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Geomorphic Monitoring of Representative Channel Areas
El Dorado Hydroelectric Project No. 184
Report Addendum

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Cover photo: Field photos taken at the Echo Creek, Sand Flat, and Forgotten Flat monitoring sites.

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1 INTRODUCTION

This addendum report presents new study data and analysis completed in 2012 to supplement the initial *Geomorphic Monitoring of Representative Channel Areas for El Dorado Hydroelectric Project No. 184 report* (Stillwater Sciences 2012) that were unable to be completed in 2011 due to agency delays in plan approval and the onset of inclement weather.

During the 2011 monitoring effort, considerable snow and duff accumulation combined with insufficient location data made finding existing cross-sections headpins at most sites extremely difficult. In addition, the snowstorms that passed through the study area in October and November curtailed the 2011 field efforts and prevented completion of all necessary data collection.

The El Dorado Irrigation District (District) owns and operates the El Dorado Hydroelectric Project (Project No. 184), which is licensed by the Federal Energy Regulatory Commission (FERC). The Project No. 184 Monitoring Program[1] requires geomorphic monitoring at representative sites throughout the project area on a 5-year interval. The specific geomorphic monitoring requirements are defined in the Project No. 184 Geomorphology Continuing Evaluation of Representative Channel Areas Monitoring Plan (Plan; EID 2011), which was approved by FERC on October 6, 2011. The primary goal of this monitoring effort is to collect the necessary data to determine if the District is meeting geomorphic-specific objectives associated with Project No. 184 operations, which are:

1. To maintain or restore channel integrity; and
2. To maintain, improve, or restore fluvial processes that provide for balanced sediment transport, channel bed material mobilization and distribution, and channel structural stability, thereby contributing to aquatic habitat diversity and healthy riparian habitat.

In the fall of 2011, the District tasked Stillwater Sciences with conducting geomorphic monitoring pursuant with Plan at representative channel sites (Figure 1-1). Per the guidelines outlined in the Plan, geomorphic monitoring includes establishment and monitoring of permanent cross-sections, longitudinal profiles, and bed and bank properties at the following sites:

- Caples Spillway Channel
- Caples Creek at Caples Meadow
- Caples Creek at Girl Scout Access
- Caples Creek at Jake Schneider Meadow
- Oyster Creek below Highway 88
- South Fork American River at Sand Flat
- Silver Fork American River at Forgotten Flat
- Lower Echo Creek

With the exception of Lower Echo Creek, all sites have established cross-sections and have had relevant geomorphic data collected within the past several years. The Plan therefore calls for re-occupying existing cross-sections where possible (to enable comparison with historical

[1] Section 7 of the El Dorado Relicensing Settlement Agreement, U.S. Forest Service 4(e) Condition No. 37, and California State Water Resources Control Board Section 401 Clean Water Act Water Quality Certification Condition No. 13

geomorphic data) and establish new cross-sections at Lower Echo Creek and other sites as needed (to establish baseline geomorphic conditions).

The purpose of this report is to present geomorphic monitoring data and comparisons with historical data at the sites where data collection could not be completed in 2011. The sites and datasets described in this addendum report are as follows:

- Silver Fork American River at Forgotten Flat: cross-section surveys, longitudinal profile survey, particle size distribution, bank stability assessment.
- Caples Spillway Channel: cross-section surveys, longitudinal profile survey, particle size distribution, bank stability assessment.
- South Fork American River below Kyburz Diversion Dam: cross-section surveys, longitudinal profile survey, particle size distribution, bank stability assessment.
- Oyster Creek: longitudinal profile survey
- Echo Creek: cross-section XS-0b (new upstream cross-section), left channel longitudinal profile survey, right channel longitudinal profile survey, particle size distribution (XS-0b), bank stability assessment (XS-0b).

Where appropriate, a general geomorphic assessment based on comparisons of historical and current geomorphic conditions is also given.

2 DATA COLLECTION AND ANALYSIS METHODS

The methods used to conduct channel geomorphic monitoring at the representative sites surveyed in the fall of 2011 and summer of 2012 and subsequent analysis of the collected data followed the Plan.

2.1 Channel Cross-sections

Three cross-sections were surveyed at each representative site. At each cross-section, existing headpins (i.e., fixed elevation points at the each end of the cross-section) were relocated where possible, or established where previous headpins could not be located. Headpins were located sufficiently back from the top of bank to ensure that they are secure in the case of future bank erosion. The GPS position of at least one headpin for each cross-section was recorded to enable relocation during future monitoring efforts. At some sites, additional temporary benchmarks were established and their positions were recorded. Both a differential GPS (position error ≤ 3 ft) and hand-held GPS (position error ≥ 9 ft) were used to record headpin and benchmark locations.

The cross-section survey was conducted in sufficient detail to capture any change in grade and to characterize the channel geometry, following standard survey procedures established by the USDA Forest Service (Harrelson et al. 1994). This included capturing left and right bank water surface elevation, thalweg, approximate bankfull water surface elevation, and ground at both headpins. The survey approach ensured that all grade breaks across the channel cross-section were measured and referenced to a common arbitrary datum (e.g., at least one cross-section headpin). Channel photographs and field notes describing channel conditions were also taken during the cross-section survey.

Where possible, results from the cross-section surveys were compared with historical data to assess recent geomorphic change, which was assessed using two indices: 1) net percent change in channel area; and 2) absolute percent change in channel area. Net percentage change in area gives an indication of total change in channel area since the last survey, while absolute percentage change in area gives an indication of change in area for discrete portions of the channel cross-section since the last survey (i.e., an indication of how much bed elevation varies independent of any change in total channel area). The Plan provides more detail on the computations involved in determining each index.

2.2 Longitudinal Profiles

A longitudinal profile of the channel thalweg through the cross-section locations was surveyed at representative sites for a minimum distance of ten times the bankfull width, where feasible. In some instances, profile length was limited by the distance that could be safely surveyed or the length that was most appropriate for characterizing the site. The longitudinal profile survey included bed elevation measurements, which were referenced to the local datum used for the cross-section survey. The longitudinal profile survey followed procedures established by the USDA Forest Service (Harrelson et al.1994), including surveying a sufficient number of points with which to capture the topography of pool, riffles, and other habitat features, as well as other significant breaks in channel gradient.

Longitudinal profile data were used to determine reach-average slope. Where historical data were available, the current longitudinal profile was compared to historical data to assess changes in slope and identify areas of local channel aggradation or incision.

2.3 Bed Particle Size Distributions

Along each cross section, a pebble count (Wolman 1954) was performed to characterize bed particle size distribution. The count entailed measuring the intermediate axis (b-axis) of a minimum of 100 particles as a means of classifying the bed particle size distribution. For the sake of simplicity, all silt- and sand-sized particles were classified as < 2mm. The dominant lithology was also noted and a photograph that best presented the bed particle size distribution was taken.

Bed particle size distribution data were used to determine commonly-used representative bed particle sizes: the particle size for which 16% of the distribution is finer (D_{16}), the particle size for which 50% of the distribution is finer (D_{50}, or the median size), and the particle size for which 84% of the distribution is finer (D_{84}). Where possible, these data were compared with historical data to assess any recent trends in bed coarsening or fining.

