	8.33	16.47	25.88	32.55	38.77	45.66	59.22	88.34	96.44	106.71	117.25	119.15	120.15	121.90	128.46	136.95	142.35	145.68	146.42	147.34
4,300	203.86	--	--	--	--	0.00	8.14	17.55	24.22	30.44	37.33	50.89	80.01	88.11	98.38	108.92	110.82	111.82	113.57	120.13	128.62	134.02	137.35	138.09	139.01
3,749	195.72	--	--	--	--	--	0.00	9.41	16.08	22.30	29.19	42.75	71.87	79.97	90.24	100.78	102.68	103.68	105.43	111.99	120.48	125.88	129.21	129.95	130.87
3,300	186.31	--	--	--	--	--	--	0.00	6.67	12.89	19.78	33.34	62.46	70.56	80.83	91.37	93.27	94.27	96.02	102.58	111.07	116.47	119.80	120.54	121.46
2,950	179.64	--	--	--	--	--	--	--	0.00	6.22	13.11	26.67	55.79	63.89	74.16	84.70	86.60	87.60	89.35	95.91	104.40	109.80	113.13	113.87	114.79
2,600	173.42	--	--	--	--	--	--	--	--	0.00	6.89	20.45	49.57	57.67	67.94	78.48	80.38	81.38	83.13	89.69	98.18	103.58	106.91	107.65	108.57
2,250	166.53	--	--	--	--	--	--	--	--	--	0.00	13.56	42.68	50.78	61.05	71.59	73.49	74.49	76.24	82.80	91.29	96.69	100.02	100.76	101.68
1,900	152.97	--	--	--	--	--	--	--	--	--	--	0.00	29.12	37.22	47.49	58.03	59.93	60.93	62.68	69.24	77.73	83.13	86.46	87.20	88.12
1,529	123.85	--	--	--	--	--	--	--	--	--	--	--	0.00	8.10	18.37	28.91	30.81	31.81	33.56	40.12	48.61	54.01	57.34	58.08	59.00
1,400	115.75	--	--	--	--	--	--	--	--	--	--	--	--	0.00	10.27	20.81	22.71	23.71	25.46	32.02	40.51	45.91	49.24	49.98	50.90
1,200	105.48	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	10.54	12.44	13.44	15.19	21.75	30.24	35.64	38.97	39.71	40.63
1,000	94.94	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	1.90	2.90	4.65	11.21	19.70	25.10	28.43	29.17	30.09
800	93.04	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	1.00	2.75	9.31	17.80	23.20	26.53	27.27	28.19
640	92.04	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	1.75	8.31	16.80	22.20	25.53	26.27	27.19
550	90.29	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	6.56	15.05	20.45	23.78	24.52	25.44
450	83.73	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	8.49	13.89	17.22	17.96	18.88
350	75.24	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	5.40	8.73	9.47	10.39
253	69.84	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	3.33	4.07	4.99
200	66.51	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	0.74	1.66
150	65.77	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	0.92
101	64.85	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00

Table 3. Transect R3: Magnitude change in wetted perimeter as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Wetted Perimeter (ft)	Ending discharge (cfs), Ending Wetted Perimeter (ft), and Magnitude Change in Wetted Perimeter																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		230.50	229.42	228.46	227.88	227.13	226.38	225.70	225.13	211.97	203.47	187.68	177.39	170.76	166.33	159.14	150.14	141.20	133.94	120.80	106.90	96.97	90.28	83.17	77.47
6,500	230.50	0.00	1.08	2.04	2.62	3.37	4.12	4.80	5.37	18.53	27.03	42.82	53.11	59.74	64.17	71.36	80.36	89.30	96.56	109.70	123.60	133.53	140.22	147.33	153.03
6,000	229.42	--	0.00	0.96	1.54	2.29	3.04	3.72	4.29	17.45	25.95	41.74	52.03	58.66	63.09	70.28	79.28	88.22	95.48	108.62	122.52	132.45	139.14	146.25	151.95
5,400	228.46	--	--	0.00	0.58	1.33	2.08	2.76	3.33	16.49	24.99	40.78	51.07	57.70	62.13	69.32	78.32	87.26	94.52	107.66	121.56	131.49	138.18	145.29	150.99
4,900	227.88	--	--	--	0.00	0.75	1.50	2.18	2.75	15.91	24.41	40.20	50.49	57.12	61.55	68.74	77.74	86.68	93.94	107.08	120.98	130.91	137.60	144.71	150.41
4,300	227.13	--	--	--	--	0.00	0.75	1.43	2.00	15.16	23.66	39.45	49.74	56.37	60.80	67.99	76.99	85.93	93.19	106.33	120.23	130.16	136.85	143.96	149.66
3,749	226.38	--	--	--	--	--	0.00	0.68	1.25	14.41	22.91	38.70	48.99	55.62	60.05	67.24	76.24	85.18	92.44	105.58	119.48	129.41	136.10	143.21	148.91
3,300	225.70	--	--	--	--	--	--	0.00	0.57	13.73	22.23	38.02	48.31	54.94	59.37	66.56	75.56	84.50	91.76	104.90	118.80	128.73	135.42	142.53	148.23
2,950	225.13	--	--	--	--	--	--	--	0.00	13.16	21.66	37.45	47.74	54.37	58.80	65.99	74.99	83.93	91.19	104.33	118.23	128.16	134.85	141.96	147.66
2,600	211.97	--	--	--	--	--	--	--	--	0.00	8.50	24.29	34.58	41.21	45.64	52.83	61.83	70.77	78.03	91.17	105.07	115.00	121.69	128.80	134.50
2,250	203.47	--	--	--	--	--	--	--	--	--	0.00	15.79	26.08	32.71	37.14	44.33	53.33	62.27	69.53	82.67	96.57	106.50	113.19	120.30	126.00
1,900	187.68	--	--	--	--	--	--	--	--	--	--	0.00	10.29	16.92	21.35	28.54	37.54	46.48	53.74	66.88	80.78	90.71	97.40	104.51	110.21
1,529	177.39	--	--	--	--	--	--	--	--	--	--	--	0.00	6.63	11.06	18.25	27.25	36.19	43.45	56.59	70.49	80.42	87.11	94.22	99.92
1,400	170.76	--	--	--	--	--	--	--	--	--	--	--	--	0.00	4.43	11.62	20.62	29.56	36.82	49.96	63.86	73.79	80.48	87.59	93.29
1,200	166.33	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	7.19	16.19	25.13	32.39	45.53	59.43	69.36	76.05	83.16	88.86
1,000	159.14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	9.00	17.94	25.20	38.34	52.24	62.17	68.86	75.97	81.67
800	150.14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	8.94	16.20	29.34	43.24	53.17	59.86	66.97	72.67
640	141.20	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	7.26	20.40	34.30	44.23	50.92	58.03	63.73
550	133.94	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	13.14	27.04	36.97	43.66	50.77	56.47
450	120.80	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	13.90	23.83	30.52	37.63	43.33
350	106.90	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	9.93	16.62	23.73	29.43
253	96.97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	6.69	13.80	19.50
200	90.28	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	7.11	12.81
150	83.17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	5.70
101	77.47	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00

Table 4. Transect R4: Magnitude change in wetted perimeter as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Wetted Perimeter (ft)	Ending discharge (cfs), Ending Wetted Perimeter (ft), and Magnitude Change in Wetted Perimeter																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		159.72	158.73	157.49	156.39	155.47	153.30	149.51	148.65	148.00	147.30	146.53	145.08	143.78	140.76	136.08	131.20	126.30	124.46	113.11	103.27	79.95	77.93	76.27	66.90
6,500	159.72	0.00	0.99	2.23	3.33	4.25	6.42	10.21	11.07	11.72	12.42	13.19	14.64	15.94	18.96	23.64	28.52	33.42	35.26	46.61	56.45	79.77	81.79	83.45	92.82
6,000	158.73	--	0.00	1.24	2.34	3.26	5.43	9.22	10.08	10.73	11.43	12.20	13.65	14.95	17.97	22.65	27.53	32.43	34.27	45.62	55.46	78.78	80.80	82.46	91.83
5,400	157.49	--	--	0.00	1.10	2.02	4.19	7.98	8.84	9.49	10.19	10.96	12.41	13.71	16.73	21.41	26.29	31.19	33.03	44.38	54.22	77.54	79.56	81.22	90.59
4,900	156.39	--	--	--	0.00	0.92	3.09	6.88	7.74	8.39	9.09	9.86	11.31	12.61	15.63	20.31	25.19	30.09	31.93	43.28	53.12	76.44	78.46	80.12	89.49
4,300	155.47	--	--	--	--	0.00	2.17	5.96	6.82	7.47	8.17	8.94	10.39	11.69	14.71	19.39	24.27	29.17	31.01	42.36	52.20	75.52	77.54	79.20	88.57
3,749	153.30	--	--	--	--	--	0.00	3.79	4.65	5.30	6.00	6.77	8.22	9.52	12.54	17.22	22.10	27.00	28.84	40.19	50.03	73.35	75.37	77.03	86.40
3,300	149.51	--	--	--	--	--	--	0.00	0.86	1.51	2.21	2.98	4.43	5.73	8.75	13.43	18.31	23.21	25.05	36.40	46.24	69.56	71.58	73.24	82.61
2,950	148.65	--	--	--	--	--	--	--	0.00	0.65	1.35	2.12	3.57	4.87	7.89	12.57	17.45	22.35	24.19	35.54	45.38	68.70	70.72	72.38	81.75
2,600	148.00	--	--	--	--	--	--	--	--	0.00	0.70	1.47	2.92	4.22	7.24	11.92	16.80	21.70	23.54	34.89	44.73	68.05	70.07	71.73	81.10
2,250	147.30	--	--	--	--	--	--	--	--	--	0.00	0.77	2.22	3.52	6.54	11.22	16.10	21.00	22.84	34.19	44.03	67.35	69.37	71.03	80.40
1,900	146.53	--	--	--	--	--	--	--	--	--	--	0.00	1.45	2.75	5.77	10.45	15.33	20.23	22.07	33.42	43.26	66.58	68.60	70.26	79.63
1,529	145.08	--	--	--	--	--	--	--	--	--	--	--	0.00	1.30	4.32	9.00	13.88	18.78	20.62	31.97	41.81	65.13	67.15	68.81	78.18
1,400	143.78	--	--	--	--	--	--	--	--	--	--	--	--	0.00	3.02	7.70	12.58	17.48	19.32	30.67	40.51	63.83	65.85	67.51	76.88
1,200	140.76	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	4.68	9.56	14.46	16.30	27.65	37.49	60.81	62.83	64.49	73.86
1,000	136.08	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	4.88	9.78	11.62	22.97	32.81	56.13	58.15	59.81	69.18
800	131.20	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	4.90	6.74	18.09	27.93	51.25	53.27	54.93	64.30
640	126.30	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	1.84	13.19	23.03	46.35	48.37	50.03	59.40
550	124.46	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	11.35	21.19	44.51	46.53	48.19	57.56
450	113.11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	9.84	33.16	35.18	36.84	46.21
350	103.27	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	23.32	25.34	27.00	36.37
253	79.95	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	2.02	3.68	13.05
200	77.93	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	1.66	11.03
150	76.27	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	9.37
101	66.90	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00

Table 5. Transect R5: Magnitude change in wetted perimeter as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Wetted Perimeter (ft)	Ending discharge (cfs), Ending Wetted Perimeter (ft), and Magnitude Change in Wetted Perimeter																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		148.73	145.59	140.00	130.10	123.75	120.22	116.43	115.24	114.36	112.88	110.45	107.68	106.47	104.68	102.77	100.36	98.40	97.10	95.50	92.83	90.36	88.68	87.40	85.74
6,500	148.73	0.00	3.14	8.73	18.63	24.98	28.51	32.30	33.49	34.37	35.85	38.28	41.05	42.26	44.05	45.96	48.37	50.33	51.63	53.23	55.90	58.37	60.05	61.33	62.99
6,000	145.59	--	0.00	5.59	15.49	21.84	25.37	29.16	30.35	31.23	32.71	35.14	37.91	39.12	40.91	42.82	45.23	47.19	48.49	50.09	52.76	55.23	56.91	58.19	59.85
5,400	140.00	--	--	0.00	9.90	16.25	19.78	23.57	24.76	25.64	27.12	29.55	32.32	33.53	35.32	37.23	39.64	41.60	42.90	44.50	47.17	49.64	51.32	52.60	54.26
4,900	130.10	--	--	--	0.00	6.35	9.88	13.67	14.86	15.74	17.22	19.65	22.42	23.63	25.42	27.33	29.74	31.70	33.00	34.60	37.27	39.74	41.42	42.70	44.36
4,300	123.75	--	--	--	--	0.00	3.53	7.32	8.51	9.39	10.87	13.30	16.07	17.28	19.07	20.98	23.39	25.35	26.65	28.25	30.92	33.39	35.07	36.35	38.01
3,749	120.22	--	--	--	--	--	0.00	3.79	4.98	5.86	7.34	9.77	12.54	13.75	15.54	17.45	19.86	21.82	23.12	24.72	27.39	29.86	31.54	32.82	34.48
3,300	116.43	--	--	--	--	--	--	0.00	1.19	2.07	3.55	5.98	8.75	9.96	11.75	13.66	16.07	18.03	19.33	20.93	23.60	26.07	27.75	29.03	30.69
2,950	115.24	--	--	--	--	--	--	--	0.00	0.88	2.36	4.79	7.56	8.77	10.56	12.47	14.88	16.84	18.14	19.74	22.41	24.88	26.56	27.84	29.50
2,600	114.36	--	--	--	--	--	--	--	--	0.00	1.48	3.91	6.68	7.89	9.68	11.59	14.00	15.96	17.26	18.86	21.53	24.00	25.68	26.96	28.62
2,250	112.88	--	--	--	--	--	--	--	--	--	0.00	2.43	5.20	6.41	8.20	10.11	12.52	14.48	15.78	17.38	20.05	22.52	24.20	25.48	27.14
1,900	110.45	--	--	--	--	--	--	--	--	--		0.00	2.77	3.98	5.77	7.68	10.09	12.05	13.35	14.95	17.62	20.09	21.77	23.05	24.71
1,529	107.68	--	--	--	--	--	--	--	--	--	--	--	0.00	1.21	3.00	4.91	7.32	9.28	10.58	12.18	14.85	17.32	19.00	20.28	21.94
1,400	106.47	--	--	--	--	--	--	--	--	--	--	--	--	0.00	1.79	3.70	6.11	8.07	9.37	10.97	13.64	16.11	17.79	19.07	20.73
1,200	104.68	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	1.91	4.32	6.28	7.58	9.18	11.85	14.32	16.00	17.28	18.94
1,000	102.77	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	2.41	4.37	5.67	7.27	9.94	12.41	14.09	15.37	17.03
800	100.36	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	1.96	3.26	4.86	7.53	10.00	11.68	12.96	14.62
640	98.40	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	1.30	2.90	5.57	8.04	9.72	11.00	12.66
550	97.10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	1.60	4.27	6.74	8.42	9.70	11.36
450	95.50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	2.67	5.14	6.82	8.10	9.76
350	92.83	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	2.47	4.15	5.43	7.09
253	90.36	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	1.68	2.96	4.62
200	88.68	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	1.28	2.94
150	87.40	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	1.66
101	85.74	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00

Table 6. Transect R6: Magnitude change in wetted perimeter as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Wetted Perimeter (ft)	Ending discharge (cfs), Ending Wetted Perimeter (ft), and Magnitude Change in Wetted Perimeter																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		138.91	133.73	128.66	125.81	123.19	121.23	115.08	112.25	108.00	105.02	100.48	95.55	93.07	89.52	86.43	82.75	79.89	78.61	77.22	74.21	71.27	69.61	66.68	63.17
6,500	138.91	0.00	5.18	10.25	13.10	15.72	17.68	23.83	26.66	30.91	33.89	38.43	43.36	45.84	49.39	52.48	56.16	59.02	60.30	61.69	64.70	67.64	69.30	72.23	75.74
6,000	133.73	--	0.00	5.07	7.92	10.54	12.50	18.65	21.48	25.73	28.71	33.25	38.18	40.66	44.21	47.30	50.98	53.84	55.12	56.51	59.52	62.46	64.12	67.05	70.56
5,400	128.66	--	--	0.00	2.85	5.47	7.43	13.58	16.41	20.66	23.64	28.18	33.11	35.59	39.14	42.23	45.91	48.77	50.05	51.44	54.45	57.39	59.05	61.98	65.49
4,900	125.81	--	--	--	0.00	2.62	4.58	10.73	13.56	17.81	20.79	25.33	30.26	32.74	36.29	39.38	43.06	45.92	47.20	48.59	51.60	54.54	56.20	59.13	62.64
4,300	123.19	--	--	--	--	0.00	1.96	8.11	10.94	15.19	18.17	22.71	27.64	30.12	33.67	36.76	40.44	43.30	44.58	45.97	48.98	51.92	53.58	56.51	60.02
3,749	121.23	--	--	--	--	--	0.00	6.15	8.98	13.23	16.21	20.75	25.68	28.16	31.71	34.80	38.48	41.34	42.62	44.01	47.02	49.96	51.62	54.55	58.06
3,300	115.08	--	--	--	--	--	--	0.00	2.83	7.08	10.06	14.60	19.53	22.01	25.56	28.65	32.33	35.19	36.47	37.86	40.87	43.81	45.47	48.40	51.91
2,950	112.25	--	--	--	--	--	--	--	0.00	4.25	7.23	11.77	16.70	19.18	22.73	25.82	29.50	32.36	33.64	35.03	38.04	40.98	42.64	45.57	49.08
2,600	108.00	--	--	--	--	--	--	--	--	0.00	2.98	7.52	12.45	14.93	18.48	21.57	25.25	28.11	29.39	30.78	33.79	36.73	38.39	41.32	44.83
2,250	105.02	--	--	--	--	--	--	--	--	--	0.00	4.54	9.47	11.95	15.50	18.59	22.27	25.13	26.41	27.80	30.81	33.75	35.41	38.34	41.85
1,900	100.48	--	--	--	--	--	--	--	--	--	--	0.00	4.93	7.41	10.96	14.05	17.73	20.59	21.87	23.26	26.27	29.21	30.87	33.80	37.31
1,529	95.55	--	--	--	--	--	--	--	--	--	--	--	0.00	2.48	6.03	9.12	12.80	15.66	16.94	18.33	21.34	24.28	25.94	28.87	32.38
1,400	93.07	--	--	--	--	--	--	--	--	--	--	--	--	0.00	3.55	6.64	10.32	13.18	14.46	15.85	18.86	21.80	23.46	26.39	29.90
1,200	89.52	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	3.09	6.77	9.63	10.91	12.30	15.31	18.25	19.91	22.84	26.35
1,000	86.43	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	3.68	6.54	7.82	9.21	12.22	15.16	16.82	19.75	23.26
800	82.75	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	2.86	4.14	5.53	8.54	11.48	13.14	16.07	19.58
640	79.89	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	1.28	2.67	5.68	8.62	10.28	13.21	16.72
550	78.61	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	1.39	4.40	7.34	9.00	11.93	15.44
450	77.22	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	3.01	5.95	7.61	10.54	14.05
350	74.21	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	2.94	4.60	7.53	11.04
253	71.27	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	1.66	4.59	8.10
200	69.61	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	2.93	6.44
150	66.68	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	3.51
101	63.17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00

Table 7. Transect R7: Magnitude change in wetted perimeter as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Wetted Perimeter (ft)	Ending discharge (cfs), Ending Wetted Perimeter (ft), and Magnitude Change in Wetted Perimeter																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		154.45	151.50	147.64	143.17	136.78	131.24	126.69	119.62	113.87	111.93	110.90	109.35	108.17	104.93	102.54	93.66	86.40	81.54	73.47	68.69	63.16	62.56	61.34	59.92
6,500	154.45	0.00	2.95	6.81	11.28	17.67	23.21	27.76	34.83	40.58	42.52	43.55	45.10	46.28	49.52	51.91	60.79	68.05	72.91	80.98	85.76	91.29	91.89	93.11	94.53
6,000	151.50	--	0.00	3.86	8.33	14.72	20.26	24.81	31.88	37.63	39.57	40.60	42.15	43.33	46.57	48.96	57.84	65.10	69.96	78.03	82.81	88.34	88.94	90.16	91.58
5,400	147.64	--	--	0.00	4.47	10.86	16.40	20.95	28.02	33.77	35.71	36.74	38.29	39.47	42.71	45.10	53.98	61.24	66.10	74.17	78.95	84.48	85.08	86.30	87.72
4,900	143.17	--	--	--	0.00	6.39	11.93	16.48	23.55	29.30	31.24	32.27	33.82	35.00	38.24	40.63	49.51	56.77	61.63	69.70	74.48	80.01	80.61	81.83	83.25
4,300	136.78	--	--	--	--	0.00	5.54	10.09	17.16	22.91	24.85	25.88	27.43	28.61	31.85	34.24	43.12	50.38	55.24	63.31	68.09	73.62	74.22	75.44	76.86
3,749	131.24	--	--	--	--	--	0.00	4.55	11.62	17.37	19.31	20.34	21.89	23.07	26.31	28.70	37.58	44.84	49.70	57.77	62.55	68.08	68.68	69.90	71.32
3,300	126.69	--	--	--	--	--	--	0.00	7.07	12.82	14.76	15.79	17.34	18.52	21.76	24.15	33.03	40.29	45.15	53.22	58.00	63.53	64.13	65.35	66.77
2,950	119.62	--	--	--	--	--	--	--	0.00	5.75	7.69	8.72	10.27	11.45	14.69	17.08	25.96	33.22	38.08	46.15	50.93	56.46	57.06	58.28	59.70
2,600	113.87	--	--	--	--	--	--	--	--	0.00	1.94	2.97	4.52	5.70	8.94	11.33	20.21	27.47	32.33	40.40	45.18	50.71	51.31	52.53	53.95
2,250	111.93	--	--	--	--	--	--	--	--	--	0.00	1.03	2.58	3.76	7.00	9.39	18.27	25.53	30.39	38.46	43.24	48.77	49.37	50.59	52.01
1,900	110.90	--	--	--	--	--	--	--	--	--	--	0.00	1.55	2.73	5.97	8.36	17.24	24.50	29.36	37.43	42.21	47.74	48.34	49.56	50.98
1,529	109.35	--	--	--	--	--	--	--	--	--	--	--	0.00	1.18	4.42	6.81	15.69	22.95	27.81	35.88	40.66	46.19	46.79	48.01	49.43
1,400	108.17	--	--	--	--	--	--	--	--	--	--	--	--	0.00	3.24	5.63	14.51	21.77	26.63	34.70	39.48	45.01	45.61	46.83	48.25
1,200	104.93	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	2.39	11.27	18.53	23.39	31.46	36.24	41.77	42.37	43.59	45.01
1,000	102.54	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	8.88	16.14	21.00	29.07	33.85	39.38	39.98	41.20	42.62
800	93.66	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	7.26	12.12	20.19	24.97	30.50	31.10	32.32	33.74
640	86.40	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	4.86	12.93	17.71	23.24	23.84	25.06	26.48
550	81.54	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	8.07	12.85	18.38	18.98	20.20	21.62
450	73.47	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	4.78	10.31	10.91	12.13	13.55
350	68.69	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	5.53	6.13	7.35	8.77
253	63.16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	0.60	1.82	3.24
200	62.56	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	1.22	2.64
150	61.34	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	1.42
101	59.92	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00

Page Left Blank

Percent Change in Wetted Perimeter

Page Left Blank

Tables 8—14 show the percent change in wetted perimeter from a starting discharge to an ending discharge. Percent change in wetted perimeter is calculated based on the percent difference between the starting wetted perimeter and ending wetted perimeter. The table shows starting discharges in descending order along the table's left column and ending discharges in descending order from left to right along the top row.