2.4 Bank Erosion Potential Assessments

A Rosgen (1996) analysis of bank erosion potential was also performed at each cross section. Determining bank erosion potential involved developing an erosion potential ‘score’ for five bank characteristics: 1) bank height/bankfull height; 2) root depth/bank height; 3) root density; 4) bank angle; and 5) an assessment of surface protection. Additional secondary characteristics included bank material and degree of stratification. Following the field data collection effort, these scores were summed and used to determine bank erosion potential for each cross-section, which ranged from very low (total score < 9.5) to extreme (total score > 50). As both banks were usually similar at the surveyed cross-sections, the erosion potential analysis covers both banks unless otherwise noted. At cross-sections where the banks were noticeably different with respect to erosion potential, the erosion potential assessment was focused on the less stable bank.

2.5 General Geomorphic Assessment

Following data compilation and analysis, a general geomorphic assessment was developed for those sites where historical data at the cross-sections existed. The assessment gives a broad indication of geomorphic change over the past 5 years based solely on comparisons of current and historical field data.

3 DATA ANALYSIS & DISCUSSION

3.1 Silver Fork American River at Forgotten Flat

3.1.1 General site description

The Silver Fork American River at Forgotten Flat study site is an approximately 500 ft long reach located 3.5 miles downstream of Silver Lake (Figure 3-1). Approximately 70 percent of 22 mi^2 drainage area upstream of the study site is regulated by Silver Lake (Cardno Entrix 2002). The channel bed through Forgotten Flat has a coarse-grained boulder framework and a plane bed morphology with a moderately steep reach average gradient.

Along with local snowmelt runoff, instream flows within Forgotten Flat are affected by flow releases from Silver Lake. In general, dam operations tend to cause a decreased spring baseflow with attenuated snowmelt runoff peak flows and increased summer baseflow compared to what would be expected under unregulated conditions.

3.1.2 Channel cross-sections

The Silver Fork American River at Forgotten Flat study site cross-sections for 2012 are shown in Figures 3-2 through 3-4. The compilation of cross-section photos for this site is provided in Appendix A. An exhaustive search was conducted in the 2011 and 2012 field campaigns to relocate historical cross-sections in the field, but to no avail. Therefore, three new monitoring cross-sections were established and their locations documented. The channel appears to be stable at all three cross-section locations. Fine sediment deposits predominately occur as lee and obstruction deposits associated with large framework boulders.

3.1.3 Longitudinal profile

The Silver Fork American River at Forgotten Flat longitudinal profile for 2012 is shown in Figure 3-5. The 2012 profile is approximately 10 bankfull widths in length (~500 ft) and extends approximately 165 ft upstream of XS-1 and approximately 55 ft downstream of XS-3, and has a reach-average slope of 0.0157. As historical longitudinal profile data for this site were not available, an assessment of longitudinal profile change was not conducted.

3.1.4 Bed particle size distributions

The Silver Fork American River at Forgotten Flat study site bed particle size distribution data for 2012 are shown in Figures 3-6 to 3-8 and representative sizes are shown in Table 3-1. The compilation of bed sediment photos for each cross-section surveyed at this site is provided in Appendix A. The 2012 data show that the bed particle size distribution is predominantly coarse gravel and larger (> 32 mm) with the median particle size at all cross-sections being coarse to very coarse gravel (between 25 and 52 mm). There are also large sand deposits along channel margins and filling interstitial void spaces between large coarse grains. The bed sediment lithology is predominantly granitic and meta-volcanic.

Table 3-1. Representative bed particle sizes for Silver Fork American River at Forgotten Flat.

Representative particle size (mm)	Monitoring year	XS-1 (Upper)	XS-2 (Middle)	XS-3 (Lower)
D_{16}	2012	< 2	< 2	< 2
D_{50}	2012	25	42	52
D_{84}	2012	260	290	290

3.1.5 Bank erosion potential

The Silver Fork American River at Forgotten Flat current bank erosion potential assessment for each cross-section surveyed is summarized in Table 3-2. The assessment shows that the banks currently have a low erosion potential and are therefore considered stable.

Table 3-2. Bank erosion potential analysis scores for Silver Fork American River at Forgotten Flat.

Bank erosion potential index	Index value[1]		
	XS-1 (Upper)	XS-2 (Middle)	XS-3 (Lower)
Bank height/bankfull height	10	4.6	1
Root depth/bank height	3	2.5	1
Root density (%)	4	7.3	2.4
Bank angle (degrees)	3.3	1.9	5.9
Surface protection (%)	5	6.1	5.5
Bank material[2]	Boulder/Soil	Boulder/Soil	Boulder/Soil
Stratification[3]	0	0	0
SUM	20.3	22.4	15.8
Erosion potential category	Low	Low	Low

[1] It should be noted that these index values are approximate and based on conformance with a qualitative assessment methodology.
[2] Value based on material type. In general, finer bank material is associated with a higher index value. See Rosgen (1996) for more detail.
[3] In general, more stratification is associated with a higher index value. See Rosgen (1996) for more detail.

3.1.6 General geomorphic assessment

There is no historical data at this site for comparison, so no general geomorphic assessment is provided. However, observations from the 2012 field campaign suggest the channel currently has moderately stable to stable channel morphology (i.e., moderately stable to stable bed elevation and low bank erosion potential throughout). Substantial willow and alder growth along channel margins and bars, coupled with the low erosion potential suggest channel adjustment is limited and only occurs during region wide large disturbance events.

3.2 Caples Spillway Channel

3.2.1 General site description

The Caples Spillway Channel conveys water released from the Caples Lake Auxiliary Dam downstream to Caples Creek near the confluence of Caples and Kirkwood Creeks (Figure 3-9). The spillway channel is an altered channel form and has two distinct sections based on channel type: a steep boulder and bedrock cascade reach and a lower gradient pool-riffle reach (Entrix 2010). Flow through the spillway channel is almost entirely controlled by releases through the Auxiliary Dam. The spillway channel was likely a much smaller natural drainage prior to project development and has been incised and enlarged by historic spill flows (Entrix 2002).

3.2.2 Channel cross-sections

The Caples Spillway Channel study site cross-sections for 2007 and 2011 are shown in Figures 3-10 to 3-12 and change metrics are summarized in Table 3-3. The compilation of cross-section photos for this site is provided in Appendix A. At this site, three cross-sections surveyed in 2007 were re-occupied. The channel bed at the upper cross-section (BL XS-1) shows moderate channel incision (i.e., negative net percent change in channel area) over the past 5 years, and a moderate amount of absolute percent change. This indicates that the entire bed essentially incised in a uniform fashion across the width of the cross-section, which is also evident from the cross-section comparison plot (Figure 3-10). The middle cross-section (BL XS-2) shows very little change between 2007 and 2011 (i.e., the net percent change and absolute percent change are around 5%). The lower cross-section (BL XS-3) left bank pin was previously installed in the base of a tree that had fallen over between 2007 and 2011, which introduces some uncertainty when comparing the 2007 and 2011 survey data. However, comparison of 2007 and 2011 data for BL XS-3 show a moderate negative net percent change and moderate absolute percent change. Comparison of the 2007 and 2011 cross-section plots at BL XS-3 shows minor bank retreat on the left bank and slight incision and bank retreat from the thalweg and across the entire right bank.