Table 8. Transect R1: Percent change in wetted perimeter as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Wetted Perimeter (ft)	Ending Discharge (cfs), Ending Wetted Perimeter (ft), and Percent Change in Wetted Perimeter																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		192.05	189.54	188.08	186.80	184.96	179.86	174.20	171.29	168.09	165.36	162.53	152.91	146.65	132.48	125.64	114.60	107.76	102.01	96.89	90.73	82.67	78.67	74.13	69.94
6,500	192.05	0.0%	1.3%	2.1%	2.7%	3.7%	6.3%	9.3%	10.8%	12.5%	13.9%	15.4%	20.4%	23.6%	31.0%	34.6%	40.3%	43.9%	46.9%	49.5%	52.8%	57.0%	59.0%	61.4%	63.6%
6,000	189.54		0.0%	0.8%	1.4%	2.4%	5.1%	8.1%	9.6%	11.3%	12.8%	14.3%	19.3%	22.6%	30.1%	33.7%	39.5%	43.1%	46.2%	48.9%	52.1%	56.4%	58.5%	60.9%	63.1%
5,400	188.08			0.0%	0.7%	1.7%	4.4%	7.4%	8.9%	10.6%	12.1%	13.6%	18.7%	22.0%	29.6%	33.2%	39.1%	42.7%	45.8%	48.5%	51.8%	56.0%	58.2%	60.6%	62.8%
4,900	186.80				0.0%	1.0%	3.7%	6.7%	8.3%	10.0%	11.5%	13.0%	18.1%	21.5%	29.1%	32.7%	38.7%	42.3%	45.4%	48.1%	51.4%	55.7%	57.9%	60.3%	62.6%
4,300	184.96					0.0%	2.8%	5.8%	7.4%	9.1%	10.6%	12.1%	17.3%	20.7%	28.4%	32.1%	38.0%	41.7%	44.8%	47.6%	50.9%	55.3%	57.5%	59.9%	62.2%
3,749	179.86						0.0%	3.1%	4.8%	6.5%	8.1%	9.6%	15.0%	18.5%	26.3%	30.1%	36.3%	40.1%	43.3%	46.1%	49.6%	54.0%	56.3%	58.8%	61.1%
3,300	174.20							0.0%	1.7%	3.5%	5.1%	6.7%	12.2%	15.8%	23.9%	27.9%	34.2%	38.1%	41.4%	44.4%	47.9%	52.5%	54.8%	57.4%	59.9%
2,950	171.29								0.0%	1.9%	3.5%	5.1%	10.7%	14.4%	22.7%	26.7%	33.1%	37.1%	40.4%	43.4%	47.0%	51.7%	54.1%	56.7%	59.2%
2,600	168.09									0.0%	1.6%	3.3%	9.0%	12.8%	21.2%	25.3%	31.8%	35.9%	39.3%	42.4%	46.0%	50.8%	53.2%	55.9%	58.4%
2,250	165.36										0.0%	1.7%	7.5%	11.3%	19.9%	24.0%	30.7%	34.8%	38.3%	41.4%	45.1%	50.0%	52.4%	55.2%	57.7%
1,900	162.53											0.0%	5.9%	9.8%	18.5%	22.7%	29.5%	33.7%	37.2%	40.4%	44.2%	49.1%	51.6%	54.4%	57.0%
1,529	152.91												0.0%	4.1%	13.4%	17.8%	25.1%	29.5%	33.3%	36.6%	40.7%	45.9%	48.6%	51.5%	54.3%
1,400	146.65													0.0%	9.7%	14.3%	21.9%	26.5%	30.4%	33.9%	38.1%	43.6%	46.4%	49.5%	52.3%
1,200	132.48														0.0%	5.2%	13.5%	18.7%	23.0%	26.9%	31.5%	37.6%	40.6%	44.0%	47.2%
1,000	125.64															0.0%	8.8%	14.2%	18.8%	22.9%	27.8%	34.2%	37.4%	41.0%	44.3%
800	114.60																0.0%	6.0%	11.0%	15.5%	20.8%	27.9%	31.4%	35.3%	39.0%
640	107.76																	0.0%	5.3%	10.1%	15.8%	23.3%	27.0%	31.2%	35.1%
550	102.01																		0.0%	5.0%	11.1%	19.0%	22.9%	27.3%	31.4%
450	96.89																			0.0%	6.4%	14.7%	18.8%	23.5%	27.8%
350	90.73																				0.0%	8.9%	13.3%	18.3%	22.9%
253	82.67																					0.0%	4.8%	10.3%	15.4%
200	78.67																						0.0%	5.8%	11.1%
150	74.13																							0.0%	5.7%
101	69.94																								0.0%

Table 9. Transect R2: Percent change in wetted perimeter as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Wetted Perimeter (ft)	Ending Discharge (cfs), Ending Wetted Perimeter (ft), and Percent Change in Wetted Perimeter																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		244.94	240.99	232.22	212.19	203.86	195.72	186.31	179.64	173.42	166.53	152.97	123.85	115.75	105.48	94.94	93.04	92.04	90.29	83.73	75.24	69.84	66.51	65.77	64.85
6,500	244.94	0.0%	1.6%	5.2%	13.4%	16.8%	20.1%	23.9%	26.7%	29.2%	32.0%	37.5%	49.4%	52.7%	56.9%	61.2%	62.0%	62.4%	63.1%	65.8%	69.3%	71.5%	72.8%	73.1%	73.5%
6,000	240.99		0.0%	3.6%	12.0%	15.4%	18.8%	22.7%	25.5%	28.0%	30.9%	36.5%	48.6%	52.0%	56.2%	60.6%	61.4%	61.8%	62.5%	65.3%	68.8%	71.0%	72.4%	72.7%	73.1%
5,400	232.22			0.0%	8.6%	12.2%	15.7%	19.8%	22.6%	25.3%	28.3%	34.1%	46.7%	50.2%	54.6%	59.1%	59.9%	60.4%	61.1%	63.9%	67.6%	69.9%	71.4%	71.7%	72.1%
4,900	212.19				0.0%	3.9%	7.8%	12.2%	15.3%	18.3%	21.5%	27.9%	41.6%	45.4%	50.3%	55.3%	56.2%	56.6%	57.4%	60.5%	64.5%	67.1%	68.7%	69.0%	69.4%
4,300	203.86					0.0%	4.0%	8.6%	11.9%	14.9%	18.3%	25.0%	39.2%	43.2%	48.3%	53.4%	54.4%	54.9%	55.7%	58.9%	63.1%	65.7%	67.4%	67.7%	68.2%
3,749	195.72						0.0%	4.8%	8.2%	11.4%	14.9%	21.8%	36.7%	40.9%	46.1%	51.5%	52.5%	53.0%	53.9%	57.2%	61.6%	64.3%	66.0%	66.4%	66.9%
3,300	186.31							0.0%	3.6%	6.9%	10.6%	17.9%	33.5%	37.9%	43.4%	49.0%	50.1%	50.6%	51.5%	55.1%	59.6%	62.5%	64.3%	64.7%	65.2%
2,950	179.64								0.0%	3.5%	7.3%	14.8%	31.1%	35.6%	41.3%	47.1%	48.2%	48.8%	49.7%	53.4%	58.1%	61.1%	63.0%	63.4%	63.9%
2,600	173.42									0.0%	4.0%	11.8%	28.6%	33.3%	39.2%	45.3%	46.3%	46.9%	47.9%	51.7%	56.6%	59.7%	61.6%	62.1%	62.6%
2,250	166.53										0.0%	8.1%	25.6%	30.5%	36.7%	43.0%	44.1%	44.7%	45.8%	49.7%	54.8%	58.1%	60.1%	60.5%	61.1%
1,900	152.97											0.0%	19.0%	24.3%	31.0%	37.9%	39.2%	39.8%	41.0%	45.3%	50.8%	54.3%	56.5%	57.0%	57.6%
1,529	123.85												0.0%	6.5%	14.8%	23.3%	24.9%	25.7%	27.1%	32.4%	39.2%	43.6%	46.3%	46.9%	47.6%
1,400	115.75													0.0%	8.9%	18.0%	19.6%	20.5%	22.0%	27.7%	35.0%	39.7%	42.5%	43.2%	44.0%
1,200	105.48														0.0%	10.0%	11.8%	12.7%	14.4%	20.6%	28.7%	33.8%	36.9%	37.6%	38.5%
1,000	94.94															0.0%	2.0%	3.1%	4.9%	11.8%	20.7%	26.4%	29.9%	30.7%	31.7%
800	93.04																0.0%	1.1%	3.0%	10.0%	19.1%	24.9%	28.5%	29.3%	30.3%
640	92.04																	0.0%	1.9%	9.0%	18.3%	24.1%	27.7%	28.5%	29.5%
550	90.29																		0.0%	7.3%	16.7%	22.6%	26.3%	27.2%	28.2%
450	83.73																			0.0%	10.1%	16.6%	20.6%	21.4%	22.5%
350	75.24																				0.0%	7.2%	11.6%	12.6%	13.8%
253	69.84																					0.0%	4.8%	5.8%	7.1%
200	66.51																						0.0%	1.1%	2.5%
150	65.77																							0.0%	1.4%
101	64.85																								0.0%

Table 10. Transect R3: Percent change in wetted perimeter as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Wetted Perimeter (ft)	Ending Discharge (cfs), Ending Wetted Perimeter (ft), and Percent Change in Wetted Perimeter																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		230.50	229.42	228.46	227.88	227.13	226.38	225.70	225.13	211.97	203.47	187.68	177.39	170.76	166.33	159.14	150.14	141.20	133.94	120.80	106.90	96.97	90.28	83.17	77.47
6,500	230.50	0.0%	0.5%	0.9%	1.1%	1.5%	1.8%	2.1%	2.3%	8.0%	11.7%	18.6%	23.0%	25.9%	27.8%	31.0%	34.9%	38.7%	41.9%	47.6%	53.6%	57.9%	60.8%	63.9%	66.4%
6,000	229.42		0.0%	0.4%	0.7%	1.0%	1.3%	1.6%	1.9%	7.6%	11.3%	18.2%	22.7%	25.6%	27.5%	30.6%	34.6%	38.5%	41.6%	47.3%	53.4%	57.7%	60.6%	63.7%	66.2%
5,400	228.46			0.0%	0.3%	0.6%	0.9%	1.2%	1.5%	7.2%	10.9%	17.8%	22.4%	25.3%	27.2%	30.3%	34.3%	38.2%	41.4%	47.1%	53.2%	57.6%	60.5%	63.6%	66.1%
4,900	227.88				0.0%	0.3%	0.7%	1.0%	1.2%	7.0%	10.7%	17.6%	22.2%	25.1%	27.0%	30.2%	34.1%	38.0%	41.2%	47.0%	53.1%	57.4%	60.4%	63.5%	66.0%
4,300	227.13					0.0%	0.3%	0.6%	0.9%	6.7%	10.4%	17.4%	21.9%	24.8%	26.8%	29.9%	33.9%	37.8%	41.0%	46.8%	52.9%	57.3%	60.3%	63.4%	65.9%
3,749	226.38						0.0%	0.3%	0.6%	6.4%	10.1%	17.1%	21.6%	24.6%	26.5%	29.7%	33.7%	37.6%	40.8%	46.6%	52.8%	57.2%	60.1%	63.3%	65.8%
3,300	225.70							0.0%	0.3%	6.1%	9.8%	16.8%	21.4%	24.3%	26.3%	29.5%	33.5%	37.4%	40.7%	46.5%	52.6%	57.0%	60.0%	63.2%	65.7%
2,950	225.13								0.0%	5.8%	9.6%	16.6%	21.2%	24.2%	26.1%	29.3%	33.3%	37.3%	40.5%	46.3%	52.5%	56.9%	59.9%	63.1%	65.6%
2,600	211.97									0.0%	4.0%	11.5%	16.3%	19.4%	21.5%	24.9%	29.2%	33.4%	36.8%	43.0%	49.6%	54.3%	57.4%	60.8%	63.5%
2,250	203.47										0.0%	7.8%	12.8%	16.1%	18.3%	21.8%	26.2%	30.6%	34.2%	40.6%	47.5%	52.3%	55.6%	59.1%	61.9%
1,900	187.68											0.0%	5.5%	9.0%	11.4%	15.2%	20.0%	24.8%	28.6%	35.6%	43.0%	48.3%	51.9%	55.7%	58.7%
1,529	177.39												0.0%	3.7%	6.2%	10.3%	15.4%	20.4%	24.5%	31.9%	39.7%	45.3%	49.1%	53.1%	56.3%
1,400	170.76													0.0%	2.6%	6.8%	12.1%	17.3%	21.6%	29.3%	37.4%	43.2%	47.1%	51.3%	54.6%
1,200	166.33														0.0%	4.3%	9.7%	15.1%	19.5%	27.4%	35.7%	41.7%	45.7%	50.0%	53.4%
1,000	159.14															0.0%	5.7%	11.3%	15.8%	24.1%	32.8%	39.1%	43.3%	47.7%	51.3%
800	150.14																0.0%	6.0%	10.8%	19.5%	28.8%	35.4%	39.9%	44.6%	48.4%
640	141.20																	0.0%	5.1%	14.4%	24.3%	31.3%	36.1%	41.1%	45.1%
550	133.94																		0.0%	9.8%	20.2%	27.6%	32.6%	37.9%	42.2%
450	120.80																			0.0%	11.5%	19.7%	25.3%	31.2%	35.9%
350	106.90																				0.0%	9.3%	15.5%	22.2%	27.5%
253	96.97																					0.0%	6.9%	14.2%	20.1%
200	90.28																						0.0%	7.9%	14.2%
150	83.17																							0.0%	6.9%
101	77.47																								0.0%

Table 11. Transect R4: Percent change in wetted perimeter as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Wetted Perimeter (ft)	Ending Discharge (cfs), Ending Wetted Perimeter (ft), and Percent Change in Wetted Perimeter																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		159.72	158.73	157.49	156.39	155.47	153.30	149.51	148.65	148.00	147.30	146.53	145.08	143.78	140.76	136.08	131.20	126.30	124.46	113.11	103.27	79.95	77.93	76.27	66.90
6,500	159.72	0.0%	0.6%	1.4%	2.1%	2.7%	4.0%	6.4%	6.9%	7.3%	7.8%	8.3%	9.2%	10.0%	11.9%	14.8%	17.9%	20.9%	22.1%	29.2%	35.3%	49.9%	51.2%	52.2%	58.1%
6,000	158.73		0.0%	0.8%	1.5%	2.1%	3.4%	5.8%	6.4%	6.8%	7.2%	7.7%	8.6%	9.4%	11.3%	14.3%	17.3%	20.4%	21.6%	28.7%	34.9%	49.6%	50.9%	51.9%	57.9%
5,400	157.49			0.0%	0.7%	1.3%	2.7%	5.1%	5.6%	6.0%	6.5%	7.0%	7.9%	8.7%	10.6%	13.6%	16.7%	19.8%	21.0%	28.2%	34.4%	49.2%	50.5%	51.6%	57.5%
4,900	156.39				0.0%	0.6%	2.0%	4.4%	4.9%	5.4%	5.8%	6.3%	7.2%	8.1%	10.0%	13.0%	16.1%	19.2%	20.4%	27.7%	34.0%	48.9%	50.2%	51.2%	57.2%
4,300	155.47					0.0%	1.4%	3.8%	4.4%	4.8%	5.3%	5.8%	6.7%	7.5%	9.5%	12.5%	15.6%	18.8%	19.9%	27.2%	33.6%	48.6%	49.9%	50.9%	57.0%
3,749	153.30						0.0%	2.5%	3.0%	3.5%	3.9%	4.4%	5.4%	6.2%	8.2%	11.2%	14.4%	17.6%	18.8%	26.2%	32.6%	47.8%	49.2%	50.2%	56.4%
3,300	149.51							0.0%	0.6%	1.0%	1.5%	2.0%	3.0%	3.8%	5.9%	9.0%	12.2%	15.5%	16.8%	24.3%	30.9%	46.5%	47.9%	49.0%	55.3%
2,950	148.65								0.0%	0.4%	0.9%	1.4%	2.4%	3.3%	5.3%	8.5%	11.7%	15.0%	16.3%	23.9%	30.5%	46.2%	47.6%	48.7%	55.0%
2,600	148.00									0.0%	0.5%	1.0%	2.0%	2.9%	4.9%	8.1%	11.4%	14.7%	15.9%	23.6%	30.2%	46.0%	47.3%	48.5%	54.8%
2,250	147.30										0.0%	0.5%	1.5%	2.4%	4.4%	7.6%	10.9%	14.3%	15.5%	23.2%	29.9%	45.7%	47.1%	48.2%	54.6%
1,900	146.53											0.0%	1.0%	1.9%	3.9%	7.1%	10.5%	13.8%	15.1%	22.8%	29.5%	45.4%	46.8%	47.9%	54.3%
1,529	145.08												0.0%	0.9%	3.0%	6.2%	9.6%	12.9%	14.2%	22.0%	28.8%	44.9%	46.3%	47.4%	53.9%
1,400	143.78													0.0%	2.1%	5.4%	8.7%	12.2%	13.4%	21.3%	28.2%	44.4%	45.8%	47.0%	53.5%
1,200	140.76														0.0%	3.3%	6.8%	10.3%	11.6%	19.6%	26.6%	43.2%	44.6%	45.8%	52.5%
1,000	136.08															0.0%	3.6%	7.2%	8.5%	16.9%	24.1%	41.2%	42.7%	44.0%	50.8%
800	131.20																0.0%	3.7%	5.1%	13.8%	21.3%	39.1%	40.6%	41.9%	49.0%
640	126.30																	0.0%	1.5%	10.4%	18.2%	36.7%	38.3%	39.6%	47.0%
550	124.46																		0.0%	9.1%	17.0%	35.8%	37.4%	38.7%	46.2%
450	113.11																			0.0%	8.7%	29.3%	31.1%	32.6%	40.9%
350	103.27																				0.0%	22.6%	24.5%	26.1%	35.2%
253	79.95																					0.0%	2.5%	4.6%	16.3%
200	77.93																						0.0%	2.1%	14.2%
150	76.27																							0.0%	12.3%
101	66.90																								0.0%

Table 12. Transect R5: Percent change in wetted perimeter as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Wetted Perimeter (ft)	Ending Discharge (cfs), Ending Wetted Perimeter (ft), and Percent Change in Wetted Perimeter																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		148.73	145.59	140.00	130.10	123.75	120.22	116.43	115.24	114.36	112.88	110.45	107.68	106.47	104.68	102.77	100.36	98.40	97.10	95.50	92.83	90.36	88.68	87.40	85.74
6,500	148.73	0.0%	2.1%	5.9%	12.5%	16.8%	19.2%	21.7%	22.5%	23.1%	24.1%	25.7%	27.6%	28.4%	29.6%	30.9%	32.5%	33.8%	34.7%	35.8%	37.6%	39.2%	40.4%	41.2%	42.4%
6,000	145.59		0.0%	3.8%	10.6%	15.0%	17.4%	20.0%	20.8%	21.5%	22.5%	24.1%	26.0%	26.9%	28.1%	29.4%	31.1%	32.4%	33.3%	34.4%	36.2%	37.9%	39.1%	40.0%	41.1%
5,400	140.00			0.0%	7.1%	11.6%	14.1%	16.8%	17.7%	18.3%	19.4%	21.1%	23.1%	24.0%	25.2%	26.6%	28.3%	29.7%	30.6%	31.8%	33.7%	35.5%	36.7%	37.6%	38.8%
4,900	130.10				0.0%	4.9%	7.6%	10.5%	11.4%	12.1%	13.2%	15.1%	17.2%	18.2%	19.5%	21.0%	22.9%	24.4%	25.4%	26.6%	28.6%	30.5%	31.8%	32.8%	34.1%
4,300	123.75					0.0%	2.9%	5.9%	6.9%	7.6%	8.8%	10.7%	13.0%	14.0%	15.4%	17.0%	18.9%	20.5%	21.5%	22.8%	25.0%	27.0%	28.3%	29.4%	30.7%
3,749	120.22						0.0%	3.2%	4.1%	4.9%	6.1%	8.1%	10.4%	11.4%	12.9%	14.5%	16.5%	18.2%	19.2%	20.6%	22.8%	24.8%	26.2%	27.3%	28.7%
3,300	116.43							0.0%	1.0%	1.8%	3.0%	5.1%	7.5%	8.6%	10.1%	11.7%	13.8%	15.5%	16.6%	18.0%	20.3%	22.4%	23.8%	24.9%	26.4%
2,950	115.24								0.0%	0.8%	2.0%	4.2%	6.6%	7.6%	9.2%	10.8%	12.9%	14.6%	15.7%	17.1%	19.4%	21.6%	23.0%	24.2%	25.6%
2,600	114.36									0.0%	1.3%	3.4%	5.8%	6.9%	8.5%	10.1%	12.2%	14.0%	15.1%	16.5%	18.8%	21.0%	22.5%	23.6%	25.0%
2,250	112.88										0.0%	2.2%	4.6%	5.7%	7.3%	9.0%	11.1%	12.8%	14.0%	15.4%	17.8%	20.0%	21.4%	22.6%	24.0%
1,900	110.45											0.0%	2.5%	3.6%	5.2%	7.0%	9.1%	10.9%	12.1%	13.5%	16.0%	18.2%	19.7%	20.9%	22.4%
1,529	107.68												0.0%	1.1%	2.8%	4.6%	6.8%	8.6%	9.8%	11.3%	13.8%	16.1%	17.6%	18.8%	20.4%
1,400	106.47													0.0%	1.7%	3.5%	5.7%	7.6%	8.8%	10.3%	12.8%	15.1%	16.7%	17.9%	19.5%
1,200	104.68														0.0%	1.8%	4.1%	6.0%	7.2%	8.8%	11.3%	13.7%	15.3%	16.5%	18.1%
1,000	102.77															0.0%	2.3%	4.3%	5.5%	7.1%	9.7%	12.1%	13.7%	15.0%	16.6%
800	100.36																0.0%	2.0%	3.2%	4.8%	7.5%	10.0%	11.6%	12.9%	14.6%
640	98.40																	0.0%	1.3%	2.9%	5.7%	8.2%	9.9%	11.2%	12.9%
550	97.10																		0.0%	1.6%	4.4%	6.9%	8.7%	10.0%	11.7%
450	95.50																			0.0%	2.8%	5.4%	7.1%	8.5%	10.2%
350	92.83																				0.0%	2.7%	4.5%	5.8%	7.6%
253	90.36																					0.0%	1.9%	3.3%	5.1%
200	88.68																						0.0%	1.4%	3.3%
150	87.40																							0.0%	1.9%
101	85.74																								0.0%

Table 13. Transect R6: Percent change in wetted perimeter as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Wetted Perimeter (ft)	Ending Discharge (cfs), Ending Wetted Perimeter (ft), and Percent Change in Wetted Perimeter																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		138.91	133.73	128.66	125.81	123.19	121.23	115.08	112.25	108.00	105.02	100.48	95.55	93.07	89.52	86.43	82.75	79.89	78.61	77.22	74.21	71.27	69.61	66.68	63.17
6,500	138.91	0.0%	3.7%	7.4%	9.4%	11.3%	12.7%	17.2%	19.2%	22.3%	24.4%	27.7%	31.2%	33.0%	35.6%	37.8%	40.4%	42.5%	43.4%	44.4%	46.6%	48.7%	49.9%	52.0%	54.5%
6,000	133.73		0.0%	3.8%	5.9%	7.9%	9.3%	13.9%	16.1%	19.2%	21.5%	24.9%	28.6%	30.4%	33.1%	35.4%	38.1%	40.3%	41.2%	42.3%	44.5%	46.7%	47.9%	50.1%	52.8%
5,400	128.66			0.0%	2.2%	4.3%	5.8%	10.6%	12.8%	16.1%	18.4%	21.9%	25.7%	27.7%	30.4%	32.8%	35.7%	37.9%	38.9%	40.0%	42.3%	44.6%	45.9%	48.2%	50.9%
4,900	125.81				0.0%	2.1%	3.6%	8.5%	10.8%	14.2%	16.5%	20.1%	24.1%	26.0%	28.8%	31.3%	34.2%	36.5%	37.5%	38.6%	41.0%	43.4%	44.7%	47.0%	49.8%
4,300	123.19					0.0%	1.6%	6.6%	8.9%	12.3%	14.7%	18.4%	22.4%	24.5%	27.3%	29.8%	32.8%	35.1%	36.2%	37.3%	39.8%	42.1%	43.5%	45.9%	48.7%
3,749	121.23						0.0%	5.1%	7.4%	10.9%	13.4%	17.1%	21.2%	23.2%	26.2%	28.7%	31.7%	34.1%	35.2%	36.3%	38.8%	41.2%	42.6%	45.0%	47.9%
3,300	115.08							0.0%	2.5%	6.2%	8.7%	12.7%	17.0%	19.1%	22.2%	24.9%	28.1%	30.6%	31.7%	32.9%	35.5%	38.1%	39.5%	42.1%	45.1%
2,950	112.25								0.0%	3.8%	6.4%	10.5%	14.9%	17.1%	20.2%	23.0%	26.3%	28.8%	30.0%	31.2%	33.9%	36.5%	38.0%	40.6%	43.7%
2,600	108.00									0.0%	2.8%	7.0%	11.5%	13.8%	17.1%	20.0%	23.4%	26.0%	27.2%	28.5%	31.3%	34.0%	35.5%	38.3%	41.5%
2,250	105.02										0.0%	4.3%	9.0%	11.4%	14.8%	17.7%	21.2%	23.9%	25.1%	26.5%	29.3%	32.1%	33.7%	36.5%	39.8%
1,900	100.48											0.0%	4.9%	7.4%	10.9%	14.0%	17.6%	20.5%	21.8%	23.1%	26.1%	29.1%	30.7%	33.6%	37.1%
1,529	95.55												0.0%	2.6%	6.3%	9.5%	13.4%	16.4%	17.7%	19.2%	22.3%	25.4%	27.1%	30.2%	33.9%
1,400	93.07													0.0%	3.8%	7.1%	11.1%	14.2%	15.5%	17.0%	20.3%	23.4%	25.2%	28.4%	32.1%
1,200	89.52														0.0%	3.5%	7.6%	10.8%	12.2%	13.7%	17.1%	20.4%	22.2%	25.5%	29.4%
1,000	86.43															0.0%	4.3%	7.6%	9.0%	10.7%	14.1%	17.5%	19.5%	22.9%	26.9%
800	82.75																0.0%	3.5%	5.0%	6.7%	10.3%	13.9%	15.9%	19.4%	23.7%
640	79.89																	0.0%	1.6%	3.3%	7.1%	10.8%	12.9%	16.5%	20.9%
550	78.61																		0.0%	1.8%	5.6%	9.3%	11.4%	15.2%	19.6%
450	77.22																			0.0%	3.9%	7.7%	9.9%	13.6%	18.2%
350	74.21																				0.0%	4.0%	6.2%	10.1%	14.9%
253	71.27																					0.0%	2.3%	6.4%	11.4%
200	69.61																						0.0%	4.2%	9.3%
150	66.68																							0.0%	5.3%
101	63.17																								0.0%

Table 14. Transect R7: Percent change in wetted perimeter as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Wetted Perimeter (ft)	Ending Discharge (cfs), Ending Wetted Perimeter (ft), and Percent Change in Wetted Perimeter																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		154.45	151.50	147.64	143.17	136.78	131.24	126.69	119.62	113.87	111.93	110.90	109.35	108.17	104.93	102.54	93.66	86.40	81.54	73.47	68.69	63.16	62.56	61.34	59.92
6,500	154.45	0.0%	1.9%	4.4%	7.3%	11.4%	15.0%	18.0%	22.6%	26.3%	27.5%	28.2%	29.2%	30.0%	32.1%	33.6%	39.4%	44.1%	47.2%	52.4%	55.5%	59.1%	59.5%	60.3%	61.2%
6,000	151.50		0.0%	2.5%	5.5%	9.7%	13.4%	16.4%	21.0%	24.8%	26.1%	26.8%	27.8%	28.6%	30.7%	32.3%	38.2%	43.0%	46.2%	51.5%	54.7%	58.3%	58.7%	59.5%	60.4%
5,400	147.64			0.0%	3.0%	7.4%	11.1%	14.2%	19.0%	22.9%	24.2%	24.9%	25.9%	26.7%	28.9%	30.5%	36.6%	41.5%	44.8%	50.2%	53.5%	57.2%	57.6%	58.5%	59.4%
4,900	143.17				0.0%	4.5%	8.3%	11.5%	16.4%	20.5%	21.8%	22.5%	23.6%	24.4%	26.7%	28.4%	34.6%	39.7%	43.0%	48.7%	52.0%	55.9%	56.3%	57.2%	58.1%
4,300	136.78					0.0%	4.1%	7.4%	12.5%	16.7%	18.2%	18.9%	20.1%	20.9%	23.3%	25.0%	31.5%	36.8%	40.4%	46.3%	49.8%	53.8%	54.3%	55.2%	56.2%
3,749	131.24						0.0%	3.5%	8.9%	13.2%	14.7%	15.5%	16.7%	17.6%	20.0%	21.9%	28.6%	34.2%	37.9%	44.0%	47.7%	51.9%	52.3%	53.3%	54.3%
3,300	126.69							0.0%	5.6%	10.1%	11.7%	12.5%	13.7%	14.6%	17.2%	19.1%	26.1%	31.8%	35.6%	42.0%	45.8%	50.1%	50.6%	51.6%	52.7%
2,950	119.62								0.0%	4.8%	6.4%	7.3%	8.6%	9.6%	12.3%	14.3%	21.7%	27.8%	31.8%	38.6%	42.6%	47.2%	47.7%	48.7%	49.9%
2,600	113.87									0.0%	1.7%	2.6%	4.0%	5.0%	7.9%	9.9%	17.7%	24.1%	28.4%	35.5%	39.7%	44.5%	45.1%	46.1%	47.4%
2,250	111.93										0.0%	0.9%	2.3%	3.4%	6.3%	8.4%	16.3%	22.8%	27.2%	34.4%	38.6%	43.6%	44.1%	45.2%	46.5%
1,900	110.90											0.0%	1.4%	2.5%	5.4%	7.5%	15.5%	22.1%	26.5%	33.8%	38.1%	43.0%	43.6%	44.7%	46.0%
1,529	109.35												0.0%	1.1%	4.0%	6.2%	14.3%	21.0%	25.4%	32.8%	37.2%	42.2%	42.8%	43.9%	45.2%
1,400	108.17													0.0%	3.0%	5.2%	13.4%	20.1%	24.6%	32.1%	36.5%	41.6%	42.2%	43.3%	44.6%
1,200	104.93														0.0%	2.3%	10.7%	17.7%	22.3%	30.0%	34.5%	39.8%	40.4%	41.5%	42.9%
1,000	102.54															0.0%	8.7%	15.7%	20.5%	28.3%	33.0%	38.4%	39.0%	40.2%	41.6%
800	93.66																0.0%	7.8%	12.9%	21.6%	26.7%	32.6%	33.2%	34.5%	36.0%
640	86.40																	0.0%	5.6%	15.0%	20.5%	26.9%	27.6%	29.0%	30.6%
550	81.54																		0.0%	9.9%	15.8%	22.5%	23.3%	24.8%	26.5%
450	73.47																			0.0%	6.5%	14.0%	14.8%	16.5%	18.4%
350	68.69																				0.0%	8.1%	8.9%	10.7%	12.8%
253	63.16																					0.0%	0.9%	2.9%	5.1%
200	62.56																						0.0%	2.0%	4.2%
150	61.34																							0.0%	2.3%
101	59.92																								0.0%

Page Left Blank

Magnitude Change in Stage

Page Left Blank

Tables 15—21show the magnitude change in river stage from a starting discharge to an ending discharge. Magnitude change in river stage is calculated based on the difference between starting river stage and ending river stage. The table shows starting discharges in descending order along the table's left column and ending discharges in descending order from left to right along the top row.

Table 15. Transect R1: Magnitude change in river stage as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting River Stage (ft)	Ending discharge (cfs), Ending River Stage (ft), and Magnitude Change in River Stage																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		99.13	98.86	98.53	98.24	97.87	97.50	97.18	96.91	96.63	96.32	95.99	95.60	95.46	95.21	94.94	94.64	94.36	94.19	93.98	93.74	93.46	93.29	93.09	92.87
6,500	99.13	0.00	0.27	0.60	0.89	1.26	1.63	1.95	2.22	2.50	2.81	3.14	3.53	3.67	3.92	4.19	4.49	4.77	4.94	5.15	5.39	5.67	5.84	6.04	6.26
6,000	98.86		0.00	0.33	0.62	0.99	1.36	1.68	1.95	2.23	2.54	2.87	3.26	3.40	3.65	3.92	4.22	4.50	4.67	4.88	5.12	5.40	5.57	5.77	5.99
5,400	98.53			0.00	0.29	0.66	1.03	1.35	1.62	1.90	2.21	2.54	2.93	3.07	3.32	3.59	3.89	4.17	4.34	4.55	4.79	5.07	5.24	5.44	5.66
4,900	98.24				0.00	0.37	0.74	1.06	1.33	1.61	1.92	2.25	2.64	2.78	3.03	3.30	3.60	3.88	4.05	4.26	4.50	4.78	4.95	5.15	5.37
4,300	97.87					0.00	0.37	0.69	0.96	1.24	1.55	1.88	2.27	2.41	2.66	2.93	3.23	3.51	3.68	3.89	4.13	4.41	4.58	4.78	5.00
3,749	97.50						0.00	0.32	0.59	0.87	1.18	1.51	1.90	2.04	2.29	2.56	2.86	3.14	3.31	3.52	3.76	4.04	4.21	4.41	4.63
3,300	97.18							0.00	0.27	0.55	0.86	1.19	1.58	1.72	1.97	2.24	2.54	2.82	2.99	3.20	3.44	3.72	3.89	4.09	4.31
2,950	96.91								0.00	0.28	0.59	0.92	1.31	1.45	1.70	1.97	2.27	2.55	2.72	2.93	3.17	3.45	3.62	3.82	4.04
2,600	96.63									0.00	0.31	0.64	1.03	1.17	1.42	1.69	1.99	2.27	2.44	2.65	2.89	3.17	3.34	3.54	3.76
2,250	96.32										0.00	0.33	0.72	0.86	1.11	1.38	1.68	1.96	2.13	2.34	2.58	2.86	3.03	3.23	3.45
1,900	95.99											0.00	0.39	0.53	0.78	1.05	1.35	1.63	1.80	2.01	2.25	2.53	2.70	2.90	3.12
1,529	95.60												0.00	0.14	0.39	0.66	0.96	1.24	1.41	1.62	1.86	2.14	2.31	2.51	2.73
1,400	95.46													0.00	0.25	0.52	0.82	1.10	1.27	1.48	1.72	2.00	2.17	2.37	2.59
1,200	95.21														0.00	0.27	0.57	0.85	1.02	1.23	1.47	1.75	1.92	2.12	2.34
1,000	94.94															0.00	0.30	0.58	0.75	0.96	1.20	1.48	1.65	1.85	2.07
800	94.64																0.00	0.28	0.45	0.66	0.90	1.18	1.35	1.55	1.77
640	94.36																	0.00	0.17	0.38	0.62	0.90	1.07	1.27	1.49
550	94.19																		0.00	0.21	0.45	0.73	0.90	1.10	1.32
450	93.98																			0.00	0.24	0.52	0.69	0.89	1.11
350	93.74																				0.00	0.28	0.45	0.65	0.87
253	93.46																					0.00	0.17	0.37	0.59
200	93.29																						0.00	0.20	0.42
150	93.09																							0.00	0.22
101	92.87																								0.00

Table 16. Transect R2: Magnitude change in river stage as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting River Stage (ft)	Ending discharge (cfs), Ending River Stage (ft), and Magnitude Change in River Stage																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		101.53	101.38	101.19	101.02	100.80	100.57	100.37	100.20	100.01	99.80	99.56	99.27	99.16	98.97	98.75	98.50	98.27	98.11	97.92	97.69	97.41	97.22	97.01	96.74
6,500	101.53	0.00	0.15	0.34	0.51	0.73	0.96	1.16	1.33	1.52	1.73	1.97	2.26	2.37	2.56	2.78	3.03	3.26	3.42	3.61	3.84	4.12	4.31	4.52	4.79
6,000	101.38		0.00	0.19	0.36	0.58	0.81	1.01	1.18	1.37	1.58	1.82	2.11	2.22	2.41	2.63	2.88	3.11	3.27	3.46	3.69	3.97	4.16	4.37	4.64
5,400	101.19			0.00	0.17	0.39	0.62	0.82	0.99	1.18	1.39	1.63	1.92	2.03	2.22	2.44	2.69	2.92	3.08	3.27	3.50	3.78	3.97	4.18	4.45
4,900	101.02				0.00	0.22	0.45	0.65	0.82	1.01	1.22	1.46	1.75	1.86	2.05	2.27	2.52	2.75	2.91	3.10	3.33	3.61	3.80	4.01	4.28
4,300	100.80					0.00	0.23	0.43	0.60	0.79	1.00	1.24	1.53	1.64	1.83	2.05	2.30	2.53	2.69	2.88	3.11	3.39	3.58	3.79	4.06
3,749	100.57						0.00	0.20	0.37	0.56	0.77	1.01	1.30	1.41	1.60	1.82	2.07	2.30	2.46	2.65	2.88	3.16	3.35	3.56	3.83
3,300	100.37							0.00	0.17	0.36	0.57	0.81	1.10	1.21	1.40	1.62	1.87	2.10	2.26	2.45	2.68	2.96	3.15	3.36	3.63
2,950	100.20								0.00	0.19	0.40	0.64	0.93	1.04	1.23	1.45	1.70	1.93	2.09	2.28	2.51	2.79	2.98	3.19	3.46
2,600	100.01									0.00	0.21	0.45	0.74	0.85	1.04	1.26	1.51	1.74	1.90	2.09	2.32	2.60	2.79	3.00	3.27
2,250	99.80										0.00	0.24	0.53	0.64	0.83	1.05	1.30	1.53	1.69	1.88	2.11	2.39	2.58	2.79	3.06
1,900	99.56											0.00	0.29	0.40	0.59	0.81	1.06	1.29	1.45	1.64	1.87	2.15	2.34	2.55	2.82
1,529	99.27												0.00	0.11	0.30	0.52	0.77	1.00	1.16	1.35	1.58	1.86	2.05	2.26	2.53
1,400	99.16													0.00	0.19	0.41	0.66	0.89	1.05	1.24	1.47	1.75	1.94	2.15	2.42
1,200	98.97														0.00	0.22	0.47	0.70	0.86	1.05	1.28	1.56	1.75	1.96	2.23
1,000	98.75															0.00	0.25	0.48	0.64	0.83	1.06	1.34	1.53	1.74	2.01
800	98.50																0.00	0.23	0.39	0.58	0.81	1.09	1.28	1.49	1.76
640	98.27																	0.00	0.16	0.35	0.58	0.86	1.05	1.26	1.53
550	98.11																		0.00	0.19	0.42	0.70	0.89	1.10	1.37
450	97.92																			0.00	0.23	0.51	0.70	0.91	1.18
350	97.69																				0.00	0.28	0.47	0.68	0.95
253	97.41																					0.00	0.19	0.40	0.67
200	97.22																						0.00	0.21	0.48
150	97.01																							0.00	0.27
101	96.74																								0.00

Table 17. Transect R3: Magnitude change in river stage as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting River Stage (ft)	Ending discharge (cfs), Ending River Stage (ft), and Magnitude Change in River Stage																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		103.03	102.82	102.56	102.31	102.00	101.69	101.41	101.17	100.91	100.63	100.31	99.93	99.78	99.53	99.25	98.93	98.63	98.43	98.19	97.91	97.57	97.35	97.10	96.79
6,500	103.03	0.00	0.21	0.47	0.72	1.03	1.34	1.62	1.86	2.12	2.40	2.72	3.10	3.25	3.50	3.78	4.10	4.40	4.60	4.84	5.12	5.46	5.68	5.93	6.24
6,000	102.82		0.00	0.26	0.51	0.82	1.13	1.41	1.65	1.91	2.19	2.51	2.89	3.04	3.29	3.57	3.89	4.19	4.39	4.63	4.91	5.25	5.47	5.72	6.03
5,400	102.56			0.00	0.25	0.56	0.87	1.15	1.39	1.65	1.93	2.25	2.63	2.78	3.03	3.31	3.63	3.93	4.13	4.37	4.65	4.99	5.21	5.46	5.77
4,900	102.31				0.00	0.31	0.62	0.90	1.14	1.40	1.68	2.00	2.38	2.53	2.78	3.06	3.38	3.68	3.88	4.12	4.40	4.74	4.96	5.21	5.52
4,300	102.00					0.00	0.31	0.59	0.83	1.09	1.37	1.69	2.07	2.22	2.47	2.75	3.07	3.37	3.57	3.81	4.09	4.43	4.65	4.90	5.21
3,749	101.69						0.00	0.28	0.52	0.78	1.06	1.38	1.76	1.91	2.16	2.44	2.76	3.06	3.26	3.50	3.78	4.12	4.34	4.59	4.90
3,300	101.41							0.00	0.24	0.50	0.78	1.10	1.48	1.63	1.88	2.16	2.48	2.78	2.98	3.22	3.50	3.84	4.06	4.31	4.62
2,950	101.17								0.00	0.26	0.54	0.86	1.24	1.39	1.64	1.92	2.24	2.54	2.74	2.98	3.26	3.60	3.82	4.07	4.38
2,600	100.91									0.00	0.28	0.60	0.98	1.13	1.38	1.66	1.98	2.28	2.48	2.72	3.00	3.34	3.56	3.81	4.12
2,250	100.63										0.00	0.32	0.70	0.85	1.10	1.38	1.70	2.00	2.20	2.44	2.72	3.06	3.28	3.53	3.84
1,900	100.31											0.00	0.38	0.53	0.78	1.06	1.38	1.68	1.88	2.12	2.40	2.74	2.96	3.21	3.52
1,529	99.93												0.00	0.15	0.40	0.68	1.00	1.30	1.50	1.74	2.02	2.36	2.58	2.83	3.14
1,400	99.78													0.00	0.25	0.53	0.85	1.15	1.35	1.59	1.87	2.21	2.43	2.68	2.99
1,200	99.53														0.00	0.28	0.60	0.90	1.10	1.34	1.62	1.96	2.18	2.43	2.74
1,000	99.25															0.00	0.32	0.62	0.82	1.06	1.34	1.68	1.90	2.15	2.46
800	98.93																0.00	0.30	0.50	0.74	1.02	1.36	1.58	1.83	2.14
640	98.63																	0.00	0.20	0.44	0.72	1.06	1.28	1.53	1.84
550	98.43																		0.00	0.24	0.52	0.86	1.08	1.33	1.64
450	98.19																			0.00	0.28	0.62	0.84	1.09	1.40
350	97.91																				0.00	0.34	0.56	0.81	1.12
253	97.57																					0.00	0.22	0.47	0.78
200	97.35																						0.00	0.25	0.56
150	97.10																							0.00	0.31
101	96.79																								0.00