Table 3-3. Summary of cross-section change metrics for Caples Dam Spillway Channel.

Channel cross-section change metric	BL XS-1 (Upper)	BL XS-2 (Middle)	BL XS-3 (Lower)
Net % change in channel area	-16.3	5.7	-11.2
Absolute % change in channel area	16	6	19

3.2.3 Longitudinal profile

The Caples Dam Spillway Channel study site longitudinal profile for 2007 and 2012 are shown in Figure 3-13. The 2012 profile is almost 20 bankfull widths in length (~500 ft), extends approximately 50 ft upstream from BL XS-1 and approximately 100 ft downstream from BL XS-3, and has a reach-average slope of 0.0036. Between 2007 and 2012, the reach average slope modestly increased from 0.0027 to 0.0036. Comparison of the two plots shows significant scour and channel incision along nearly the entire profile extent.

3.2.4 Bed particle size distributions

The Caples Spillway Channel study site bed particle size distribution data for 2007 and 2012 are shown in Figures 3-14 to 3-16 and representative sizes are shown in Table 3-4. The compilation of bed sediment photos for each cross-section surveyed at this site is provided in Appendix A. The 2012 data show that the bed is predominantly finer than cobble (< 128 mm) with the median size at all cross-sections being medium to very coarse gravel (between 11 and 50 mm). The current bed sediment lithology is a mixed lithology and predominantly granitic. Comparison of 2012 data with 2007 data shows a noticeable bed fining at BL XS-1 and a noticeable bed coarsening of the bed sediment size at BL XS-2 and BL XS-3.

Table 3-4. Representative bed particle sizes for Caples Dam Spillway Channel.

Representative particle size (mm)	Monitoring year	BL XS-1 (Upper)	BL XS-2 (Middle)	BL XS-3 (Lower)
D_{16}	2007	6.1	< 2	< 2
	2012	30	< 2	5
D_{50}	2007	60	2.8	14.5
	2012	50	11	20
D_{84}	2007	170	13.9	27.9
	2012	90	24	40

3.2.5 Bank erosion potential

The Caples Spillway Channel study site current bank erosion potential assessment for each cross-section surveyed is summarized in Table 3-5. The bank erosion assessment shows that banks at each cross-section have a high or moderately high erosion potential index.

Table 3-5. Bank erosion potential analysis scores for Caples Spillway Channel.

Bank erosion potential index	Index value[1]		
	BL XS-1 (Upper)	BL XS-2 (Middle)	BL XS-3 (Lower)
Bank height/bankfull height	10	10	10
Root depth/bank height	6.5	6	5
Root bank height (%)	6	4	5
Bank angle (degrees)	5	4.5	3.9
Surface protection (%)	5	7	2.5
Bank material[2]	0	0	0
Stratification[3]	0	0	0
SUM	32.5	31.5	26.4
Erosion potential category	High	High	Moderate

[1] It should be noted that these index values are approximate and based on conformance with a qualitative assessment methodology.
[2] Value based on material type. In general, finer bank material is associated with a higher index value. See Rosgen (1996) for more detail.
[3] In general, more stratification is associated with a higher index value. See Rosgen (1996) for more detail.

3.2.6 General geomorphic assessment

Based on the comparison of historical and current data, the Caples Spillway Channel study site appears to be moderately unstable with significant channel incision and eroding banks along most of the reach. The imbalance of sediment and flow that has resulted in the observed channel incision has also caused bed coarsening throughout most of the study site, suggesting that the rate of channel incision will decrease over time as the channel bed continues to coarsen (i.e., flows will no longer be able to mobilize bed sediment). Overall, the total capacity for geomorphic channel change within the Spillway Channel is almost entirely controlled by the frequency and magnitude of releases from the Auxillary Dam.

3.3 South Fork American River below Kyburz Diversion Dam

3.3.1 General site description

The South Fork American River below Kyburz Diversion Dam study site is located approximately a quarter mile downstream of the Kyburz Diversion Dam near the confluence of the South Fork and Silver Fork American River (Figure 3-17). The channel through the study site is a steep, coarse-bedded, bedrock controlled channel with a low sinuosity step pool morphology, a moderately steep reach-average channel slope, and a moderate degree of entrenchment (i.e., a moderate width to depth ratio).

3.3.2 Channel cross-sections

The South Fork American River below Kyburz Diversion Dam study site cross-sections for 2011 and 2012 are shown in Figures 3-18 through 3-20 (XS-1 and XS-2 were surveyed in winter 2011, XS-3 was surveyed summer 2012). The compilation of cross-section photos for this site is provided in Appendix A. Two historical cross-section locations were located and reoccupied but historical data is not available for comparison. It is assumed the cross-sections markers are from 1997 but no documentation could be provided to confirm. The channel appears to be stable at all three cross-section locations. Mobile sediment is predominantly found as lee and obstruction deposits filling interstitial void spaces between large framework boulders.

3.3.3 Longitudinal profile

The South Fork American River below Kyburz Diversion Dam study site longitudinal profile for 2012 is shown in Figure 3-21. The 2012 profile is approximately 20 bankfull widths in length (~2,000 ft) and extends approximately 35 ft upstream from the upper cross-section (XS-1) and approximately 100 ft downstream from the lower cross-section (XS-3), and has a reach-average slope of 0.0155. As historical longitudinal profile data for this site were not available, an assessment of longitudinal profile change was not conducted.

3.3.4 Bed particle size distributions

The South Fork American River below Kyburz Diversion Dam study site bed particle size distribution data for 2012 are shown in Figures 3-22 to 3-23 and representative sizes are shown in Table 3-6. The compilation of bed sediment photos for each cross-section surveyed at this site is provided in Appendix A. Bed particle size data was not collected at cross-sections XS-1 in 2012 because water depths and flows prohibited safe channel access at that location. Overall, the bed particle size distributions show that coarsest fraction is in the boulder size class (> 256 mm) and that the median grain size is cobble (107–144 mm).

Table 3-6. Representative bed particle sizes for South Fork American below Kyburz Diversion Dam.

Representative particle size (mm)	Monitoring year	XS-1 (Upper)	XS-2 (Middle)	XS-3 (Lower)
D_{16}	2012	n/a	< 2	48
D_{50}	2012	n/a	144	107
D_{84}	2012	n/a	380	255

3.3.5 Bank erosion potential

The South Fork American River below Kyburz Diversion Dam study site current bank erosion potential assessment for each cross-section surveyed is summarized in Table 3-7. The assessment shows that all banks have essentially the same degree of low bank erosion potential due to both banks being armored by a combination of large sediment (cobbles and boulders) and bedrock. Large portions of the right bank have additional engineered rock slope protection associated with the Highway 50 road fill prism.

Table 3-7. Bank erosion potential analysis scores for South Fork American below Kyburz Diversion Dam.

Bank erosion potential index	Index value[1]		
	XS-1[4] (Upper)	XS-2[5] (Middle)	XS-3[4] (Lower)
Bank height/bankfull height	1.9	1.9	10
Root depth/bank height	3.9	5	3.9
Root density (%)	6.5	5.2	5.9
Bank angle (degrees)	1.9	2.8	3.3
Surface protection (%)	6.5	4.3	4.2
Bank material[2]	Boulder/cobble, sand matrix, -5	Boulder, -10	Boulder, -10
Stratification[3]	0	0	0
SUM	20.7 (15.7 adjusted)	19.2 (9.2 adjusted)	27.3 (17.3 adjusted)
Erosion potential category	Low	Low	Low

1 It should be noted that these index values are approximate and based on conformance with a qualitative assessment methodology.
2 Value based on material type. In general, finer bank material is associated with a higher index value. See Rosgen (1996) for more detail.
3 In general, more stratification is associated with a higher index value. See Rosgen (1996) for more detail.
4 Assessment is focused on the left bank due to proximity of right bank to Highway 50 road prism fill and rock slope protection.
5 Assessment is focused on right bank due to proximity of left bank to canal infrastructure.

3.3.6 General geomorphic assessment

There is no historical data at this site for comparison, so no general geomorphic assessment is provided. However, observations from the 2011 and 2012 field campaigns suggest the channel currently has a stable channel morphology (i.e., stable bed elevation and low bank erosion potential throughout). The large coarse bed sediment essentially 'locks' the channel form and bed elevation, and geomorphic change is therefore only possible during very large, infrequent flood events.

3.4 Oyster Creek below Highway 88

3.4.1 General site description

The Oyster Creek below Highway 88 study site is located approximately 1,500 ft downstream of where Highway 88 crosses over the creek (Figure 3-24). The channel through the site flows along the southern border of a low gradient meadow. The channel has pool-riffle morphology, a moderately to highly sinuous planform, a moderate channel gradient, and is entrenched within the meadow floodplain. A well-developed, low-elevation terrace observed during 2007 field investigations (Blue Line Consulting 2009) is still intact and currently supports willow and conifer stands.

Instream flows at the Oyster Creek study site are affected by natural hydrologic processes, leakage from Silver Lake, and local road drainage. Leakage from Silver Lake and local road drainage have increased instream flows in Oyster Creek compared to the pre highway and reservoir construction channel. A recent assessment of daily mean flow shows average monthly values range from 1 to 2 cfs during the winter months to approximately 15 cfs during the summer months (Blue Line Consulting 2009). During storms, the highway drainage system concentrates a considerable amount of road runoff into Oyster Creek at the Highway 88 bridge, resulting in a large pulse of water entering the channel downstream of the bridge (EID 2003).

3.4.2 Channel cross-sections

The Oyster Creek below Highway 88 study site cross-sections for 2007 and 2011 are presented and discussed in the initial *Geomorphic Monitoring of Representative Channel Areas for El Dorado Hydroelectric Project No. 184 Report* (Stillwater Sciences 2012).

3.4.3 Longitudinal profile

The Oyster Creek below Highway 88 study site longitudinal profile for 2012 is shown in Figure 3-25. The 2012 profile is approximately 20 bankfull widths in length (~500 ft) and extends approximately 25 ft upstream from XS-7, approximately 100 ft downstream from XS-5, and has a relatively low reach-average slope of 0.0068. As historical longitudinal profile data for this site were not available, an assessment of longitudinal profile change was not conducted.

3.4.4 Bed particle size distributions

The Oyster Creek below Highway 88 study site bed particle size data for 2007 and 2011 are presented and discussed in the initial *Geomorphic Monitoring of Representative Channel Areas for El Dorado Hydroelectric Project No. 184 Report*.

3.4.5 Bank erosion potential

The Oyster Creek below Highway 88 study site bank erosion potential discussion is presented and discussed in the initial *Geomorphic Monitoring of Representative Channel Areas for El Dorado Hydroelectric Project No. 184 Report*.

3.4.6 General geomorphic assessment

Based on the comparison of historical and current data presented here and in the initial *Geomorphic Monitoring of Representative Channel Areas for El Dorado Hydroelectric Project No. 184 Report*., the Oyster Creek below Highway 88 site appears to have a relatively stable channel bed elevation with steep banks and high erosion potential at meander bends.

3.5 Lower Echo Creek

3.5.1 General site description

The Lower Echo Creek study site is approximately 1,000 ft long and is located between the South Upper Truckee Road bridge crossing and the confluence with the Upper Truckee River (Figure 3-26). The channel is located atop a forested depositional alluvial fan deposit and splits into two channels less than 200 ft downstream from the South Upper Truckee Road bridge crossing. Channels within this type of depositional geomorphic environment tend to migrate quite readily. The channels have a forced pool-riffle morphology, are relatively shallow and steep, and have a moderate degree of sinuosity.

Instream flows at the Lower Echo Creek study site are affected by natural hydrologic processes associated with snowmelt and spring runoff events as well as flow regulation at Echo Lake. Simulated average monthly flows for a normal water year (i.e., long-term average conditions) shows the highest daily mean flows occur in January, followed by April, May, and July (EID 2003).

3.5.2 Channel cross-sections

The Lower Echo Creek site cross-sections XS-1 and XS-2 for 2011 are presented in the initial *Geomorphic Monitoring of Representative Channel Areas for El Dorado Hydroelectric Project No. 184 Report*. During the summer 2012 field effort, a new upstream cross-section, XS-0b was established downstream of the original XS-0 location due to difficulty in surveying a longitudinal profile through extremely dense riparian vegetation between XS-0 and XS-1 locations (Figure 3-27). Every effort was made to establish this new long-term monitoring cross-section at a location that is representative of average conditions at this portion of the study site.

3.5.3 Longitudinal profile

The Lower Echo Creek study site longitudinal profiles for 2012 are shown in Figures 3-28 and 3-29. The 2012 left channel profile is approximately 20 bankfull widths in length (~400 ft) and extends approximately 40 ft upstream from XS-0b and approximately 20 ft downstream from XS-2. The 2012 right channel profile is approximately 20 bankfull widths in length (~350 ft) and extends approximately 40 ft upstream from XS-0b and 60 ft downstream from XS-2. The reach-average channel gradients for both profiles are similar and moderately steep at 0.017 (right channel) and 0.018 (left channel). As historical longitudinal profile data for this site were not available, an assessment of longitudinal profile change was not conducted.

3.5.4 Bed particle size distributions

The Lower Echo Creek bed particle size distribution data for 2011 are presented in the initial *Geomorphic Monitoring of Representative Channel Areas for El Dorado Hydroelectric Project*

No. 184 Report. The 2012 particle size distribution data for XS-0b is provided in Table 3-8 and Figures 3-30 and 3-31 the compilation of bed sediment photos for XS-0b is provided in Appendix A. Overall, the bed particle size distribution is similar to that at XS-0, with the majority of bed sediment being finer than coarse cobble (<130 mm) and the median bed particle size ranging from very coarse gravel (60 mm) in the left channel and fine cobble (70 mm) in the right channel. The XS-0b bed sediment lithology is a mixed lithology and predominantly granitic.