Table 18. Transect R4: Magnitude change in river stage as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting River Stage (ft)	Ending discharge (cfs), Ending River Stage (ft), and Magnitude Change in River Stage																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		95.97	95.70	95.35	95.05	94.66	94.27	93.93	93.65	93.35	93.03	92.68	92.26	92.10	91.84	91.56	91.24	90.95	90.77	90.54	90.29	90.01	89.83	89.63	89.40
6,500	95.97	0.00	0.27	0.62	0.92	1.31	1.70	2.04	2.32	2.62	2.94	3.29	3.71	3.87	4.13	4.41	4.73	5.02	5.20	5.43	5.68	5.96	6.14	6.34	6.57
6,000	95.70		0.00	0.35	0.65	1.04	1.43	1.77	2.05	2.35	2.67	3.02	3.44	3.60	3.86	4.14	4.46	4.75	4.93	5.16	5.41	5.69	5.87	6.07	6.30
5,400	95.35			0.00	0.30	0.69	1.08	1.42	1.70	2.00	2.32	2.67	3.09	3.25	3.51	3.79	4.11	4.40	4.58	4.81	5.06	5.34	5.52	5.72	5.95
4,900	95.05				0.00	0.39	0.78	1.12	1.40	1.70	2.02	2.37	2.79	2.95	3.21	3.49	3.81	4.10	4.28	4.51	4.76	5.04	5.22	5.42	5.65
4,300	94.66					0.00	0.39	0.73	1.01	1.31	1.63	1.98	2.40	2.56	2.82	3.10	3.42	3.71	3.89	4.12	4.37	4.65	4.83	5.03	5.26
3,749	94.27						0.00	0.34	0.62	0.92	1.24	1.59	2.01	2.17	2.43	2.71	3.03	3.32	3.50	3.73	3.98	4.26	4.44	4.64	4.87
3,300	93.93							0.00	0.28	0.58	0.90	1.25	1.67	1.83	2.09	2.37	2.69	2.98	3.16	3.39	3.64	3.92	4.10	4.30	4.53
2,950	93.65								0.00	0.30	0.62	0.97	1.39	1.55	1.81	2.09	2.41	2.70	2.88	3.11	3.36	3.64	3.82	4.02	4.25
2,600	93.35									0.00	0.32	0.67	1.09	1.25	1.51	1.79	2.11	2.40	2.58	2.81	3.06	3.34	3.52	3.72	3.95
2,250	93.03										0.00	0.35	0.77	0.93	1.19	1.47	1.79	2.08	2.26	2.49	2.74	3.02	3.20	3.40	3.63
1,900	92.68											0.00	0.42	0.58	0.84	1.12	1.44	1.73	1.91	2.14	2.39	2.67	2.85	3.05	3.28
1,529	92.26												0.00	0.16	0.42	0.70	1.02	1.31	1.49	1.72	1.97	2.25	2.43	2.63	2.86
1,400	92.10													0.00	0.26	0.54	0.86	1.15	1.33	1.56	1.81	2.09	2.27	2.47	2.70
1,200	91.84														0.00	0.28	0.60	0.89	1.07	1.30	1.55	1.83	2.01	2.21	2.44
1,000	91.56															0.00	0.32	0.61	0.79	1.02	1.27	1.55	1.73	1.93	2.16
800	91.24																0.00	0.29	0.47	0.70	0.95	1.23	1.41	1.61	1.84
640	90.95																	0.00	0.18	0.41	0.66	0.94	1.12	1.32	1.55
550	90.77																		0.00	0.23	0.48	0.76	0.94	1.14	1.37
450	90.54																			0.00	0.25	0.53	0.71	0.91	1.14
350	90.29																				0.00	0.28	0.46	0.66	0.89
253	90.01																					0.00	0.18	0.38	0.61
200	89.83																						0.00	0.20	0.43
150	89.63																							0.00	0.23
101	89.40																								0.00

Table 19. Transect R5: Magnitude change in river stage as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting River Stage (ft)	Ending discharge (cfs), Ending River Stage (ft), and Magnitude Change in River Stage																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		98.47	98.16	97.78	97.44	97.00	96.57	96.18	95.86	95.52	95.15	94.74	94.25	94.07	93.76	93.42	93.04	92.69	92.47	92.20	91.89	91.53	91.30	91.04	90.74
6,500	98.47	0.00	0.31	0.69	1.03	1.47	1.90	2.29	2.61	2.95	3.32	3.73	4.22	4.40	4.71	5.05	5.43	5.78	6.00	6.27	6.58	6.94	7.17	7.43	7.73
6,000	98.16		0.00	0.38	0.72	1.16	1.59	1.98	2.30	2.64	3.01	3.42	3.91	4.09	4.40	4.74	5.12	5.47	5.69	5.96	6.27	6.63	6.86	7.12	7.42
5,400	97.78			0.00	0.34	0.78	1.21	1.60	1.92	2.26	2.63	3.04	3.53	3.71	4.02	4.36	4.74	5.09	5.31	5.58	5.89	6.25	6.48	6.74	7.04
4,900	97.44				0.00	0.44	0.87	1.26	1.58	1.92	2.29	2.70	3.19	3.37	3.68	4.02	4.40	4.75	4.97	5.24	5.55	5.91	6.14	6.40	6.70
4,300	97.00					0.00	0.43	0.82	1.14	1.48	1.85	2.26	2.75	2.93	3.24	3.58	3.96	4.31	4.53	4.80	5.11	5.47	5.70	5.96	6.26
3,749	96.57						0.00	0.39	0.71	1.05	1.42	1.83	2.32	2.50	2.81	3.15	3.53	3.88	4.10	4.37	4.68	5.04	5.27	5.53	5.83
3,300	96.18							0.00	0.32	0.66	1.03	1.44	1.93	2.11	2.42	2.76	3.14	3.49	3.71	3.98	4.29	4.65	4.88	5.14	5.44
2,950	95.86								0.00	0.34	0.71	1.12	1.61	1.79	2.10	2.44	2.82	3.17	3.39	3.66	3.97	4.33	4.56	4.82	5.12
2,600	95.52									0.00	0.37	0.78	1.27	1.45	1.76	2.10	2.48	2.83	3.05	3.32	3.63	3.99	4.22	4.48	4.78
2,250	95.15										0.00	0.41	0.90	1.08	1.39	1.73	2.11	2.46	2.68	2.95	3.26	3.62	3.85	4.11	4.41
1,900	94.74											0.00	0.49	0.67	0.98	1.32	1.70	2.05	2.27	2.54	2.85	3.21	3.44	3.70	4.00
1,529	94.25												0.00	0.18	0.49	0.83	1.21	1.56	1.78	2.05	2.36	2.72	2.95	3.21	3.51
1,400	94.07													0.00	0.31	0.65	1.03	1.38	1.60	1.87	2.18	2.54	2.77	3.03	3.33
1,200	93.76														0.00	0.34	0.72	1.07	1.29	1.56	1.87	2.23	2.46	2.72	3.02
1,000	93.42															0.00	0.38	0.73	0.95	1.22	1.53	1.89	2.12	2.38	2.68
800	93.04																0.00	0.35	0.57	0.84	1.15	1.51	1.74	2.00	2.30
640	92.69																	0.00	0.22	0.49	0.80	1.16	1.39	1.65	1.95
550	92.47																		0.00	0.27	0.58	0.94	1.17	1.43	1.73
450	92.20																			0.00	0.31	0.67	0.90	1.16	1.46
350	91.89																				0.00	0.36	0.59	0.85	1.15
253	91.53																					0.00	0.23	0.49	0.79
200	91.30																						0.00	0.26	0.56
150	91.04																							0.00	0.30
101	90.74																								0.00

Table 20. Transect R6: Magnitude change in river stage as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting River Stage (ft)	Ending discharge (cfs), Ending River Stage (ft), and Magnitude Change in River Stage																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		98.82	98.52	98.13	97.78	97.33	96.89	96.49	96.16	95.80	95.42	94.99	94.48	94.29	93.96	93.60	93.20	92.82	92.59	92.30	91.97	91.59	91.35	91.08	90.77
6,500	98.82	0.00	0.30	0.69	1.04	1.49	1.93	2.33	2.66	3.02	3.40	3.83	4.34	4.53	4.86	5.22	5.62	6.00	6.23	6.52	6.85	7.23	7.47	7.74	8.05
6,000	98.52		0.00	0.39	0.74	1.19	1.63	2.03	2.36	2.72	3.10	3.53	4.04	4.23	4.56	4.92	5.32	5.70	5.93	6.22	6.55	6.93	7.17	7.44	7.75
5,400	98.13			0.00	0.35	0.80	1.24	1.64	1.97	2.33	2.71	3.14	3.65	3.84	4.17	4.53	4.93	5.31	5.54	5.83	6.16	6.54	6.78	7.05	7.36
4,900	97.78				0.00	0.45	0.89	1.29	1.62	1.98	2.36	2.79	3.30	3.49	3.82	4.18	4.58	4.96	5.19	5.48	5.81	6.19	6.43	6.70	7.01
4,300	97.33					0.00	0.44	0.84	1.17	1.53	1.91	2.34	2.85	3.04	3.37	3.73	4.13	4.51	4.74	5.03	5.36	5.74	5.98	6.25	6.56
3,749	96.89						0.00	0.40	0.73	1.09	1.47	1.90	2.41	2.60	2.93	3.29	3.69	4.07	4.30	4.59	4.92	5.30	5.54	5.81	6.12
3,300	96.49							0.00	0.33	0.69	1.07	1.50	2.01	2.20	2.53	2.89	3.29	3.67	3.90	4.19	4.52	4.90	5.14	5.41	5.72
2,950	96.16								0.00	0.36	0.74	1.17	1.68	1.87	2.20	2.56	2.96	3.34	3.57	3.86	4.19	4.57	4.81	5.08	5.39
2,600	95.80									0.00	0.38	0.81	1.32	1.51	1.84	2.20	2.60	2.98	3.21	3.50	3.83	4.21	4.45	4.72	5.03
2,250	95.42										0.00	0.43	0.94	1.13	1.46	1.82	2.22	2.60	2.83	3.12	3.45	3.83	4.07	4.34	4.65
1,900	94.99											0.00	0.51	0.70	1.03	1.39	1.79	2.17	2.40	2.69	3.02	3.40	3.64	3.91	4.22
1,529	94.48												0.00	0.19	0.52	0.88	1.28	1.66	1.89	2.18	2.51	2.89	3.13	3.40	3.71
1,400	94.29													0.00	0.33	0.69	1.09	1.47	1.70	1.99	2.32	2.70	2.94	3.21	3.52
1,200	93.96														0.00	0.36	0.76	1.14	1.37	1.66	1.99	2.37	2.61	2.88	3.19
1,000	93.60															0.00	0.40	0.78	1.01	1.30	1.63	2.01	2.25	2.52	2.83
800	93.20																0.00	0.38	0.61	0.90	1.23	1.61	1.85	2.12	2.43
640	92.82																	0.00	0.23	0.52	0.85	1.23	1.47	1.74	2.05
550	92.59																		0.00	0.29	0.62	1.00	1.24	1.51	1.82
450	92.30																			0.00	0.33	0.71	0.95	1.22	1.53
350	91.97																				0.00	0.38	0.62	0.89	1.20
253	91.59																					0.00	0.24	0.51	0.82
200	91.35																						0.00	0.27	0.58
150	91.08																							0.00	0.31
101	90.77																								0.00

Table 21. Transect R7: Magnitude change in river stage as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting River Stage (ft)	Ending discharge (cfs), Ending River Stage (ft), and Magnitude Change in River Stage																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		102.56	102.23	101.81	101.44	100.97	100.51	100.11	99.78	99.42	99.04	98.63	98.15	97.97	97.67	97.34	96.98	96.65	96.45	96.20	95.93	95.62	95.42	95.21	94.96
6,500	102.56	0.00	0.33	0.75	1.12	1.59	2.05	2.45	2.78	3.14	3.52	3.93	4.41	4.59	4.89	5.22	5.58	5.91	6.11	6.36	6.63	6.94	7.14	7.35	7.60
6,000	102.23		0.00	0.42	0.79	1.26	1.72	2.12	2.45	2.81	3.19	3.60	4.08	4.26	4.56	4.89	5.25	5.58	5.78	6.03	6.30	6.61	6.81	7.02	7.27
5,400	101.81			0.00	0.37	0.84	1.30	1.70	2.03	2.39	2.77	3.18	3.66	3.84	4.14	4.47	4.83	5.16	5.36	5.61	5.88	6.19	6.39	6.60	6.85
4,900	101.44				0.00	0.47	0.93	1.33	1.66	2.02	2.40	2.81	3.29	3.47	3.77	4.10	4.46	4.79	4.99	5.24	5.51	5.82	6.02	6.23	6.48
4,300	100.97					0.00	0.46	0.86	1.19	1.55	1.93	2.34	2.82	3.00	3.30	3.63	3.99	4.32	4.52	4.77	5.04	5.35	5.55	5.76	6.01
3,749	100.51						0.00	0.40	0.73	1.09	1.47	1.88	2.36	2.54	2.84	3.17	3.53	3.86	4.06	4.31	4.58	4.89	5.09	5.30	5.55
3,300	100.11							0.00	0.33	0.69	1.07	1.48	1.96	2.14	2.44	2.77	3.13	3.46	3.66	3.91	4.18	4.49	4.69	4.90	5.15
2,950	99.78								0.00	0.36	0.74	1.15	1.63	1.81	2.11	2.44	2.80	3.13	3.33	3.58	3.85	4.16	4.36	4.57	4.82
2,600	99.42									0.00	0.38	0.79	1.27	1.45	1.75	2.08	2.44	2.77	2.97	3.22	3.49	3.80	4.00	4.21	4.46
2,250	99.04										0.00	0.41	0.89	1.07	1.37	1.70	2.06	2.39	2.59	2.84	3.11	3.42	3.62	3.83	4.08
1,900	98.63											0.00	0.48	0.66	0.96	1.29	1.65	1.98	2.18	2.43	2.70	3.01	3.21	3.42	3.67
1,529	98.15												0.00	0.18	0.48	0.81	1.17	1.50	1.70	1.95	2.22	2.53	2.73	2.94	3.19
1,400	97.97													0.00	0.30	0.63	0.99	1.32	1.52	1.77	2.04	2.35	2.55	2.76	3.01
1,200	97.67														0.00	0.33	0.69	1.02	1.22	1.47	1.74	2.05	2.25	2.46	2.71
1,000	97.34															0.00	0.36	0.69	0.89	1.14	1.41	1.72	1.92	2.13	2.38
800	96.98																0.00	0.33	0.53	0.78	1.05	1.36	1.56	1.77	2.02
640	96.65																	0.00	0.20	0.45	0.72	1.03	1.23	1.44	1.69
550	96.45																		0.00	0.25	0.52	0.83	1.03	1.24	1.49
450	96.20																			0.00	0.27	0.58	0.78	0.99	1.24
350	95.93																				0.00	0.31	0.51	0.72	0.97
253	95.62																					0.00	0.20	0.41	0.66
200	95.42																						0.00	0.21	0.46
150	95.21																							0.00	0.25
101	94.96																								0.00

Page Left Blank

Percent Change in Stage

Page Left Blank

Tables 22—28 show the percent change in relative river stage from a starting discharge to an ending discharge. Percent change in relative river stage is calculated based on the percent difference between the starting relative river stage and ending relative river stage. The table shows starting discharges in descending order along the table's left column and ending discharges in descending order from left to right along the top row.

Table 22. Transect R1: Percent change in relative river stage as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Relative River Stage[1] (ft)	Ending Discharge (cfs), Ending Relative River Stage (ft), and Percent Change in Relative River Stage																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		6.26	5.99	5.66	5.37	5.00	4.63	4.31	4.04	3.76	3.45	3.12	2.73	2.59	2.34	2.07	1.77	1.49	1.32	1.11	0.87	0.59	0.42	0.22	0.00
6,500	6.26	0.0%	4.3%	9.6%	14.2%	20.1%	26.0%	31.2%	35.5%	39.9%	44.9%	50.2%	56.4%	58.6%	62.6%	66.9%	71.7%	76.2%	78.9%	82.3%	86.1%	90.6%	93.3%	96.5%	100.0%
6,000	5.99		0.0%	5.5%	10.4%	16.5%	22.7%	28.0%	32.6%	37.2%	42.4%	47.9%	54.4%	56.8%	60.9%	65.4%	70.5%	75.1%	78.0%	81.5%	85.5%	90.2%	93.0%	96.3%	100.0%
5,400	5.66			0.0%	5.1%	11.7%	18.2%	23.9%	28.6%	33.6%	39.0%	44.9%	51.8%	54.2%	58.7%	63.4%	68.7%	73.7%	76.7%	80.4%	84.6%	89.6%	92.6%	96.1%	100.0%
4,900	5.37				0.0%	6.9%	13.8%	19.7%	24.8%	30.0%	35.8%	41.9%	49.2%	51.8%	56.4%	61.5%	67.0%	72.3%	75.4%	79.3%	83.8%	89.0%	92.2%	95.9%	100.0%
4,300	5.00					0.0%	7.4%	13.8%	19.2%	24.8%	31.0%	37.6%	45.4%	48.2%	53.2%	58.6%	64.6%	70.2%	73.6%	77.8%	82.6%	88.2%	91.6%	95.6%	100.0%
3,749	4.63						0.0%	6.9%	12.7%	18.8%	25.5%	32.6%	41.0%	44.1%	49.5%	55.3%	61.8%	67.8%	71.5%	76.0%	81.2%	87.3%	90.9%	95.2%	100.0%
3,300	4.31							0.0%	6.3%	12.8%	20.0%	27.6%	36.7%	39.9%	45.7%	52.0%	58.9%	65.4%	69.4%	74.2%	79.8%	86.3%	90.3%	94.9%	100.0%
2,950	4.04								0.0%	6.9%	14.6%	22.8%	32.4%	35.9%	42.1%	48.8%	56.2%	63.1%	67.3%	72.5%	78.5%	85.4%	89.6%	94.6%	100.0%
2,600	3.76									0.0%	8.2%	17.0%	27.4%	31.1%	37.8%	44.9%	52.9%	60.4%	64.9%	70.5%	76.9%	84.3%	88.8%	94.1%	100.0%
2,250	3.45										0.0%	9.6%	20.9%	24.9%	32.2%	40.0%	48.7%	56.8%	61.7%	67.8%	74.8%	82.9%	87.8%	93.6%	100.0%
1,900	3.12											0.0%	12.5%	17.0%	25.0%	33.7%	43.3%	52.2%	57.7%	64.4%	72.1%	81.1%	86.5%	92.9%	100.0%
1,529	2.73												0.0%	5.1%	14.3%	24.2%	35.2%	45.4%	51.6%	59.3%	68.1%	78.4%	84.6%	91.9%	100.0%
1,400	2.59													0.0%	9.7%	20.1%	31.7%	42.5%	49.0%	57.1%	66.4%	77.2%	83.8%	91.5%	100.0%
1,200	2.34														0.0%	11.5%	24.4%	36.3%	43.6%	52.6%	62.8%	74.8%	82.1%	90.6%	100.0%
1,000	2.07															0.0%	14.5%	28.0%	36.2%	46.4%	58.0%	71.5%	79.7%	89.4%	100.0%
800	1.77																0.0%	15.8%	25.4%	37.3%	50.8%	66.7%	76.3%	87.6%	100.0%
640	1.49																	0.0%	11.4%	25.5%	41.6%	60.4%	71.8%	85.2%	100.0%
550	1.32																		0.0%	15.9%	34.1%	55.3%	68.2%	83.3%	100.0%
450	1.11																			0.0%	21.6%	46.8%	62.2%	80.2%	100.0%
350	0.87																				0.0%	32.2%	51.7%	74.7%	100.0%
253	0.59																					0.0%	28.8%	62.7%	100.0%
200	0.42																						0.0%	47.6%	100.0%
150	0.22																							0.0%	100.0%
101	0.00																								0.0%

Key:
[1] Relative river stage is a value representing the number of feet the river is above it's water surface elevation at a baseline flow of 101 cfs.