Table 3-8. Representative bed particle sizes for Lower Echo Creek XS-0b.

Representative particle size (mm)	Monitoring year	XS-0b Left (Upper)	XS-0b Right (Middle)
D_{16}	2007	--	--
	2011	30	40
D_{50}	2007	--	--
	2011	60	70
D_{84}	2007	--	--
	2011	114	129

3.5.5 Bank erosion potential

The Lower Echo Creek site current bank erosion potential assessment for cross-section XS-0b is summarized in Table 3-9. The assessment shows the banks at XS-0b have a moderate erosion potential, which is somewhat higher than the assessed erosion potential for the cross-sections downstream.

Table 3-9. Bank erosion potential analysis scores for Lower Echo Creek XS-0b.

Bank erosion potential index	Index value[1]	
	XS-0b Left[4] (Upper)	XS-0b Right (Upper)
Bank height/bankfull height	10	7.9
Root depth/bank height	3	3
Root density (%)	4.4	1.9
Bank angle (degrees)	5	10
Surface protection (%)	5.9	1.6
Bank material[2]	0	0
Stratification[3]	0	0
SUM	28.3	24.4
Erosion potential category	Moderate	Moderate

[1] It should be noted that these index values are approximate and based on conformance with a qualitative assessment methodology.
[2] Value based on material type. In general, finer bank material is associated with a higher index value. See Rosgen (1996) for more detail.
[3] In general, more stratification is associated with a higher index value. See Rosgen (1996) for more detail.
[4] Assessment focuses on right bank of left channel. Downstream of reach banks are undercut. Left bank cannot be adequately described with this methodology due to multiple debris torrent tracks and high flow swales.

3.5.6 General geomorphic assessment

There is no historical data at this site for comparison, so no general geomorphic assessment is provided. However, observations from the 2011 and 2012 field campaigns suggest the channel currently has moderately stable to stable channel morphology (i.e., moderately stable to stable bed elevation and low to moderate bank erosion potential throughout).

4 LITERATURE CITED

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Figures

Figure 1-1. Map of geomorphic monitoring sites.

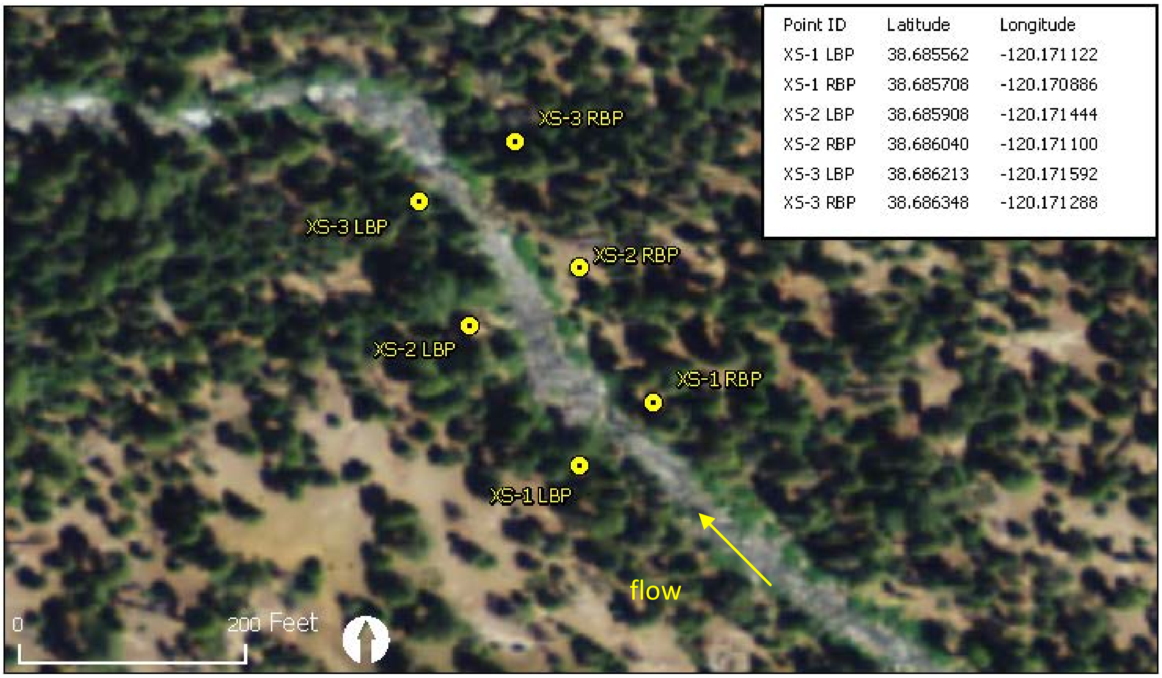


Figure 3-1. Site map of Forgotten Flat site showing cross-section endpins and coordinates (in decimal degrees). LBP is left bank pin and RBP is right bank pin.

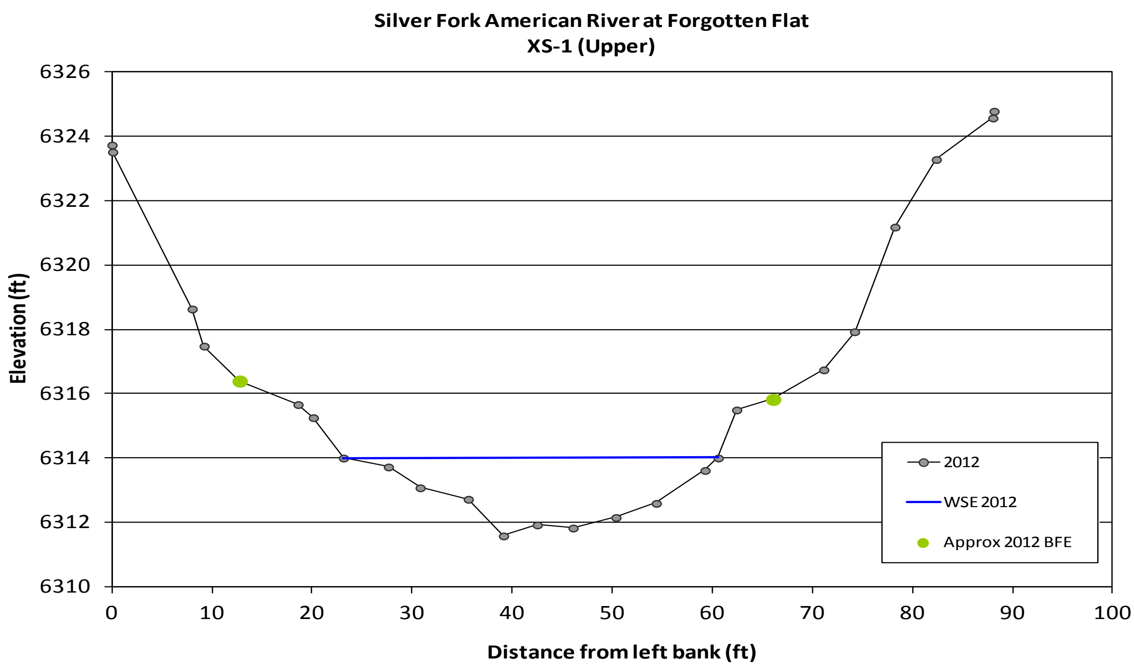


Figure 3-2. Silver Fork American River at Forgotten Flat XS-1 survey data. Elevation is an approximation of NAVD88 based on GPS survey. Legend abbreviations: WSE = water surface elevation; BFE = bankfull elevation.

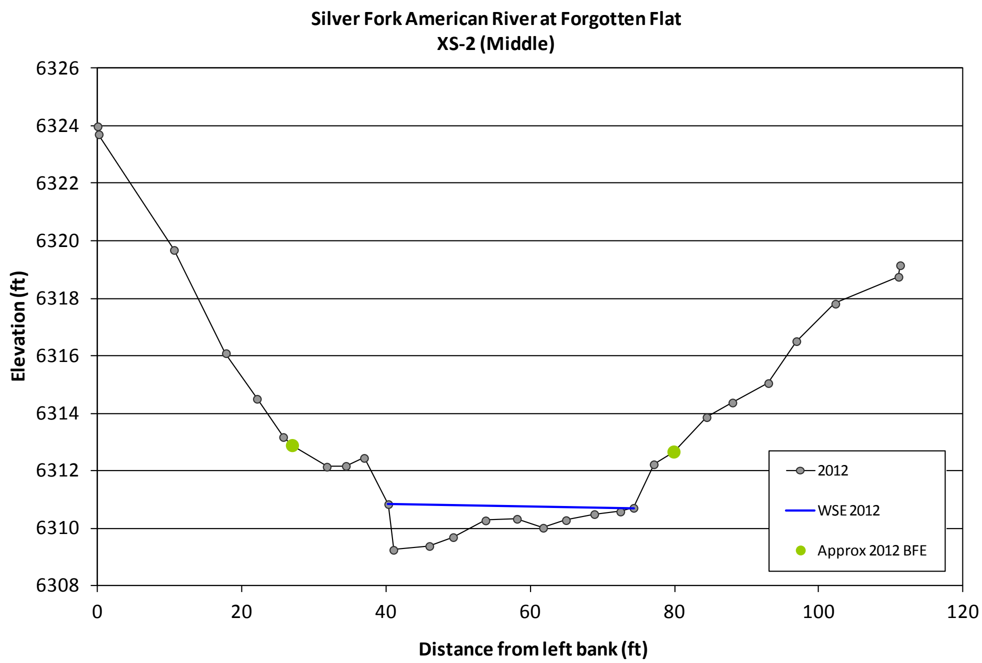


Figure 3-3. Silver Fork American River at Forgotten Flat XS-2 survey data. Elevation is an approximation of NAVD88 based on GPS survey. Legend abbreviations: WSE = water surface elevation; BFE = bankfull elevation.

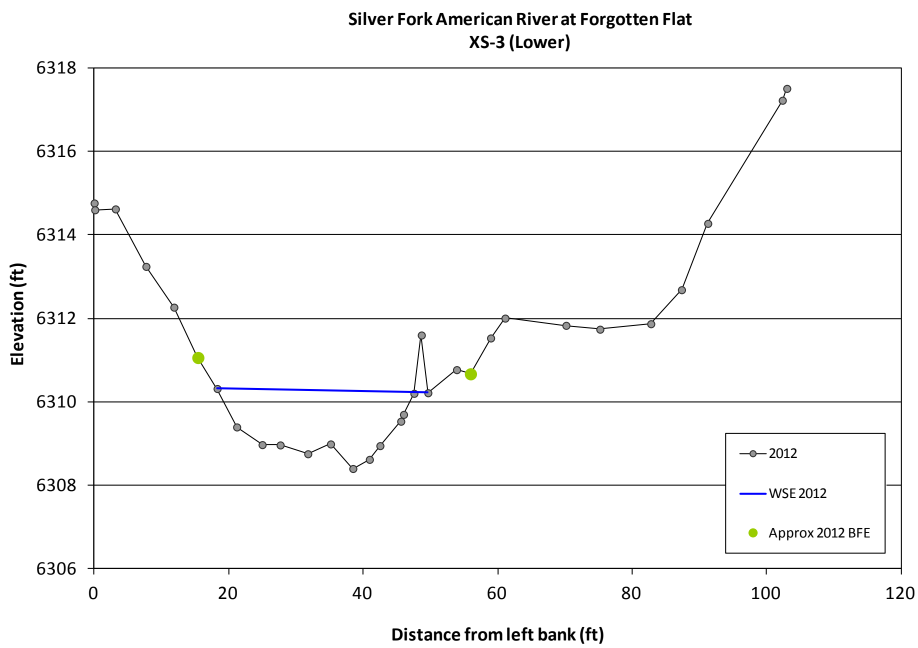


Figure 3-4. Silver Fork American River at Forgotten Flat XS-3 survey data. Elevation is an approximation of NAVD88 based on GPS survey. Legend abbreviations: WSE = water surface elevation; BFE = bankfull elevation.

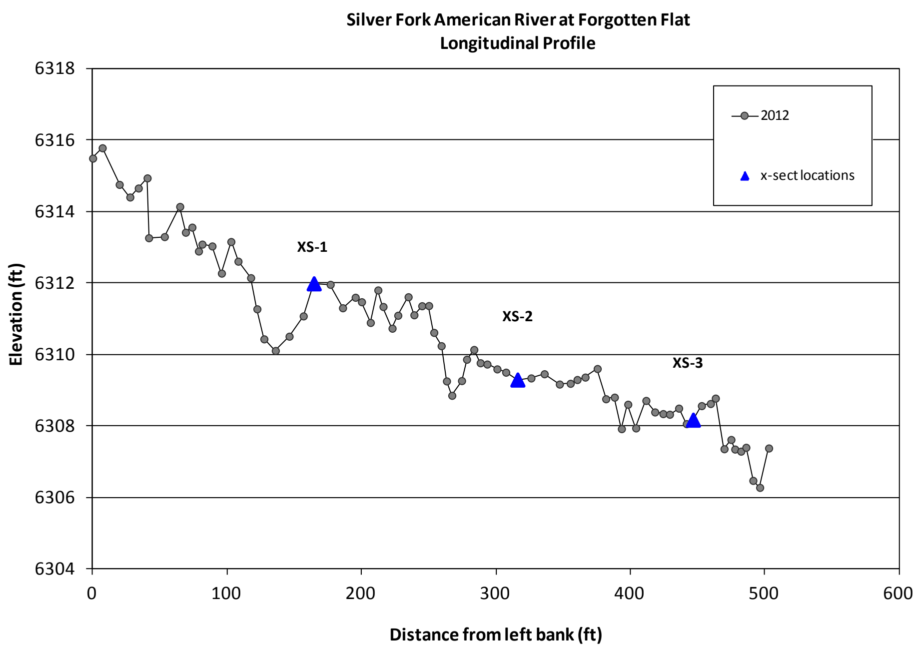


Figure 3-5. Silver Fork American River at Forgotten Flat longitudinal profile survey data. Elevation is an approximation of NAVD88 based on GPS survey. Legend abbreviations: WSE = water surface elevation; BFE = bankfull elevation.