Table 23. Transect R2: Percent change in relative river stage as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Relative River Stage[1] (ft)	Ending Discharge (cfs), Ending Relative River Stage (ft), and Percent Change in Relative River Stage																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		4.79	4.64	4.45	4.28	4.06	3.83	3.63	3.46	3.27	3.06	2.82	2.53	2.42	2.23	2.01	1.76	1.53	1.37	1.18	0.95	0.67	0.48	0.27	0.00
6,500	4.79	0.0%	3.1%	7.1%	10.6%	15.2%	20.0%	24.2%	27.8%	31.7%	36.1%	41.1%	47.2%	49.5%	53.4%	58.0%	63.3%	68.1%	71.4%	75.4%	80.2%	86.0%	90.0%	94.4%	100.0%
6,000	4.64		0.0%	4.1%	7.8%	12.5%	17.5%	21.8%	25.4%	29.5%	34.1%	39.2%	45.5%	47.8%	51.9%	56.7%	62.1%	67.0%	70.5%	74.6%	79.5%	85.6%	89.7%	94.2%	100.0%
5,400	4.45			0.0%	3.8%	8.8%	13.9%	18.4%	22.2%	26.5%	31.2%	36.6%	43.1%	45.6%	49.9%	54.8%	60.4%	65.6%	69.2%	73.5%	78.7%	84.9%	89.2%	93.9%	100.0%
4,900	4.28				0.0%	5.1%	10.5%	15.2%	19.2%	23.6%	28.5%	34.1%	40.9%	43.5%	47.9%	53.0%	58.9%	64.3%	68.0%	72.4%	77.8%	84.3%	88.8%	93.7%	100.0%
4,300	4.06					0.0%	5.7%	10.6%	14.8%	19.5%	24.6%	30.5%	37.7%	40.4%	45.1%	50.5%	56.7%	62.3%	66.3%	70.9%	76.6%	83.5%	88.2%	93.3%	100.0%
3,749	3.83						0.0%	5.2%	9.7%	14.6%	20.1%	26.4%	33.9%	36.8%	41.8%	47.5%	54.0%	60.1%	64.2%	69.2%	75.2%	82.5%	87.5%	93.0%	100.0%
3,300	3.63							0.0%	4.7%	9.9%	15.7%	22.3%	30.3%	33.3%	38.6%	44.6%	51.5%	57.9%	62.3%	67.5%	73.8%	81.5%	86.8%	92.6%	100.0%
2,950	3.46								0.0%	5.5%	11.6%	18.5%	26.9%	30.1%	35.5%	41.9%	49.1%	55.8%	60.4%	65.9%	72.5%	80.6%	86.1%	92.2%	100.0%
2,600	3.27									0.0%	6.4%	13.8%	22.6%	26.0%	31.8%	38.5%	46.2%	53.2%	58.1%	63.9%	70.9%	79.5%	85.3%	91.7%	100.0%
2,250	3.06										0.0%	7.8%	17.3%	20.9%	27.1%	34.3%	42.5%	50.0%	55.2%	61.4%	69.0%	78.1%	84.3%	91.2%	100.0%
1,900	2.82											0.0%	10.3%	14.2%	20.9%	28.7%	37.6%	45.7%	51.4%	58.2%	66.3%	76.2%	83.0%	90.4%	100.0%
1,529	2.53												0.0%	4.3%	11.9%	20.6%	30.4%	39.5%	45.8%	53.4%	62.5%	73.5%	81.0%	89.3%	100.0%
1,400	2.42													0.0%	7.9%	16.9%	27.3%	36.8%	43.4%	51.2%	60.7%	72.3%	80.2%	88.8%	100.0%
1,200	2.23														0.0%	9.9%	21.1%	31.4%	38.6%	47.1%	57.4%	70.0%	78.5%	87.9%	100.0%
1,000	2.01															0.0%	12.4%	23.9%	31.8%	41.3%	52.7%	66.7%	76.1%	86.6%	100.0%
800	1.76																0.0%	13.1%	22.2%	33.0%	46.0%	61.9%	72.7%	84.7%	100.0%
640	1.53																	0.0%	10.5%	22.9%	37.9%	56.2%	68.6%	82.4%	100.0%
550	1.37																		0.0%	13.9%	30.7%	51.1%	65.0%	80.3%	100.0%
450	1.18																			0.0%	19.5%	43.2%	59.3%	77.1%	100.0%
350	0.95																				0.0%	29.5%	49.5%	71.6%	100.0%
253	0.67																					0.0%	28.4%	59.7%	100.0%
200	0.48																						0.0%	43.7%	100.0%
150	0.27																							0.0%	100.0%
101	0.00																								0.0%

Key:
[1] Relative river stage is a value representing the number of feet the river is above it's water surface elevation at a baseline flow of 101 cfs.

Table 24. Transect R3: Percent change in relative river stage as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Relative River Stage[1] (ft)	Ending Discharge (cfs), Ending Relative River Stage (ft), and Percent Change in Relative River Stage																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		6.24	6.03	5.77	5.52	5.21	4.90	4.62	4.38	4.12	3.84	3.52	3.14	2.99	2.74	2.46	2.14	1.84	1.64	1.40	1.12	0.78	0.56	0.31	0.00
6,500	6.24	0.0%	3.4%	7.5%	11.5%	16.5%	21.5%	26.0%	29.8%	34.0%	38.5%	43.6%	49.7%	52.1%	56.1%	60.6%	65.7%	70.5%	73.7%	77.6%	82.1%	87.5%	91.0%	95.0%	100.0%
6,000	6.03		0.0%	4.3%	8.5%	13.6%	18.7%	23.4%	27.4%	31.7%	36.3%	41.6%	47.9%	50.4%	54.6%	59.2%	64.5%	69.5%	72.8%	76.8%	81.4%	87.1%	90.7%	94.9%	100.0%
5,400	5.77			0.0%	4.3%	9.7%	15.1%	19.9%	24.1%	28.6%	33.4%	39.0%	45.6%	48.2%	52.5%	57.4%	62.9%	68.1%	71.6%	75.7%	80.6%	86.5%	90.3%	94.6%	100.0%
4,900	5.52				0.0%	5.6%	11.2%	16.3%	20.7%	25.4%	30.4%	36.2%	43.1%	45.8%	50.4%	55.4%	61.2%	66.7%	70.3%	74.6%	79.7%	85.9%	89.9%	94.4%	100.0%
4,300	5.21					0.0%	6.0%	11.3%	15.9%	20.9%	26.3%	32.4%	39.7%	42.6%	47.4%	52.8%	58.9%	64.7%	68.5%	73.1%	78.5%	85.0%	89.3%	94.0%	100.0%
3,749	4.90						0.0%	5.7%	10.6%	15.9%	21.6%	28.2%	35.9%	39.0%	44.1%	49.8%	56.3%	62.4%	66.5%	71.4%	77.1%	84.1%	88.6%	93.7%	100.0%
3,300	4.62							0.0%	5.2%	10.8%	16.9%	23.8%	32.0%	35.3%	40.7%	46.8%	53.7%	60.2%	64.5%	69.7%	75.8%	83.1%	87.9%	93.3%	100.0%
2,950	4.38								0.0%	5.9%	12.3%	19.6%	28.3%	31.7%	37.4%	43.8%	51.1%	58.0%	62.6%	68.0%	74.4%	82.2%	87.2%	92.9%	100.0%
2,600	4.12									0.0%	6.8%	14.6%	23.8%	27.4%	33.5%	40.3%	48.1%	55.3%	60.2%	66.0%	72.8%	81.1%	86.4%	92.5%	100.0%
2,250	3.84										0.0%	8.3%	18.2%	22.1%	28.6%	35.9%	44.3%	52.1%	57.3%	63.5%	70.8%	79.7%	85.4%	91.9%	100.0%
1,900	3.52											0.0%	10.8%	15.1%	22.2%	30.1%	39.2%	47.7%	53.4%	60.2%	68.2%	77.8%	84.1%	91.2%	100.0%
1,529	3.14												0.0%	4.8%	12.7%	21.7%	31.8%	41.4%	47.8%	55.4%	64.3%	75.2%	82.2%	90.1%	100.0%
1,400	2.99													0.0%	8.4%	17.7%	28.4%	38.5%	45.2%	53.2%	62.5%	73.9%	81.3%	89.6%	100.0%
1,200	2.74														0.0%	10.2%	21.9%	32.8%	40.1%	48.9%	59.1%	71.5%	79.6%	88.7%	100.0%
1,000	2.46															0.0%	13.0%	25.2%	33.3%	43.1%	54.5%	68.3%	77.2%	87.4%	100.0%
800	2.14																0.0%	14.0%	23.4%	34.6%	47.7%	63.6%	73.8%	85.5%	100.0%
640	1.84																	0.0%	10.9%	23.9%	39.1%	57.6%	69.6%	83.2%	100.0%
550	1.64																		0.0%	14.6%	31.7%	52.4%	65.9%	81.1%	100.0%
450	1.40																			0.0%	20.0%	44.3%	60.0%	77.9%	100.0%
350	1.12																				0.0%	30.4%	50.0%	72.3%	100.0%
253	0.78																					0.0%	28.2%	60.3%	100.0%
200	0.56																						0.0%	44.6%	100.0%
150	0.31																							0.0%	100.0%
101	0.00																								0.0%

Key:
[1] Relative river stage is a value representing the number of feet the river is above it's water surface elevation at a baseline flow of 101 cfs.

Table 25. Transect R4: Percent change in relative river stage as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Relative River Stage[1] (ft)	Ending Discharge (cfs), Ending Relative River Stage (ft), and Percent Change in Relative River Stage																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		6.57	6.30	5.95	5.65	5.26	4.87	4.53	4.25	3.95	3.63	3.28	2.86	2.70	2.44	2.16	1.84	1.55	1.37	1.14	0.89	0.61	0.43	0.23	0.00
6,500	6.57	0.0%	4.1%	9.4%	14.0%	19.9%	25.9%	31.1%	35.3%	39.9%	44.7%	50.1%	56.5%	58.9%	62.9%	67.1%	72.0%	76.4%	79.1%	82.6%	86.5%	90.7%	93.5%	96.5%	100.0%
6,000	6.30		0.0%	5.6%	10.3%	16.5%	22.7%	28.1%	32.5%	37.3%	42.4%	47.9%	54.6%	57.1%	61.3%	65.7%	70.8%	75.4%	78.3%	81.9%	85.9%	90.3%	93.2%	96.3%	100.0%
5,400	5.95			0.0%	5.0%	11.6%	18.2%	23.9%	28.6%	33.6%	39.0%	44.9%	51.9%	54.6%	59.0%	63.7%	69.1%	73.9%	77.0%	80.8%	85.0%	89.7%	92.8%	96.1%	100.0%
4,900	5.65				0.0%	6.9%	13.8%	19.8%	24.8%	30.1%	35.8%	41.9%	49.4%	52.2%	56.8%	61.8%	67.4%	72.6%	75.8%	79.8%	84.2%	89.2%	92.4%	95.9%	100.0%
4,300	5.26					0.0%	7.4%	13.9%	19.2%	24.9%	31.0%	37.6%	45.6%	48.7%	53.6%	58.9%	65.0%	70.5%	74.0%	78.3%	83.1%	88.4%	91.8%	95.6%	100.0%
3,749	4.87						0.0%	7.0%	12.7%	18.9%	25.5%	32.6%	41.3%	44.6%	49.9%	55.6%	62.2%	68.2%	71.9%	76.6%	81.7%	87.5%	91.2%	95.3%	100.0%
3,300	4.53							0.0%	6.2%	12.8%	19.9%	27.6%	36.9%	40.4%	46.1%	52.3%	59.4%	65.8%	69.8%	74.8%	80.4%	86.5%	90.5%	94.9%	100.0%
2,950	4.25								0.0%	7.1%	14.6%	22.8%	32.7%	36.5%	42.6%	49.2%	56.7%	63.5%	67.8%	73.2%	79.1%	85.6%	89.9%	94.6%	100.0%
2,600	3.95									0.0%	8.1%	17.0%	27.6%	31.6%	38.2%	45.3%	53.4%	60.8%	65.3%	71.1%	77.5%	84.6%	89.1%	94.2%	100.0%
2,250	3.63										0.0%	9.6%	21.2%	25.6%	32.8%	40.5%	49.3%	57.3%	62.3%	68.6%	75.5%	83.2%	88.2%	93.7%	100.0%
1,900	3.28											0.0%	12.8%	17.7%	25.6%	34.1%	43.9%	52.7%	58.2%	65.2%	72.9%	81.4%	86.9%	93.0%	100.0%
1,529	2.86												0.0%	5.6%	14.7%	24.5%	35.7%	45.8%	52.1%	60.1%	68.9%	78.7%	85.0%	92.0%	100.0%
1,400	2.70													0.0%	9.6%	20.0%	31.9%	42.6%	49.3%	57.8%	67.0%	77.4%	84.1%	91.5%	100.0%
1,200	2.44														0.0%	11.5%	24.6%	36.5%	43.9%	53.3%	63.5%	75.0%	82.4%	90.6%	100.0%
1,000	2.16															0.0%	14.8%	28.2%	36.6%	47.2%	58.8%	71.8%	80.1%	89.4%	100.0%
800	1.84																0.0%	15.8%	25.5%	38.0%	51.6%	66.8%	76.6%	87.5%	100.0%
640	1.55																	0.0%	11.6%	26.5%	42.6%	60.6%	72.3%	85.2%	100.0%
550	1.37																		0.0%	16.8%	35.0%	55.5%	68.6%	83.2%	100.0%
450	1.14																			0.0%	21.9%	46.5%	62.3%	79.8%	100.0%
350	0.89																				0.0%	31.5%	51.7%	74.2%	100.0%
253	0.61																					0.0%	29.5%	62.3%	100.0%
200	0.43																						0.0%	46.5%	100.0%
150	0.23																							0.0%	100.0%
101	0.00																								0.0%

Key:
[1] Relative river stage is a value representing the number of feet the river is above it's water surface elevation at a baseline flow of 101 cfs.

Table 26. Transect R5: Percent change in relative river stage as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Relative River Stage[1] (ft)	Ending Discharge (cfs), Ending Relative River Stage (ft), and Percent Change in Relative River Stage																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		7.73	7.42	7.04	6.70	6.26	5.83	5.44	5.12	4.78	4.41	4.00	3.51	3.33	3.02	2.68	2.30	1.95	1.73	1.46	1.15	0.79	0.56	0.30	0.00
6,500	7.73	0.0%	4.0%	8.9%	13.3%	19.0%	24.6%	29.6%	33.8%	38.2%	42.9%	48.3%	54.6%	56.9%	60.9%	65.3%	70.2%	74.8%	77.6%	81.1%	85.1%	89.8%	92.8%	96.1%	100.0%
6,000	7.42		0.0%	5.1%	9.7%	15.6%	21.4%	26.7%	31.0%	35.6%	40.6%	46.1%	52.7%	55.1%	59.3%	63.9%	69.0%	73.7%	76.7%	80.3%	84.5%	89.4%	92.5%	96.0%	100.0%
5,400	7.04			0.0%	4.8%	11.1%	17.2%	22.7%	27.3%	32.1%	37.4%	43.2%	50.1%	52.7%	57.1%	61.9%	67.3%	72.3%	75.4%	79.3%	83.7%	88.8%	92.0%	95.7%	100.0%
4,900	6.70				0.0%	6.6%	13.0%	18.8%	23.6%	28.7%	34.2%	40.3%	47.6%	50.3%	54.9%	60.0%	65.7%	70.9%	74.2%	78.2%	82.8%	88.2%	91.6%	95.5%	100.0%
4,300	6.26					0.0%	6.9%	13.1%	18.2%	23.6%	29.6%	36.1%	43.9%	46.8%	51.8%	57.2%	63.3%	68.8%	72.4%	76.7%	81.6%	87.4%	91.1%	95.2%	100.0%
3,749	5.83						0.0%	6.7%	12.2%	18.0%	24.4%	31.4%	39.8%	42.9%	48.2%	54.0%	60.5%	66.6%	70.3%	75.0%	80.3%	86.4%	90.4%	94.9%	100.0%
3,300	5.44							0.0%	5.9%	12.1%	18.9%	26.5%	35.5%	38.8%	44.5%	50.7%	57.7%	64.2%	68.2%	73.2%	78.9%	85.5%	89.7%	94.5%	100.0%
2,950	5.12								0.0%	6.6%	13.9%	21.9%	31.4%	35.0%	41.0%	47.7%	55.1%	61.9%	66.2%	71.5%	77.5%	84.6%	89.1%	94.1%	100.0%
2,600	4.78									0.0%	7.7%	16.3%	26.6%	30.3%	36.8%	43.9%	51.9%	59.2%	63.8%	69.5%	75.9%	83.5%	88.3%	93.7%	100.0%
2,250	4.41										0.0%	9.3%	20.4%	24.5%	31.5%	39.2%	47.8%	55.8%	60.8%	66.9%	73.9%	82.1%	87.3%	93.2%	100.0%
1,900	4.00											0.0%	12.2%	16.8%	24.5%	33.0%	42.5%	51.2%	56.7%	63.5%	71.2%	80.2%	86.0%	92.5%	100.0%
1,529	3.51												0.0%	5.1%	14.0%	23.6%	34.5%	44.4%	50.7%	58.4%	67.2%	77.5%	84.0%	91.5%	100.0%
1,400	3.33													0.0%	9.3%	19.5%	30.9%	41.4%	48.0%	56.2%	65.5%	76.3%	83.2%	91.0%	100.0%
1,200	3.02														0.0%	11.3%	23.8%	35.4%	42.7%	51.7%	61.9%	73.8%	81.5%	90.1%	100.0%
1,000	2.68															0.0%	14.2%	27.2%	35.4%	45.5%	57.1%	70.5%	79.1%	88.8%	100.0%
800	2.30																0.0%	15.2%	24.8%	36.5%	50.0%	65.7%	75.7%	87.0%	100.0%
640	1.95																	0.0%	11.3%	25.1%	41.0%	59.5%	71.3%	84.6%	100.0%
550	1.73																		0.0%	15.6%	33.5%	54.3%	67.6%	82.7%	100.0%
450	1.46																			0.0%	21.2%	45.9%	61.6%	79.5%	100.0%
350	1.15																				0.0%	31.3%	51.3%	73.9%	100.0%
253	0.79																					0.0%	29.1%	62.0%	100.0%
200	0.56																						0.0%	46.4%	100.0%
150	0.30																							0.0%	100.0%
101	0.00																								0.0%

Key:
[1] Relative river stage is a value representing the number of feet the river is above it's water surface elevation at a baseline flow of 101 cfs.

Table 27. Transect R6: Percent change in relative river stage as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Relative River Stage[1] (ft)	Ending Discharge (cfs), Ending Relative River Stage (ft), and Percent Change in Relative River Stage																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		8.05	7.75	7.36	7.01	6.56	6.12	5.72	5.39	5.03	4.65	4.22	3.71	3.52	3.19	2.83	2.43	2.05	1.82	1.53	1.20	0.82	0.58	0.31	0.00
6,500	8.05	0.0%	3.7%	8.6%	12.9%	18.5%	24.0%	28.9%	33.0%	37.5%	42.2%	47.6%	53.9%	56.3%	60.4%	64.8%	69.8%	74.5%	77.4%	81.0%	85.1%	89.8%	92.8%	96.1%	100.0%
6,000	7.75		0.0%	5.0%	9.5%	15.4%	21.0%	26.2%	30.5%	35.1%	40.0%	45.5%	52.1%	54.6%	58.8%	63.5%	68.6%	73.5%	76.5%	80.3%	84.5%	89.4%	92.5%	96.0%	100.0%
5,400	7.36			0.0%	4.8%	10.9%	16.8%	22.3%	26.8%	31.7%	36.8%	42.7%	49.6%	52.2%	56.7%	61.5%	67.0%	72.1%	75.3%	79.2%	83.7%	88.9%	92.1%	95.8%	100.0%
4,900	7.01				0.0%	6.4%	12.7%	18.4%	23.1%	28.2%	33.7%	39.8%	47.1%	49.8%	54.5%	59.6%	65.3%	70.8%	74.0%	78.2%	82.9%	88.3%	91.7%	95.6%	100.0%
4,300	6.56					0.0%	6.7%	12.8%	17.8%	23.3%	29.1%	35.7%	43.4%	46.3%	51.4%	56.9%	63.0%	68.8%	72.3%	76.7%	81.7%	87.5%	91.2%	95.3%	100.0%
3,749	6.12						0.0%	6.5%	11.9%	17.8%	24.0%	31.0%	39.4%	42.5%	47.9%	53.8%	60.3%	66.5%	70.3%	75.0%	80.4%	86.6%	90.5%	94.9%	100.0%
3,300	5.72							0.0%	5.8%	12.1%	18.7%	26.2%	35.1%	38.5%	44.2%	50.5%	57.5%	64.2%	68.2%	73.3%	79.0%	85.7%	89.9%	94.6%	100.0%
2,950	5.39								0.0%	6.7%	13.7%	21.7%	31.2%	34.7%	40.8%	47.5%	54.9%	62.0%	66.2%	71.6%	77.7%	84.8%	89.2%	94.2%	100.0%
2,600	5.03									0.0%	7.6%	16.1%	26.2%	30.0%	36.6%	43.7%	51.7%	59.2%	63.8%	69.6%	76.1%	83.7%	88.5%	93.8%	100.0%
2,250	4.65										0.0%	9.2%	20.2%	24.3%	31.4%	39.1%	47.7%	55.9%	60.9%	67.1%	74.2%	82.4%	87.5%	93.3%	100.0%
1,900	4.22											0.0%	12.1%	16.6%	24.4%	32.9%	42.4%	51.4%	56.9%	63.7%	71.6%	80.6%	86.3%	92.7%	100.0%
1,529	3.71												0.0%	5.1%	14.0%	23.7%	34.5%	44.7%	50.9%	58.8%	67.7%	77.9%	84.4%	91.6%	100.0%
1,400	3.52													0.0%	9.4%	19.6%	31.0%	41.8%	48.3%	56.5%	65.9%	76.7%	83.5%	91.2%	100.0%
1,200	3.19														0.0%	11.3%	23.8%	35.7%	42.9%	52.0%	62.4%	74.3%	81.8%	90.3%	100.0%
1,000	2.83															0.0%	14.1%	27.6%	35.7%	45.9%	57.6%	71.0%	79.5%	89.0%	100.0%
800	2.43																0.0%	15.6%	25.1%	37.0%	50.6%	66.3%	76.1%	87.2%	100.0%
640	2.05																	0.0%	11.2%	25.4%	41.5%	60.0%	71.7%	84.9%	100.0%
550	1.82																		0.0%	15.9%	34.1%	54.9%	68.1%	83.0%	100.0%
450	1.53																			0.0%	21.6%	46.4%	62.1%	79.7%	100.0%
350	1.20																				0.0%	31.7%	51.7%	74.2%	100.0%
253	0.82																					0.0%	29.3%	62.2%	100.0%
200	0.58																						0.0%	46.6%	100.0%
150	0.31																							0.0%	100.0%
101	0.00																								0.0%

Key:
[1] Relative river stage is a value representing the number of feet the river is above it's water surface elevation at a baseline flow of 101 cfs.