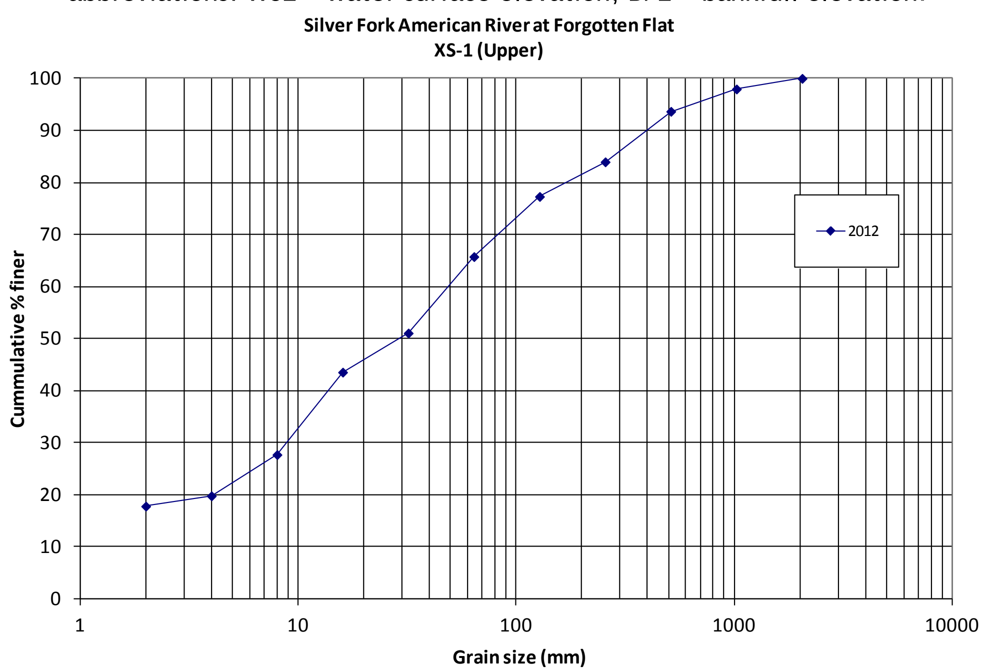


Figure 3-6. Silver Fork American River at Forgotten Flat XS-1 bed particle size distribution.

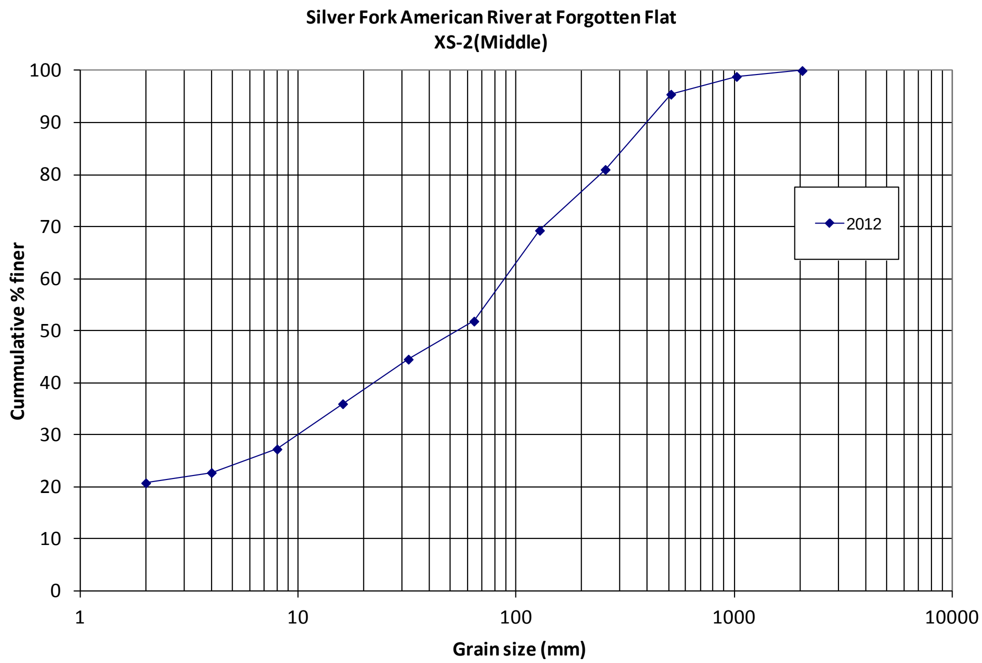


Figure 3-7. Silver Fork American River at Forgotten Flat XS-2 bed particle size distribution.

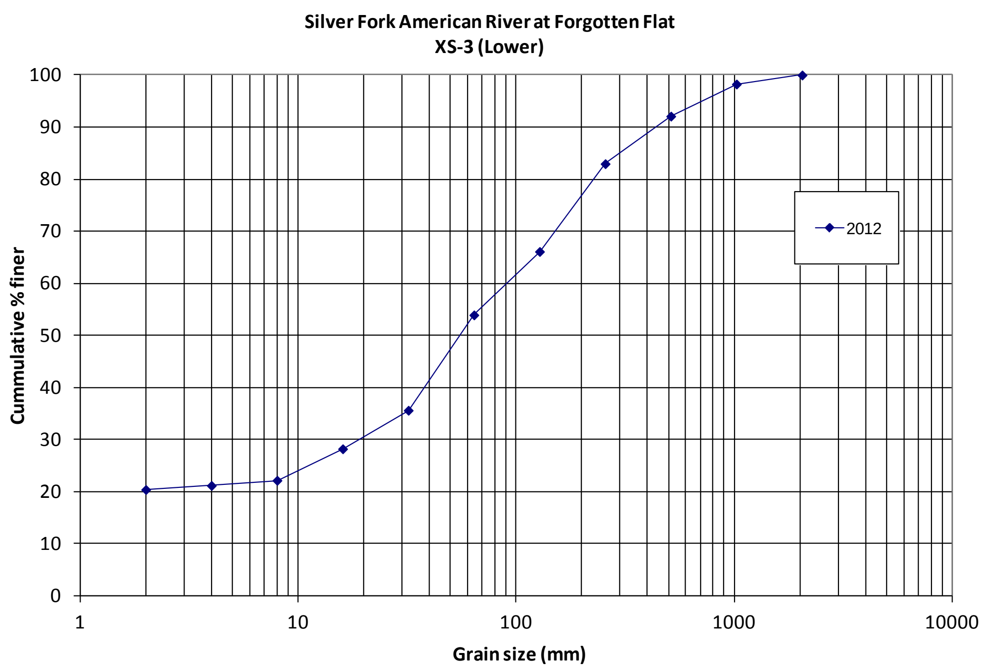
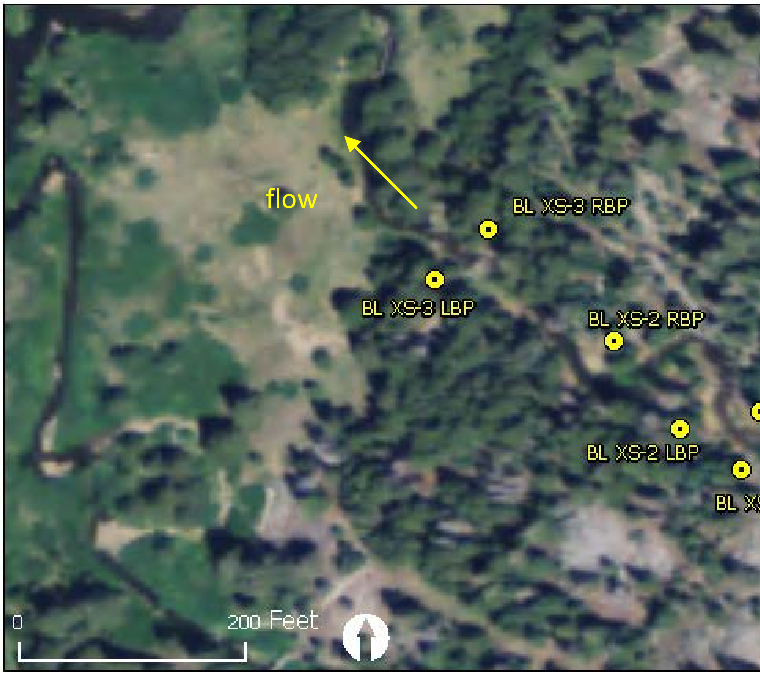