Table 28. Transect R7: Percent change in relative river stage as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Relative River Stage[1] (ft)	Ending Discharge (cfs), Ending Relative River Stage (ft), and Percent Change in Relative River Stage																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		7.60	7.27	6.85	6.48	6.01	5.55	5.15	4.82	4.46	4.08	3.67	3.19	3.01	2.71	2.38	2.02	1.69	1.49	1.24	0.97	0.66	0.46	0.25	0.00
6,500	7.60	0.0%	4.3%	9.9%	14.7%	20.9%	27.0%	32.2%	36.6%	41.3%	46.3%	51.7%	58.0%	60.4%	64.3%	68.7%	73.4%	77.8%	80.4%	83.7%	87.2%	91.3%	93.9%	96.7%	100.0%
6,000	7.27		0.0%	5.8%	10.9%	17.3%	23.7%	29.2%	33.7%	38.7%	43.9%	49.5%	56.1%	58.6%	62.7%	67.3%	72.2%	76.8%	79.5%	82.9%	86.7%	90.9%	93.7%	96.6%	100.0%
5,400	6.85			0.0%	5.4%	12.3%	19.0%	24.8%	29.6%	34.9%	40.4%	46.4%	53.4%	56.1%	60.4%	65.3%	70.5%	75.3%	78.2%	81.9%	85.8%	90.4%	93.3%	96.4%	100.0%
4,900	6.48				0.0%	7.3%	14.4%	20.5%	25.6%	31.2%	37.0%	43.4%	50.8%	53.5%	58.2%	63.3%	68.8%	73.9%	77.0%	80.9%	85.0%	89.8%	92.9%	96.1%	100.0%
4,300	6.01					0.0%	7.7%	14.3%	19.8%	25.8%	32.1%	38.9%	46.9%	49.9%	54.9%	60.4%	66.4%	71.9%	75.2%	79.4%	83.9%	89.0%	92.3%	95.8%	100.0%
3,749	5.55						0.0%	7.2%	13.2%	19.6%	26.5%	33.9%	42.5%	45.8%	51.2%	57.1%	63.6%	69.5%	73.2%	77.7%	82.5%	88.1%	91.7%	95.5%	100.0%
3,300	5.15							0.0%	6.4%	13.4%	20.8%	28.7%	38.1%	41.6%	47.4%	53.8%	60.8%	67.2%	71.1%	75.9%	81.2%	87.2%	91.1%	95.1%	100.0%
2,950	4.82								0.0%	7.5%	15.4%	23.9%	33.8%	37.6%	43.8%	50.6%	58.1%	64.9%	69.1%	74.3%	79.9%	86.3%	90.5%	94.8%	100.0%
2,600	4.46									0.0%	8.5%	17.7%	28.5%	32.5%	39.2%	46.6%	54.7%	62.1%	66.6%	72.2%	78.3%	85.2%	89.7%	94.4%	100.0%
2,250	4.08										0.0%	10.0%	21.8%	26.2%	33.6%	41.7%	50.5%	58.6%	63.5%	69.6%	76.2%	83.8%	88.7%	93.9%	100.0%
1,900	3.67											0.0%	13.1%	18.0%	26.2%	35.1%	45.0%	54.0%	59.4%	66.2%	73.6%	82.0%	87.5%	93.2%	100.0%
1,529	3.19												0.0%	5.6%	15.0%	25.4%	36.7%	47.0%	53.3%	61.1%	69.6%	79.3%	85.6%	92.2%	100.0%
1,400	3.01													0.0%	10.0%	20.9%	32.9%	43.9%	50.5%	58.8%	67.8%	78.1%	84.7%	91.7%	100.0%
1,200	2.71														0.0%	12.2%	25.5%	37.6%	45.0%	54.2%	64.2%	75.6%	83.0%	90.8%	100.0%
1,000	2.38															0.0%	15.1%	29.0%	37.4%	47.9%	59.2%	72.3%	80.7%	89.5%	100.0%
800	2.02																0.0%	16.3%	26.2%	38.6%	52.0%	67.3%	77.2%	87.6%	100.0%
640	1.69																	0.0%	11.8%	26.6%	42.6%	60.9%	72.8%	85.2%	100.0%
550	1.49																		0.0%	16.8%	34.9%	55.7%	69.1%	83.2%	100.0%
450	1.24																			0.0%	21.8%	46.8%	62.9%	79.8%	100.0%
350	0.97																				0.0%	32.0%	52.6%	74.2%	100.0%
253	0.66																					0.0%	30.3%	62.1%	100.0%
200	0.46																						0.0%	45.7%	100.0%
150	0.25																							0.0%	100.0%
101	0.00																								0.0%

Key:
[1] Relative river stage is a value representing the number of feet the river is above it's water surface elevation at a baseline flow of 101 cfs.

Page Left Blank

Magnitude Change in Average Velocity

Page Left Blank

Tables 29—35 show the magnitude change in average velocity from a starting discharge to an ending discharge. Magnitude change in average velocity is calculated based on the difference between the starting average velocity and ending average velocity. The table shows starting discharges in descending order along the table's left column and ending discharges in descending order from left to right along the top row.

Table 29. Transect R1: Magnitude change in average velocity as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Average Velocity (ft/sec)	Ending discharge (cfs), Ending Average Velocity (ft/sec), and Magnitude Change in Average Velocity																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		5.80	5.63	5.36	5.11	4.80	4.57	4.40	4.19	3.97	3.69	3.36	3.01	2.92	2.86	2.63	2.42	2.17	2.03	1.83	1.61	1.36	1.19	1.00	0.77
6,500	5.80	0.00	0.17	0.44	0.69	1.00	1.23	1.40	1.61	1.83	2.11	2.44	2.79	2.88	2.94	3.17	3.38	3.63	3.77	3.97	4.19	4.44	4.61	4.80	5.03
6,000	5.63		0.00	0.27	0.52	0.83	1.06	1.23	1.44	1.66	1.94	2.27	2.62	2.71	2.77	3.00	3.21	3.46	3.60	3.80	4.02	4.27	4.44	4.63	4.86
5,400	5.36			0.00	0.25	0.56	0.79	0.96	1.17	1.39	1.67	2.00	2.35	2.44	2.50	2.73	2.94	3.19	3.33	3.53	3.75	4.00	4.17	4.36	4.59
4,900	5.11				0.00	0.31	0.54	0.71	0.92	1.14	1.42	1.75	2.10	2.19	2.25	2.48	2.69	2.94	3.08	3.28	3.50	3.75	3.92	4.11	4.34
4,300	4.80					0.00	0.23	0.40	0.61	0.83	1.11	1.44	1.79	1.88	1.94	2.17	2.38	2.63	2.77	2.97	3.19	3.44	3.61	3.80	4.03
3,749	4.57						0.00	0.17	0.38	0.60	0.88	1.21	1.56	1.65	1.71	1.94	2.15	2.40	2.54	2.74	2.96	3.21	3.38	3.57	3.80
3,300	4.40							0.00	0.21	0.43	0.71	1.04	1.39	1.48	1.54	1.77	1.98	2.23	2.37	2.57	2.79	3.04	3.21	3.40	3.63
2,950	4.19								0.00	0.22	0.50	0.83	1.18	1.27	1.33	1.56	1.77	2.02	2.16	2.36	2.58	2.83	3.00	3.19	3.42
2,600	3.97									0.00	0.28	0.61	0.96	1.05	1.11	1.34	1.55	1.80	1.94	2.14	2.36	2.61	2.78	2.97	3.20
2,250	3.69										0.00	0.33	0.68	0.77	0.83	1.06	1.27	1.52	1.66	1.86	2.08	2.33	2.50	2.69	2.92
1,900	3.36											0.00	0.35	0.44	0.50	0.73	0.94	1.19	1.33	1.53	1.75	2.00	2.17	2.36	2.59
1,529	3.01												0.00	0.09	0.15	0.38	0.59	0.84	0.98	1.18	1.40	1.65	1.82	2.01	2.24
1,400	2.92													0.00	0.06	0.29	0.50	0.75	0.89	1.09	1.31	1.56	1.73	1.92	2.15
1,200	2.86														0.00	0.23	0.44	0.69	0.83	1.03	1.25	1.50	1.67	1.86	2.09
1,000	2.63															0.00	0.21	0.46	0.60	0.80	1.02	1.27	1.44	1.63	1.86
800	2.42																0.00	0.25	0.39	0.59	0.81	1.06	1.23	1.42	1.65
640	2.17																	0.00	0.14	0.34	0.56	0.81	0.98	1.17	1.40
550	2.03																		0.00	0.20	0.42	0.67	0.84	1.03	1.26
450	1.83																			0.00	0.22	0.47	0.64	0.83	1.06
350	1.61																				0.00	0.25	0.42	0.61	0.84
253	1.36																					0.00	0.17	0.36	0.59
200	1.19																						0.00	0.19	0.42
150	1.00																							0.00	0.23
101	0.77																								0.00

Table 30. Transect R2: Magnitude change in average velocity as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Average Velocity (ft/sec)	Ending discharge (cfs), Ending Average Velocity (ft/sec), and Magnitude Change in Average Velocity																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		5.64	5.37	5.13	5.09	4.79	4.45	4.20	3.95	3.67	3.35	3.18	3.16	3.13	3.05	2.95	2.55	2.18	1.99	1.84	1.71	1.46	1.30	1.07	0.83
6,500	5.64	0.00	0.27	0.51	0.55	0.85	1.19	1.44	1.69	1.97	2.29	2.46	2.48	2.51	2.59	2.69	3.09	3.46	3.65	3.80	3.93	4.18	4.34	4.57	4.81
6,000	5.37		0.00	0.24	0.28	0.58	0.92	1.17	1.42	1.70	2.02	2.19	2.21	2.24	2.32	2.42	2.82	3.19	3.38	3.53	3.66	3.91	4.07	4.30	4.54
5,400	5.13			0.00	0.04	0.34	0.68	0.93	1.18	1.46	1.78	1.95	1.97	2.00	2.08	2.18	2.58	2.95	3.14	3.29	3.42	3.67	3.83	4.06	4.30
4,900	5.09				0.00	0.30	0.64	0.89	1.14	1.42	1.74	1.91	1.93	1.96	2.04	2.14	2.54	2.91	3.10	3.25	3.38	3.63	3.79	4.02	4.26
4,300	4.79					0.00	0.34	0.59	0.84	1.12	1.44	1.61	1.63	1.66	1.74	1.84	2.24	2.61	2.80	2.95	3.08	3.33	3.49	3.72	3.96
3,749	4.45						0.00	0.25	0.50	0.78	1.10	1.27	1.29	1.32	1.40	1.50	1.90	2.27	2.46	2.61	2.74	2.99	3.15	3.38	3.62
3,300	4.20							0.00	0.25	0.53	0.85	1.02	1.04	1.07	1.15	1.25	1.65	2.02	2.21	2.36	2.49	2.74	2.90	3.13	3.37
2,950	3.95								0.00	0.28	0.60	0.77	0.79	0.82	0.90	1.00	1.40	1.77	1.96	2.11	2.24	2.49	2.65	2.88	3.12
2,600	3.67									0.00	0.32	0.49	0.51	0.54	0.62	0.72	1.12	1.49	1.68	1.83	1.96	2.21	2.37	2.60	2.84
2,250	3.35										0.00	0.17	0.19	0.22	0.30	0.40	0.80	1.17	1.36	1.51	1.64	1.89	2.05	2.28	2.52
1,900	3.18											0.00	0.02	0.05	0.13	0.23	0.63	1.00	1.19	1.34	1.47	1.72	1.88	2.11	2.35
1,529	3.16												0.00	0.03	0.11	0.21	0.61	0.98	1.17	1.32	1.45	1.70	1.86	2.09	2.33
1,400	3.13													0.00	0.08	0.18	0.58	0.95	1.14	1.29	1.42	1.67	1.83	2.06	2.30
1,200	3.05														0.00	0.10	0.50	0.87	1.06	1.21	1.34	1.59	1.75	1.98	2.22
1,000	2.95															0.00	0.40	0.77	0.96	1.11	1.24	1.49	1.65	1.88	2.12
800	2.55																0.00	0.37	0.56	0.71	0.84	1.09	1.25	1.48	1.72
640	2.18																	0.00	0.19	0.34	0.47	0.72	0.88	1.11	1.35
550	1.99																		0.00	0.15	0.28	0.53	0.69	0.92	1.16
450	1.84																			0.00	0.13	0.38	0.54	0.77	1.01
350	1.71																				0.00	0.25	0.41	0.64	0.88
253	1.46																					0.00	0.16	0.39	0.63
200	1.30																						0.00	0.23	0.47
150	1.07																							0.00	0.24
101	0.83																								0.00

Table 31. Transect R3: Magnitude change in average velocity as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Average Velocity (ft/sec)	Ending discharge (cfs), Ending Average Velocity (ft/sec), and Magnitude Change in Average Velocity																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		4.64	4.43	4.16	3.92	3.62	3.32	3.05	2.83	2.75	2.58	2.48	2.26	2.21	2.05	1.88	1.71	1.55	1.46	1.4	1.33	1.17	1.07	0.96	0.79
6,500	4.64	0.00	0.21	0.48	0.72	1.02	1.32	1.59	1.81	1.89	2.06	2.16	2.38	2.43	2.59	2.76	2.93	3.09	3.18	3.24	3.31	3.47	3.57	3.68	3.85
6,000	4.43		0.00	0.27	0.51	0.81	1.11	1.38	1.60	1.68	1.85	1.95	2.17	2.22	2.38	2.55	2.72	2.88	2.97	3.03	3.10	3.26	3.36	3.47	3.64
5,400	4.16			0.00	0.24	0.54	0.84	1.11	1.33	1.41	1.58	1.68	1.90	1.95	2.11	2.28	2.45	2.61	2.70	2.76	2.83	2.99	3.09	3.20	3.37
4,900	3.92				0.00	0.30	0.60	0.87	1.09	1.17	1.34	1.44	1.66	1.71	1.87	2.04	2.21	2.37	2.46	2.52	2.59	2.75	2.85	2.96	3.13
4,300	3.62					0.00	0.30	0.57	0.79	0.87	1.04	1.14	1.36	1.41	1.57	1.74	1.91	2.07	2.16	2.22	2.29	2.45	2.55	2.66	2.83
3,749	3.32						0.00	0.27	0.49	0.57	0.74	0.84	1.06	1.11	1.27	1.44	1.61	1.77	1.86	1.92	1.99	2.15	2.25	2.36	2.53
3,300	3.05							0.00	0.22	0.30	0.47	0.57	0.79	0.84	1.00	1.17	1.34	1.50	1.59	1.65	1.72	1.88	1.98	2.09	2.26
2,950	2.83								0.00	0.08	0.25	0.35	0.57	0.62	0.78	0.95	1.12	1.28	1.37	1.43	1.50	1.66	1.76	1.87	2.04
2,600	2.75									0.00	0.17	0.27	0.49	0.54	0.70	0.87	1.04	1.20	1.29	1.35	1.42	1.58	1.68	1.79	1.96
2,250	2.58										0.00	0.10	0.32	0.37	0.53	0.70	0.87	1.03	1.12	1.18	1.25	1.41	1.51	1.62	1.79
1,900	2.48											0.00	0.22	0.27	0.43	0.60	0.77	0.93	1.02	1.08	1.15	1.31	1.41	1.52	1.69
1,529	2.26												0.00	0.05	0.21	0.38	0.55	0.71	0.80	0.86	0.93	1.09	1.19	1.30	1.47
1,400	2.21													0.00	0.16	0.33	0.50	0.66	0.75	0.81	0.88	1.04	1.14	1.25	1.42
1,200	2.05														0.00	0.17	0.34	0.50	0.59	0.65	0.72	0.88	0.98	1.09	1.26
1,000	1.88															0.00	0.17	0.33	0.42	0.48	0.55	0.71	0.81	0.92	1.09
800	1.71																0.00	0.16	0.25	0.31	0.38	0.54	0.64	0.75	0.92
640	1.55																	0.00	0.09	0.15	0.22	0.38	0.48	0.59	0.76
550	1.46																		0.00	0.06	0.13	0.29	0.39	0.50	0.67
450	1.40																			0.00	0.07	0.23	0.33	0.44	0.61
350	1.33																				0.00	0.16	0.26	0.37	0.54
253	1.17																					0.00	0.10	0.21	0.38
200	1.07																						0.00	0.11	0.28
150	0.96																							0.00	0.17
101	0.79																								0.00

Table 32. Transect R4: Magnitude change in average velocity as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Average Velocity (ft/sec)	Ending discharge (cfs), Ending Average Velocity (ft/sec), and Magnitude Change in Average Velocity																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		6.50	6.26	5.95	5.68	5.30	4.96	4.73	4.46	4.16	3.84	3.49	3.07	2.93	2.70	2.46	2.16	1.86	1.64	1.48	1.23	1.18	0.99	0.78	0.61
6,500	6.50	0.00	0.24	0.55	0.82	1.20	1.54	1.77	2.04	2.34	2.66	3.01	3.43	3.57	3.80	4.04	4.34	4.64	4.86	5.02	5.27	5.32	5.51	5.72	5.89
6,000	6.26		0.00	0.31	0.58	0.96	1.30	1.53	1.80	2.10	2.42	2.77	3.19	3.33	3.56	3.80	4.10	4.40	4.62	4.78	5.03	5.08	5.27	5.48	5.65
5,400	5.95			0.00	0.27	0.65	0.99	1.22	1.49	1.79	2.11	2.46	2.88	3.02	3.25	3.49	3.79	4.09	4.31	4.47	4.72	4.77	4.96	5.17	5.34
4,900	5.68				0.00	0.38	0.72	0.95	1.22	1.52	1.84	2.19	2.61	2.75	2.98	3.22	3.52	3.82	4.04	4.20	4.45	4.50	4.69	4.90	5.07
4,300	5.30					0.00	0.34	0.57	0.84	1.14	1.46	1.81	2.23	2.37	2.60	2.84	3.14	3.44	3.66	3.82	4.07	4.12	4.31	4.52	4.69
3,749	4.96						0.00	0.23	0.50	0.80	1.12	1.47	1.89	2.03	2.26	2.50	2.80	3.10	3.32	3.48	3.73	3.78	3.97	4.18	4.35
3,300	4.73							0.00	0.27	0.57	0.89	1.24	1.66	1.80	2.03	2.27	2.57	2.87	3.09	3.25	3.50	3.55	3.74	3.95	4.12
2,950	4.46								0.00	0.30	0.62	0.97	1.39	1.53	1.76	2.00	2.30	2.60	2.82	2.98	3.23	3.28	3.47	3.68	3.85
2,600	4.16									0.00	0.32	0.67	1.09	1.23	1.46	1.70	2.00	2.30	2.52	2.68	2.93	2.98	3.17	3.38	3.55
2,250	3.84										0.00	0.35	0.77	0.91	1.14	1.38	1.68	1.98	2.20	2.36	2.61	2.66	2.85	3.06	3.23
1,900	3.49											0.00	0.42	0.56	0.79	1.03	1.33	1.63	1.85	2.01	2.26	2.31	2.50	2.71	2.88
1,529	3.07												0.00	0.14	0.37	0.61	0.91	1.21	1.43	1.59	1.84	1.89	2.08	2.29	2.46
1,400	2.93													0.00	0.23	0.47	0.77	1.07	1.29	1.45	1.70	1.75	1.94	2.15	2.32
1,200	2.70														0.00	0.24	0.54	0.84	1.06	1.22	1.47	1.52	1.71	1.92	2.09
1,000	2.46															0.00	0.30	0.60	0.82	0.98	1.23	1.28	1.47	1.68	1.85
800	2.16																0.00	0.30	0.52	0.68	0.93	0.98	1.17	1.38	1.55
640	1.86																	0.00	0.22	0.38	0.63	0.68	0.87	1.08	1.25
550	1.64																		0.00	0.16	0.41	0.46	0.65	0.86	1.03
450	1.48																			0.00	0.25	0.30	0.49	0.70	0.87
350	1.23																				0.00	0.05	0.24	0.45	0.62
253	1.18																					0.00	0.19	0.40	0.57
200	0.99																						0.00	0.21	0.38
150	0.78																							0.00	0.17
101	0.61																								0.00

Table 33. Transect R5: Magnitude change in average velocity as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Average Velocity (ft/sec)	Ending discharge (cfs), Ending Average Velocity (ft/sec), and Magnitude Change in Average Velocity																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		4.85	4.70	4.61	4.56	4.44	4.18	3.97	3.73	3.46	3.19	2.92	2.60	2.48	2.27	2.04	1.79	1.56	1.42	1.25	1.07	0.87	0.74	0.61	0.46
6,500	4.85	0.00	0.15	0.24	0.29	0.41	0.67	0.88	1.12	1.39	1.66	1.93	2.25	2.37	2.58	2.81	3.06	3.29	3.43	3.60	3.78	3.98	4.11	4.24	4.39
6,000	4.70		0.00	0.09	0.14	0.26	0.52	0.73	0.97	1.24	1.51	1.78	2.10	2.22	2.43	2.66	2.91	3.14	3.28	3.45	3.63	3.83	3.96	4.09	4.24
5,400	4.61			0.00	0.05	0.17	0.43	0.64	0.88	1.15	1.42	1.69	2.01	2.13	2.34	2.57	2.82	3.05	3.19	3.36	3.54	3.74	3.87	4.00	4.15
4,900	4.56				0.00	0.12	0.38	0.59	0.83	1.10	1.37	1.64	1.96	2.08	2.29	2.52	2.77	3.00	3.14	3.31	3.49	3.69	3.82	3.95	4.10
4,300	4.44					0.00	0.26	0.47	0.71	0.98	1.25	1.52	1.84	1.96	2.17	2.40	2.65	2.88	3.02	3.19	3.37	3.57	3.70	3.83	3.98
3,749	4.18						0.00	0.21	0.45	0.72	0.99	1.26	1.58	1.70	1.91	2.14	2.39	2.62	2.76	2.93	3.11	3.31	3.44	3.57	3.72
3,300	3.97							0.00	0.24	0.51	0.78	1.05	1.37	1.49	1.70	1.93	2.18	2.41	2.55	2.72	2.90	3.10	3.23	3.36	3.51
2,950	3.73								0.00	0.27	0.54	0.81	1.13	1.25	1.46	1.69	1.94	2.17	2.31	2.48	2.66	2.86	2.99	3.12	3.27
2,600	3.46									0.00	0.27	0.54	0.86	0.98	1.19	1.42	1.67	1.90	2.04	2.21	2.39	2.59	2.72	2.85	3.00
2,250	3.19										0.00	0.27	0.59	0.71	0.92	1.15	1.40	1.63	1.77	1.94	2.12	2.32	2.45	2.58	2.73
1,900	2.92											0.00	0.32	0.44	0.65	0.88	1.13	1.36	1.50	1.67	1.85	2.05	2.18	2.31	2.46
1,529	2.60												0.00	0.12	0.33	0.56	0.81	1.04	1.18	1.35	1.53	1.73	1.86	1.99	2.14
1,400	2.48													0.00	0.21	0.44	0.69	0.92	1.06	1.23	1.41	1.61	1.74	1.87	2.02
1,200	2.27														0.00	0.23	0.48	0.71	0.85	1.02	1.20	1.40	1.53	1.66	1.81
1,000	2.04															0.00	0.25	0.48	0.62	0.79	0.97	1.17	1.30	1.43	1.58
800	1.79																0.00	0.23	0.37	0.54	0.72	0.92	1.05	1.18	1.33
640	1.56																	0.00	0.14	0.31	0.49	0.69	0.82	0.95	1.10
550	1.42																		0.00	0.17	0.35	0.55	0.68	0.81	0.96
450	1.25																			0.00	0.18	0.38	0.51	0.64	0.79
350	1.07																				0.00	0.20	0.33	0.46	0.61
253	0.87																					0.00	0.13	0.26	0.41
200	0.74																						0.00	0.13	0.28
150	0.61																							0.00	0.15
101	0.46																								0.00

Table 34. Transect R6: Magnitude change in average velocity as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Average Velocity (ft/sec)	Ending discharge (cfs), Ending Average Velocity (ft/sec), and Magnitude Change in Average Velocity																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		6.00	5.88	5.69	5.42	5.03	4.61	4.43	4.18	3.98	3.68	3.40	3.04	2.92	2.71	2.46	2.19	1.93	1.75	1.52	1.30	1.05	0.89	0.74	0.57
6,500	6.00	0.00	0.12	0.31	0.58	0.97	1.39	1.57	1.82	2.02	2.32	2.60	2.96	3.08	3.29	3.54	3.81	4.07	4.25	4.48	4.70	4.95	5.11	5.26	5.43
6,000	5.88		0.00	0.19	0.46	0.85	1.27	1.45	1.70	1.90	2.20	2.48	2.84	2.96	3.17	3.42	3.69	3.95	4.13	4.36	4.58	4.83	4.99	5.14	5.31
5,400	5.69			0.00	0.27	0.66	1.08	1.26	1.51	1.71	2.01	2.29	2.65	2.77	2.98	3.23	3.50	3.76	3.94	4.17	4.39	4.64	4.80	4.95	5.12
4,900	5.42				0.00	0.39	0.81	0.99	1.24	1.44	1.74	2.02	2.38	2.50	2.71	2.96	3.23	3.49	3.67	3.90	4.12	4.37	4.53	4.68	4.85
4,300	5.03					0.00	0.42	0.60	0.85	1.05	1.35	1.63	1.99	2.11	2.32	2.57	2.84	3.10	3.28	3.51	3.73	3.98	4.14	4.29	4.46
3,749	4.61						0.00	0.18	0.43	0.63	0.93	1.21	1.57	1.69	1.90	2.15	2.42	2.68	2.86	3.09	3.31	3.56	3.72	3.87	4.04
3,300	4.43							0.00	0.25	0.45	0.75	1.03	1.39	1.51	1.72	1.97	2.24	2.50	2.68	2.91	3.13	3.38	3.54	3.69	3.86
2,950	4.18								0.00	0.20	0.50	0.78	1.14	1.26	1.47	1.72	1.99	2.25	2.43	2.66	2.88	3.13	3.29	3.44	3.61
2,600	3.98									0.00	0.30	0.58	0.94	1.06	1.27	1.52	1.79	2.05	2.23	2.46	2.68	2.93	3.09	3.24	3.41
2,250	3.68										0.00	0.28	0.64	0.76	0.97	1.22	1.49	1.75	1.93	2.16	2.38	2.63	2.79	2.94	3.11
1,900	3.40											0.00	0.36	0.48	0.69	0.94	1.21	1.47	1.65	1.88	2.10	2.35	2.51	2.66	2.83
1,529	3.04												0.00	0.12	0.33	0.58	0.85	1.11	1.29	1.52	1.74	1.99	2.15	2.30	2.47
1,400	2.92													0.00	0.21	0.46	0.73	0.99	1.17	1.40	1.62	1.87	2.03	2.18	2.35
1,200	2.71														0.00	0.25	0.52	0.78	0.96	1.19	1.41	1.66	1.82	1.97	2.14
1,000	2.46															0.00	0.27	0.53	0.71	0.94	1.16	1.41	1.57	1.72	1.89
800	2.19																0.00	0.26	0.44	0.67	0.89	1.14	1.30	1.45	1.62
640	1.93																	0.00	0.18	0.41	0.63	0.88	1.04	1.19	1.36
550	1.75																		0.00	0.23	0.45	0.70	0.86	1.01	1.18
450	1.52																			0.00	0.22	0.47	0.63	0.78	0.95
350	1.30																				0.00	0.25	0.41	0.56	0.73
253	1.05																					0.00	0.16	0.31	0.48
200	0.89																						0.00	0.15	0.32
150	0.74																							0.00	0.17
101	0.57																								0.00

Table 35. Transect R7: Magnitude change in average velocity as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Average Velocity (ft/sec)	Ending discharge (cfs), Ending Average Velocity (ft/sec), and Magnitude Change in Average Velocity																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		5.75	5.6	5.4	5.27	5.13	4.96	4.79	4.76	4.67	4.38	4.02	3.59	3.44	3.22	2.93	2.79	2.62	2.53	2.48	2.28	2.02	1.76	1.5	1.18
6,500	5.75	0.00	0.15	0.35	0.48	0.62	0.79	0.96	0.99	1.08	1.37	1.73	2.16	2.31	2.53	2.82	2.96	3.13	3.22	3.27	3.47	3.73	3.99	4.25	4.57
6,000	5.60		0.00	0.20	0.33	0.47	0.64	0.81	0.84	0.93	1.22	1.58	2.01	2.16	2.38	2.67	2.81	2.98	3.07	3.12	3.32	3.58	3.84	4.10	4.42
5,400	5.40			0.00	0.13	0.27	0.44	0.61	0.64	0.73	1.02	1.38	1.81	1.96	2.18	2.47	2.61	2.78	2.87	2.92	3.12	3.38	3.64	3.90	4.22
4,900	5.27				0.00	0.14	0.31	0.48	0.51	0.60	0.89	1.25	1.68	1.83	2.05	2.34	2.48	2.65	2.74	2.79	2.99	3.25	3.51	3.77	4.09
4,300	5.13					0.00	0.17	0.34	0.37	0.46	0.75	1.11	1.54	1.69	1.91	2.20	2.34	2.51	2.60	2.65	2.85	3.11	3.37	3.63	3.95
3,749	4.96						0.00	0.17	0.20	0.29	0.58	0.94	1.37	1.52	1.74	2.03	2.17	2.34	2.43	2.48	2.68	2.94	3.20	3.46	3.78
3,300	4.79							0.00	0.03	0.12	0.41	0.77	1.20	1.35	1.57	1.86	2.00	2.17	2.26	2.31	2.51	2.77	3.03	3.29	3.61
2,950	4.76								0.00	0.09	0.38	0.74	1.17	1.32	1.54	1.83	1.97	2.14	2.23	2.28	2.48	2.74	3.00	3.26	3.58
2,600	4.67									0.00	0.29	0.65	1.08	1.23	1.45	1.74	1.88	2.05	2.14	2.19	2.39	2.65	2.91	3.17	3.49
2,250	4.38										0.00	0.36	0.79	0.94	1.16	1.45	1.59	1.76	1.85	1.90	2.10	2.36	2.62	2.88	3.20
1,900	4.02											0.00	0.43	0.58	0.80	1.09	1.23	1.40	1.49	1.54	1.74	2.00	2.26	2.52	2.84
1,529	3.59												0.00	0.15	0.37	0.66	0.80	0.97	1.06	1.11	1.31	1.57	1.83	2.09	2.41
1,400	3.44													0.00	0.22	0.51	0.65	0.82	0.91	0.96	1.16	1.42	1.68	1.94	2.26
1,200	3.22														0.00	0.29	0.43	0.60	0.69	0.74	0.94	1.20	1.46	1.72	2.04
1,000	2.93															0.00	0.14	0.31	0.40	0.45	0.65	0.91	1.17	1.43	1.75
800	2.79																0.00	0.17	0.26	0.31	0.51	0.77	1.03	1.29	1.61
640	2.62																	0.00	0.09	0.14	0.34	0.60	0.86	1.12	1.44
550	2.53																		0.00	0.05	0.25	0.51	0.77	1.03	1.35
450	2.48																			0.00	0.20	0.46	0.72	0.98	1.30
350	2.28																				0.00	0.26	0.52	0.78	1.10
253	2.02																					0.00	0.26	0.52	0.84
200	1.76																						0.00	0.26	0.58
150	1.50																							0.00	0.32
101	1.18																								0.00

Page Left Blank

Percent Change in Average Velocity

Page Left Blank

Tables 35—42 show the percent change in average velocity from a starting discharge to an ending discharge. Percent change in average velocity is calculated based on the percent difference between the starting average velocity and ending average velocity. The table shows starting discharges in descending order along the table's left column and ending discharges in descending order from left to right along the top row.

Table 36. Transect R1: Percent change in average velocity as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Average Velocity (ft/sec)	Ending discharge (cfs), Ending Average Velocity (ft/sec), and Percent Change in Average Velocity																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		5.80	5.63	5.36	5.11	4.80	4.57	4.40	4.19	3.97	3.69	3.36	3.01	2.92	2.86	2.63	2.42	2.17	2.03	1.83	1.61	1.36	1.19	1.00	0.77
6,500	5.80	0.0%	2.9%	7.6%	11.9%	17.2%	21.2%	24.1%	27.8%	31.6%	36.4%	42.1%	48.1%	49.7%	50.7%	54.7%	58.3%	62.6%	65.0%	68.4%	72.2%	76.6%	79.5%	82.8%	86.7%
6,000	5.63		0.0%	4.8%	9.2%	14.7%	18.8%	21.8%	25.6%	29.5%	34.5%	40.3%	46.5%	48.1%	49.2%	53.3%	57.0%	61.5%	63.9%	67.5%	71.4%	75.8%	78.9%	82.2%	86.3%
5,400	5.36			0.0%	4.7%	10.4%	14.7%	17.9%	21.8%	25.9%	31.2%	37.3%	43.8%	45.5%	46.6%	50.9%	54.9%	59.5%	62.1%	65.9%	70.0%	74.6%	77.8%	81.3%	85.6%
4,900	5.11				0.0%	6.1%	10.6%	13.9%	18.0%	22.3%	27.8%	34.2%	41.1%	42.9%	44.0%	48.5%	52.6%	57.5%	60.3%	64.2%	68.5%	73.4%	76.7%	80.4%	84.9%
4,300	4.80					0.0%	4.8%	8.3%	12.7%	17.3%	23.1%	30.0%	37.3%	39.2%	40.4%	45.2%	49.6%	54.8%	57.7%	61.9%	66.5%	71.7%	75.2%	79.2%	84.0%
3,749	4.57						0.0%	3.7%	8.3%	13.1%	19.3%	26.5%	34.1%	36.1%	37.4%	42.5%	47.0%	52.5%	55.6%	60.0%	64.8%	70.2%	74.0%	78.1%	83.2%
3,300	4.40							0.0%	4.8%	9.8%	16.1%	23.6%	31.6%	33.6%	35.0%	40.2%	45.0%	50.7%	53.9%	58.4%	63.4%	69.1%	73.0%	77.3%	82.5%
2,950	4.19								0.0%	5.3%	11.9%	19.8%	28.2%	30.3%	31.7%	37.2%	42.2%	48.2%	51.6%	56.3%	61.6%	67.5%	71.6%	76.1%	81.6%
2,600	3.97									0.0%	7.1%	15.4%	24.2%	26.4%	28.0%	33.8%	39.0%	45.3%	48.9%	53.9%	59.4%	65.7%	70.0%	74.8%	80.6%
2,250	3.69										0.0%	8.9%	18.4%	20.9%	22.5%	28.7%	34.4%	41.2%	45.0%	50.4%	56.4%	63.1%	67.8%	72.9%	79.1%
1,900	3.36											0.0%	10.4%	13.1%	14.9%	21.7%	28.0%	35.4%	39.6%	45.5%	52.1%	59.5%	64.6%	70.2%	77.1%
1,529	3.01												0.0%	3.0%	5.0%	12.6%	19.6%	27.9%	32.6%	39.2%	46.5%	54.8%	60.5%	66.8%	74.4%
1,400	2.92													0.0%	2.1%	9.9%	17.1%	25.7%	30.5%	37.3%	44.9%	53.4%	59.2%	65.8%	73.6%
1,200	2.86														0.0%	8.0%	15.4%	24.1%	29.0%	36.0%	43.7%	52.4%	58.4%	65.0%	73.1%
1,000	2.63															0.0%	8.0%	17.5%	22.8%	30.4%	38.8%	48.3%	54.8%	62.0%	70.7%
800	2.42																0.0%	10.3%	16.1%	24.4%	33.5%	43.8%	50.8%	58.7%	68.2%
640	2.17																	0.0%	6.5%	15.7%	25.8%	37.3%	45.2%	53.9%	64.5%
550	2.03																		0.0%	9.9%	20.7%	33.0%	41.4%	50.7%	62.1%
450	1.83																			0.0%	12.0%	25.7%	35.0%	45.4%	57.9%
350	1.61																				0.0%	15.5%	26.1%	37.9%	52.2%
253	1.36																					0.0%	12.5%	26.5%	43.4%
200	1.19																						0.0%	16.0%	35.3%
150	1.00																							0.0%	23.0%
101	0.77																								0.0%

Table 37. Transect R2: Percent change in average velocity as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Average Velocity (ft/sec)	Ending discharge (cfs), Ending Average Velocity (ft/sec), and Percent Change in Average Velocity																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		5.64	5.37	5.13	5.09	4.79	4.45	4.20	3.95	3.67	3.35	3.18	3.16	3.13	3.05	2.95	2.55	2.18	1.99	1.84	1.71	1.46	1.30	1.07	0.83
6,500	5.64	0.0%	4.8%	9.0%	9.8%	15.1%	21.1%	25.5%	30.0%	34.9%	40.6%	43.6%	44.0%	44.5%	45.9%	47.7%	54.8%	61.3%	64.7%	67.4%	69.7%	74.1%	77.0%	81.0%	85.3%
6,000	5.37		0.0%	4.5%	5.2%	10.8%	17.1%	21.8%	26.4%	31.7%	37.6%	40.8%	41.2%	41.7%	43.2%	45.1%	52.5%	59.4%	62.9%	65.7%	68.2%	72.8%	75.8%	80.1%	84.5%
5,400	5.13			0.0%	0.8%	6.6%	13.3%	18.1%	23.0%	28.5%	34.7%	38.0%	38.4%	39.0%	40.5%	42.5%	50.3%	57.5%	61.2%	64.1%	66.7%	71.5%	74.7%	79.1%	83.8%
4,900	5.09				0.0%	5.9%	12.6%	17.5%	22.4%	27.9%	34.2%	37.5%	37.9%	38.5%	40.1%	42.0%	49.9%	57.2%	60.9%	63.9%	66.4%	71.3%	74.5%	79.0%	83.7%
4,300	4.79					0.0%	7.1%	12.3%	17.5%	23.4%	30.1%	33.6%	34.0%	34.7%	36.3%	38.4%	46.8%	54.5%	58.5%	61.6%	64.3%	69.5%	72.9%	77.7%	82.7%
3,749	4.45						0.0%	5.6%	11.2%	17.5%	24.7%	28.5%	29.0%	29.7%	31.5%	33.7%	42.7%	51.0%	55.3%	58.7%	61.6%	67.2%	70.8%	76.0%	81.3%
3,300	4.20							0.0%	6.0%	12.6%	20.2%	24.3%	24.8%	25.5%	27.4%	29.8%	39.3%	48.1%	52.6%	56.2%	59.3%	65.2%	69.0%	74.5%	80.2%
2,950	3.95								0.0%	7.1%	15.2%	19.5%	20.0%	20.8%	22.8%	25.3%	35.4%	44.8%	49.6%	53.4%	56.7%	63.0%	67.1%	72.9%	79.0%
2,600	3.67									0.0%	8.7%	13.4%	13.9%	14.7%	16.9%	19.6%	30.5%	40.6%	45.8%	49.9%	53.4%	60.2%	64.6%	70.8%	77.4%
2,250	3.35										0.0%	5.1%	5.7%	6.6%	9.0%	11.9%	23.9%	34.9%	40.6%	45.1%	49.0%	56.4%	61.2%	68.1%	75.2%
1,900	3.18											0.0%	0.6%	1.6%	4.1%	7.2%	19.8%	31.4%	37.4%	42.1%	46.2%	54.1%	59.1%	66.4%	73.9%
1,529	3.16												0.0%	0.9%	3.5%	6.6%	19.3%	31.0%	37.0%	41.8%	45.9%	53.8%	58.9%	66.1%	73.7%
1,400	3.13													0.0%	2.6%	5.8%	18.5%	30.4%	36.4%	41.2%	45.4%	53.4%	58.5%	65.8%	73.5%
1,200	3.05														0.0%	3.3%	16.4%	28.5%	34.8%	39.7%	43.9%	52.1%	57.4%	64.9%	72.8%
1,000	2.95															0.0%	13.6%	26.1%	32.5%	37.6%	42.0%	50.5%	55.9%	63.7%	71.9%
800	2.55																0.0%	14.5%	22.0%	27.8%	32.9%	42.7%	49.0%	58.0%	67.5%
640	2.18																	0.0%	8.7%	15.6%	21.6%	33.0%	40.4%	50.9%	61.9%
550	1.99																		0.0%	7.5%	14.1%	26.6%	34.7%	46.2%	58.3%
450	1.84																			0.0%	7.1%	20.7%	29.3%	41.8%	54.9%
350	1.71																				0.0%	14.6%	24.0%	37.4%	51.5%
253	1.46																					0.0%	11.0%	26.7%	43.2%
200	1.30																						0.0%	17.7%	36.2%
150	1.07																							0.0%	22.4%
101	0.83																								0.0%

Table 38. Transect R3: Percent change in average velocity as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Average Velocity (ft/sec)	Ending discharge (cfs), Ending Average Velocity (ft/sec), and Percent Change in Average Velocity																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		4.64	4.43	4.16	3.92	3.62	3.32	3.05	2.83	2.75	2.58	2.48	2.26	2.21	2.05	1.88	1.71	1.55	1.46	1.40	1.33	1.17	1.07	0.96	0.79
6,500	4.64	0.0%	4.5%	10.3%	15.5%	22.0%	28.4%	34.3%	39.0%	40.7%	44.4%	46.6%	51.3%	52.4%	55.8%	59.5%	63.1%	66.6%	68.5%	69.8%	71.3%	74.8%	76.9%	79.3%	83.0%
6,000	4.43		0.0%	6.1%	11.5%	18.3%	25.1%	31.2%	36.1%	37.9%	41.8%	44.0%	49.0%	50.1%	53.7%	57.6%	61.4%	65.0%	67.0%	68.4%	70.0%	73.6%	75.8%	78.3%	82.2%
5,400	4.16			0.0%	5.8%	13.0%	20.2%	26.7%	32.0%	33.9%	38.0%	40.4%	45.7%	46.9%	50.7%	54.8%	58.9%	62.7%	64.9%	66.3%	68.0%	71.9%	74.3%	76.9%	81.0%
4,900	3.92				0.0%	7.7%	15.3%	22.2%	27.8%	29.8%	34.2%	36.7%	42.3%	43.6%	47.7%	52.0%	56.4%	60.5%	62.8%	64.3%	66.1%	70.2%	72.7%	75.5%	79.8%
4,300	3.62					0.0%	8.3%	15.7%	21.8%	24.0%	28.7%	31.5%	37.6%	39.0%	43.4%	48.1%	52.8%	57.2%	59.7%	61.3%	63.3%	67.7%	70.4%	73.5%	78.2%
3,749	3.32						0.0%	8.1%	14.8%	17.2%	22.3%	25.3%	31.9%	33.4%	38.3%	43.4%	48.5%	53.3%	56.0%	57.8%	59.9%	64.8%	67.8%	71.1%	76.2%
3,300	3.05							0.0%	7.2%	9.8%	15.4%	18.7%	25.9%	27.5%	32.8%	38.4%	43.9%	49.2%	52.1%	54.1%	56.4%	61.6%	64.9%	68.5%	74.1%
2,950	2.83								0.0%	2.8%	8.8%	12.4%	20.1%	21.9%	27.6%	33.6%	39.6%	45.2%	48.4%	50.5%	53.0%	58.7%	62.2%	66.1%	72.1%
2,600	2.75									0.0%	6.2%	9.8%	17.8%	19.6%	25.5%	31.6%	37.8%	43.6%	46.9%	49.1%	51.6%	57.5%	61.1%	65.1%	71.3%
2,250	2.58										0.0%	3.9%	12.4%	14.3%	20.5%	27.1%	33.7%	39.9%	43.4%	45.7%	48.4%	54.7%	58.5%	62.8%	69.4%
1,900	2.48											0.0%	8.9%	10.9%	17.3%	24.2%	31.0%	37.5%	41.1%	43.5%	46.4%	52.8%	56.9%	61.3%	68.1%
1,529	2.26												0.0%	2.2%	9.3%	16.8%	24.3%	31.4%	35.4%	38.1%	41.2%	48.2%	52.7%	57.5%	65.0%
1,400	2.21													0.0%	7.2%	14.9%	22.6%	29.9%	33.9%	36.7%	39.8%	47.1%	51.6%	56.6%	64.3%
1,200	2.05														0.0%	8.3%	16.6%	24.4%	28.8%	31.7%	35.1%	42.9%	47.8%	53.2%	61.5%
1,000	1.88															0.0%	9.0%	17.6%	22.3%	25.5%	29.3%	37.8%	43.1%	48.9%	58.0%
800	1.71																0.0%	9.4%	14.6%	18.1%	22.2%	31.6%	37.4%	43.9%	53.8%
640	1.55																	0.0%	5.8%	9.7%	14.2%	24.5%	31.0%	38.1%	49.0%
550	1.46																		0.0%	4.1%	8.9%	19.9%	26.7%	34.2%	45.9%
450	1.40																			0.0%	5.0%	16.4%	23.6%	31.4%	43.6%
350	1.33																				0.0%	12.0%	19.5%	27.8%	40.6%
253	1.17																					0.0%	8.5%	17.9%	32.5%
200	1.07																						0.0%	10.3%	26.2%
150	0.96																							0.0%	17.7%
101	0.79																								0.0%

Table 39. Transect R4: Percent change in average velocity as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Average Velocity (ft/sec)	Ending discharge (cfs), Ending Average Velocity (ft/sec), and Percent Change in Average Velocity																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		6.50	6.26	5.95	5.68	5.30	4.96	4.73	4.46	4.16	3.84	3.49	3.07	2.93	2.70	2.46	2.16	1.86	1.64	1.48	1.23	1.18	0.99	0.78	0.61
6,500	6.50	0.0%	3.7%	8.5%	12.6%	18.5%	23.7%	27.2%	31.4%	36.0%	40.9%	46.3%	52.8%	54.9%	58.5%	62.2%	66.8%	71.4%	74.8%	77.2%	81.1%	81.8%	84.8%	88.0%	90.6%
6,000	6.26		0.0%	5.0%	9.3%	15.3%	20.8%	24.4%	28.8%	33.5%	38.7%	44.2%	51.0%	53.2%	56.9%	60.7%	65.5%	70.3%	73.8%	76.4%	80.4%	81.2%	84.2%	87.5%	90.3%
5,400	5.95			0.0%	4.5%	10.9%	16.6%	20.5%	25.0%	30.1%	35.5%	41.3%	48.4%	50.8%	54.6%	58.7%	63.7%	68.7%	72.4%	75.1%	79.3%	80.2%	83.4%	86.9%	89.7%
4,900	5.68				0.0%	6.7%	12.7%	16.7%	21.5%	26.8%	32.4%	38.6%	46.0%	48.4%	52.5%	56.7%	62.0%	67.3%	71.1%	73.9%	78.3%	79.2%	82.6%	86.3%	89.3%
4,300	5.30					0.0%	6.4%	10.8%	15.8%	21.5%	27.5%	34.2%	42.1%	44.7%	49.1%	53.6%	59.2%	64.9%	69.1%	72.1%	76.8%	77.7%	81.3%	85.3%	88.5%
3,749	4.96						0.0%	4.6%	10.1%	16.1%	22.6%	29.6%	38.1%	40.9%	45.6%	50.4%	56.5%	62.5%	66.9%	70.2%	75.2%	76.2%	80.0%	84.3%	87.7%
3,300	4.73							0.0%	5.7%	12.1%	18.8%	26.2%	35.1%	38.1%	42.9%	48.0%	54.3%	60.7%	65.3%	68.7%	74.0%	75.1%	79.1%	83.5%	87.1%
2,950	4.46								0.0%	6.7%	13.9%	21.7%	31.2%	34.3%	39.5%	44.8%	51.6%	58.3%	63.2%	66.8%	72.4%	73.5%	77.8%	82.5%	86.3%
2,600	4.16									0.0%	7.7%	16.1%	26.2%	29.6%	35.1%	40.9%	48.1%	55.3%	60.6%	64.4%	70.4%	71.6%	76.2%	81.3%	85.3%
2,250	3.84										0.0%	9.1%	20.1%	23.7%	29.7%	35.9%	43.8%	51.6%	57.3%	61.5%	68.0%	69.3%	74.2%	79.7%	84.1%
1,900	3.49											0.0%	12.0%	16.0%	22.6%	29.5%	38.1%	46.7%	53.0%	57.6%	64.8%	66.2%	71.6%	77.7%	82.5%
1,529	3.07												0.0%	4.6%	12.1%	19.9%	29.6%	39.4%	46.6%	51.8%	59.9%	61.6%	67.8%	74.6%	80.1%
1,400	2.93													0.0%	7.8%	16.0%	26.3%	36.5%	44.0%	49.5%	58.0%	59.7%	66.2%	73.4%	79.2%
1,200	2.70														0.0%	8.9%	20.0%	31.1%	39.3%	45.2%	54.4%	56.3%	63.3%	71.1%	77.4%
1,000	2.46															0.0%	12.2%	24.4%	33.3%	39.8%	50.0%	52.0%	59.8%	68.3%	75.2%
800	2.16																0.0%	13.9%	24.1%	31.5%	43.1%	45.4%	54.2%	63.9%	71.8%
640	1.86																	0.0%	11.8%	20.4%	33.9%	36.6%	46.8%	58.1%	67.2%
550	1.64																		0.0%	9.8%	25.0%	28.0%	39.6%	52.4%	62.8%
450	1.48																			0.0%	16.9%	20.3%	33.1%	47.3%	58.8%
350	1.23																				0.0%	4.1%	19.5%	36.6%	50.4%
253	1.18																					0.0%	16.1%	33.9%	48.3%
200	0.99																						0.0%	21.2%	38.4%
150	0.78																							0.0%	21.8%
101	0.61																								0.0%

Table 40. Transect R5: Percent change in average velocity as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Average Velocity (ft/sec)	Ending discharge (cfs), Ending Average Velocity (ft/sec), and Percent Change in Average Velocity																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		4.85	4.70	4.61	4.56	4.44	4.18	3.97	3.73	3.46	3.19	2.92	2.60	2.48	2.27	2.04	1.79	1.56	1.42	1.25	1.07	0.87	0.74	0.61	0.46
6,500	4.85	0.0%	3.1%	4.9%	6.0%	8.5%	13.8%	18.1%	23.1%	28.7%	34.2%	39.8%	46.4%	48.9%	53.2%	57.9%	63.1%	67.8%	70.7%	74.2%	77.9%	82.1%	84.7%	87.4%	90.5%
6,000	4.70		0.0%	1.9%	3.0%	5.5%	11.1%	15.5%	20.6%	26.4%	32.1%	37.9%	44.7%	47.2%	51.7%	56.6%	61.9%	66.8%	69.8%	73.4%	77.2%	81.5%	84.3%	87.0%	90.2%
5,400	4.61			0.0%	1.1%	3.7%	9.3%	13.9%	19.1%	24.9%	30.8%	36.7%	43.6%	46.2%	50.8%	55.7%	61.2%	66.2%	69.2%	72.9%	76.8%	81.1%	83.9%	86.8%	90.0%
4,900	4.56				0.0%	2.6%	8.3%	12.9%	18.2%	24.1%	30.0%	36.0%	43.0%	45.6%	50.2%	55.3%	60.7%	65.8%	68.9%	72.6%	76.5%	80.9%	83.8%	86.6%	89.9%
4,300	4.44					0.0%	5.9%	10.6%	16.0%	22.1%	28.2%	34.2%	41.4%	44.1%	48.9%	54.1%	59.7%	64.9%	68.0%	71.8%	75.9%	80.4%	83.3%	86.3%	89.6%
3,749	4.18						0.0%	5.0%	10.8%	17.2%	23.7%	30.1%	37.8%	40.7%	45.7%	51.2%	57.2%	62.7%	66.0%	70.1%	74.4%	79.2%	82.3%	85.4%	89.0%
3,300	3.97							0.0%	6.0%	12.8%	19.6%	26.4%	34.5%	37.5%	42.8%	48.6%	54.9%	60.7%	64.2%	68.5%	73.0%	78.1%	81.4%	84.6%	88.4%
2,950	3.73								0.0%	7.2%	14.5%	21.7%	30.3%	33.5%	39.1%	45.3%	52.0%	58.2%	61.9%	66.5%	71.3%	76.7%	80.2%	83.6%	87.7%
2,600	3.46									0.0%	7.8%	15.6%	24.9%	28.3%	34.4%	41.0%	48.3%	54.9%	59.0%	63.9%	69.1%	74.9%	78.6%	82.4%	86.7%
2,250	3.19										0.0%	8.5%	18.5%	22.3%	28.8%	36.1%	43.9%	51.1%	55.5%	60.8%	66.5%	72.7%	76.8%	80.9%	85.6%
1,900	2.92											0.0%	11.0%	15.1%	22.3%	30.1%	38.7%	46.6%	51.4%	57.2%	63.4%	70.2%	74.7%	79.1%	84.2%
1,529	2.60												0.0%	4.6%	12.7%	21.5%	31.2%	40.0%	45.4%	51.9%	58.8%	66.5%	71.5%	76.5%	82.3%
1,400	2.48													0.0%	8.5%	17.7%	27.8%	37.1%	42.7%	49.6%	56.9%	64.9%	70.2%	75.4%	81.5%
1,200	2.27														0.0%	10.1%	21.1%	31.3%	37.4%	44.9%	52.9%	61.7%	67.4%	73.1%	79.7%
1,000	2.04															0.0%	12.3%	23.5%	30.4%	38.7%	47.5%	57.4%	63.7%	70.1%	77.5%
800	1.79																0.0%	12.8%	20.7%	30.2%	40.2%	51.4%	58.7%	65.9%	74.3%
640	1.56																	0.0%	9.0%	19.9%	31.4%	44.2%	52.6%	60.9%	70.5%
550	1.42																		0.0%	12.0%	24.6%	38.7%	47.9%	57.0%	67.6%
450	1.25																			0.0%	14.4%	30.4%	40.8%	51.2%	63.2%
350	1.07																				0.0%	18.7%	30.8%	43.0%	57.0%
253	0.87																					0.0%	14.9%	29.9%	47.1%
200	0.74																						0.0%	17.6%	37.8%
150	0.61																							0.0%	24.6%
101	0.46																								0.0%

Table 41. Transect R6: Percent change in average velocity as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Average Velocity (ft/sec)	Ending discharge (cfs), Ending Average Velocity (ft/sec), and Percent Change in Average Velocity																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		6.00	5.88	5.69	5.42	5.03	4.61	4.43	4.18	3.98	3.68	3.40	3.04	2.92	2.71	2.46	2.19	1.93	1.75	1.52	1.30	1.05	0.89	0.74	0.57
6,500	6.00	0.0%	2.0%	5.2%	9.7%	16.2%	23.2%	26.2%	30.3%	33.7%	38.7%	43.3%	49.3%	51.3%	54.8%	59.0%	63.5%	67.8%	70.8%	74.7%	78.3%	82.5%	85.2%	87.7%	90.5%
6,000	5.88		0.0%	3.2%	7.8%	14.5%	21.6%	24.7%	28.9%	32.3%	37.4%	42.2%	48.3%	50.3%	53.9%	58.2%	62.8%	67.2%	70.2%	74.1%	77.9%	82.1%	84.9%	87.4%	90.3%
5,400	5.69			0.0%	4.7%	11.6%	19.0%	22.1%	26.5%	30.1%	35.3%	40.2%	46.6%	48.7%	52.4%	56.8%	61.5%	66.1%	69.2%	73.3%	77.2%	81.5%	84.4%	87.0%	90.0%
4,900	5.42				0.0%	7.2%	14.9%	18.3%	22.9%	26.6%	32.1%	37.3%	43.9%	46.1%	50.0%	54.6%	59.6%	64.4%	67.7%	72.0%	76.0%	80.6%	83.6%	86.3%	89.5%
4,300	5.03					0.0%	8.3%	11.9%	16.9%	20.9%	26.8%	32.4%	39.6%	41.9%	46.1%	51.1%	56.5%	61.6%	65.2%	69.8%	74.2%	79.1%	82.3%	85.3%	88.7%
3,749	4.61						0.0%	3.9%	9.3%	13.7%	20.2%	26.2%	34.1%	36.7%	41.2%	46.6%	52.5%	58.1%	62.0%	67.0%	71.8%	77.2%	80.7%	83.9%	87.6%
3,300	4.43							0.0%	5.6%	10.2%	16.9%	23.3%	31.4%	34.1%	38.8%	44.5%	50.6%	56.4%	60.5%	65.7%	70.7%	76.3%	79.9%	83.3%	87.1%
2,950	4.18								0.0%	4.8%	12.0%	18.7%	27.3%	30.1%	35.2%	41.1%	47.6%	53.8%	58.1%	63.6%	68.9%	74.9%	78.7%	82.3%	86.4%
2,600	3.98									0.0%	7.5%	14.6%	23.6%	26.6%	31.9%	38.2%	45.0%	51.5%	56.0%	61.8%	67.3%	73.6%	77.6%	81.4%	85.7%
2,250	3.68										0.0%	7.6%	17.4%	20.7%	26.4%	33.2%	40.5%	47.6%	52.4%	58.7%	64.7%	71.5%	75.8%	79.9%	84.5%
1,900	3.40											0.0%	10.6%	14.1%	20.3%	27.6%	35.6%	43.2%	48.5%	55.3%	61.8%	69.1%	73.8%	78.2%	83.2%
1,529	3.04												0.0%	3.9%	10.9%	19.1%	28.0%	36.5%	42.4%	50.0%	57.2%	65.5%	70.7%	75.7%	81.3%
1,400	2.92													0.0%	7.2%	15.8%	25.0%	33.9%	40.1%	47.9%	55.5%	64.0%	69.5%	74.7%	80.5%
1,200	2.71														0.0%	9.2%	19.2%	28.8%	35.4%	43.9%	52.0%	61.3%	67.2%	72.7%	79.0%
1,000	2.46															0.0%	11.0%	21.5%	28.9%	38.2%	47.2%	57.3%	63.8%	69.9%	76.8%
800	2.19																0.0%	11.9%	20.1%	30.6%	40.6%	52.1%	59.4%	66.2%	74.0%
640	1.93																	0.0%	9.3%	21.2%	32.6%	45.6%	53.9%	61.7%	70.5%
550	1.75																		0.0%	13.1%	25.7%	40.0%	49.1%	57.7%	67.4%
450	1.52																			0.0%	14.5%	30.9%	41.4%	51.3%	62.5%
350	1.30																				0.0%	19.2%	31.5%	43.1%	56.2%
253	1.05																					0.0%	15.2%	29.5%	45.7%
200	0.89																						0.0%	16.9%	36.0%
150	0.74																							0.0%	23.0%
101	0.57																								0.0%

Table 42. Transect R7: Percent change in average velocity as a factor of starting discharge versus ending discharge.

Starting Discharge (cfs)	Starting Average Velocity (ft/sec)	Ending discharge (cfs), Ending Average Velocity (ft/sec), and Percent Change in Average Velocity																							
		6,500	**6,000**	**5,400**	**4,900**	**4,300**	**3,749**	**3,300**	**2,950**	**2,600**	**2,250**	**1,900**	**1,529**	**1,400**	**1,200**	**1,000**	**800**	**640**	**550**	**450**	**350**	**253**	**200**	**150**	**101**
		5.75	5.60	5.40	5.27	5.13	4.96	4.79	4.76	4.67	4.38	4.02	3.59	3.44	3.22	2.93	2.79	2.62	2.53	2.48	2.28	2.02	1.76	1.50	1.18
6,500	5.75	0.0%	2.6%	6.1%	8.3%	10.8%	13.7%	16.7%	17.2%	18.8%	23.8%	30.1%	37.6%	40.2%	44.0%	49.0%	51.5%	54.4%	56.0%	56.9%	60.3%	64.9%	69.4%	73.9%	79.5%
6,000	5.60		0.0%	3.6%	5.9%	8.4%	11.4%	14.5%	15.0%	16.6%	21.8%	28.2%	35.9%	38.6%	42.5%	47.7%	50.2%	53.2%	54.8%	55.7%	59.3%	63.9%	68.6%	73.2%	78.9%
5,400	5.40			0.0%	2.4%	5.0%	8.1%	11.3%	11.9%	13.5%	18.9%	25.6%	33.5%	36.3%	40.4%	45.7%	48.3%	51.5%	53.1%	54.1%	57.8%	62.6%	67.4%	72.2%	78.1%
4,900	5.27				0.0%	2.7%	5.9%	9.1%	9.7%	11.4%	16.9%	23.7%	31.9%	34.7%	38.9%	44.4%	47.1%	50.3%	52.0%	52.9%	56.7%	61.7%	66.6%	71.5%	77.6%
4,300	5.13					0.0%	3.3%	6.6%	7.2%	9.0%	14.6%	21.6%	30.0%	32.9%	37.2%	42.9%	45.6%	48.9%	50.7%	51.7%	55.6%	60.6%	65.7%	70.8%	77.0%
3,749	4.96						0.0%	3.4%	4.0%	5.8%	11.7%	19.0%	27.6%	30.6%	35.1%	40.9%	43.8%	47.2%	49.0%	50.0%	54.0%	59.3%	64.5%	69.8%	76.2%
3,300	4.79							0.0%	0.6%	2.5%	8.6%	16.1%	25.1%	28.2%	32.8%	38.8%	41.8%	45.3%	47.2%	48.2%	52.4%	57.8%	63.3%	68.7%	75.4%
2,950	4.76								0.0%	1.9%	8.0%	15.5%	24.6%	27.7%	32.4%	38.4%	41.4%	45.0%	46.8%	47.9%	52.1%	57.6%	63.0%	68.5%	75.2%
2,600	4.67									0.0%	6.2%	13.9%	23.1%	26.3%	31.0%	37.3%	40.3%	43.9%	45.8%	46.9%	51.2%	56.7%	62.3%	67.9%	74.7%
2,250	4.38										0.0%	8.2%	18.0%	21.5%	26.5%	33.1%	36.3%	40.2%	42.2%	43.4%	47.9%	53.9%	59.8%	65.8%	73.1%
1,900	4.02											0.0%	10.7%	14.4%	19.9%	27.1%	30.6%	34.8%	37.1%	38.3%	43.3%	49.8%	56.2%	62.7%	70.6%
1,529	3.59												0.0%	4.2%	10.3%	18.4%	22.3%	27.0%	29.5%	30.9%	36.5%	43.7%	51.0%	58.2%	67.1%
1,400	3.44													0.0%	6.4%	14.8%	18.9%	23.8%	26.5%	27.9%	33.7%	41.3%	48.8%	56.4%	65.7%
1,200	3.22														0.0%	9.0%	13.4%	18.6%	21.4%	23.0%	29.2%	37.3%	45.3%	53.4%	63.4%
1,000	2.93															0.0%	4.8%	10.6%	13.7%	15.4%	22.2%	31.1%	39.9%	48.8%	59.7%
800	2.79																0.0%	6.1%	9.3%	11.1%	18.3%	27.6%	36.9%	46.2%	57.7%
640	2.62																	0.0%	3.4%	5.3%	13.0%	22.9%	32.8%	42.7%	55.0%
550	2.53																		0.0%	2.0%	9.9%	20.2%	30.4%	40.7%	53.4%
450	2.48																			0.0%	8.1%	18.5%	29.0%	39.5%	52.4%
350	2.28																				0.0%	11.4%	22.8%	34.2%	48.2%
253	2.02																					0.0%	12.9%	25.7%	41.6%
200	1.76																						0.0%	14.8%	33.0%
150	1.50																							0.0%	21.3%
101	1.18																								0.0%

Page Left Blank