Figure 3-8. Silver Fork American River at Forgotten Flat XS-3 bed particle size distribution.



Point ID	Latitude	Longitude
BL XS-1 LBP	38.707273	-120.068810
BL XS-1 RBP	38.707410	-120.068746
BL XS-2 LBP	38.707375	-120.068992
BL XS-2 RBP	38.707592	-120.069190
BL XS-3 LBP	38.707757	-120.069733
BL XS-3 RBP	38.707873	-120.069567

Figure 3-9. Site map of Caples Spillway Channel site showing cross-section endpins and coordinates (in decimal degrees). LBP is left bank pin and RBP is right bank pin. The longitudinal profile starting location is also noted.

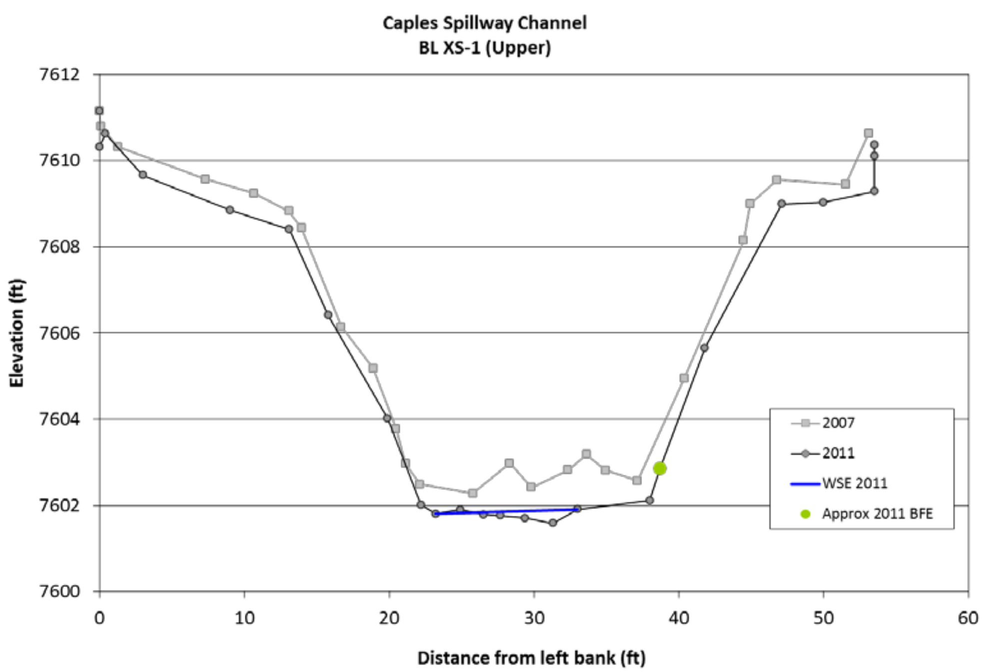


Figure 3-10. Caples Spillway Channel BL XS-1 survey data. Elevation is shown relative to the datum used for the 2007 survey (see Cardno Entrix 2011). Legend abbreviations: WSE = water surface elevation; BFE = bankfull elevation.

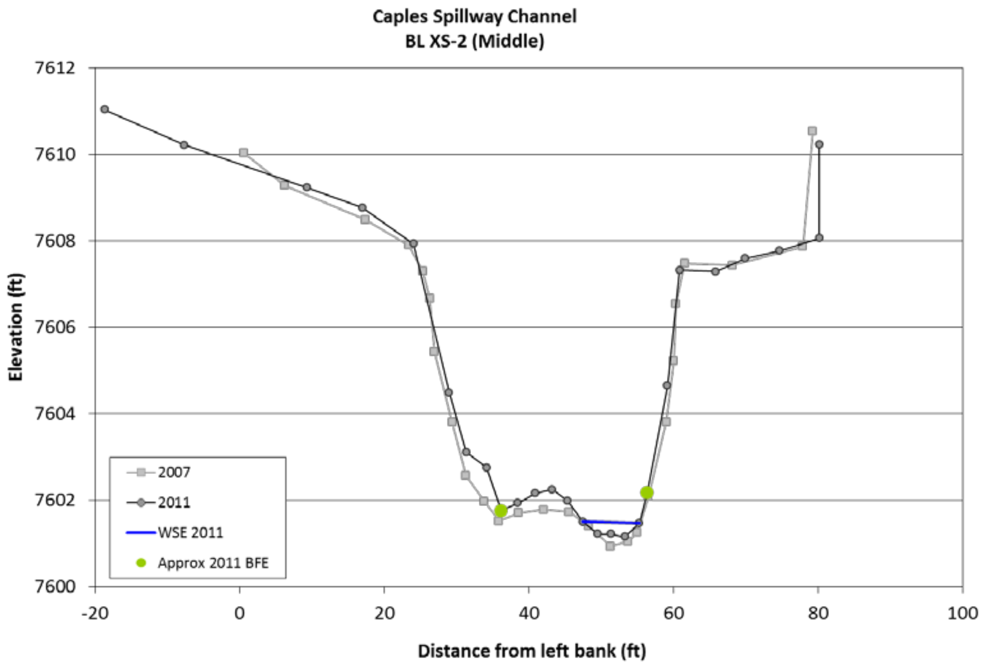


Figure 3-11. Caples Spillway Channel BL XS-2 survey data. Elevation is shown relative to the datum used for the 2007 survey (see Cardno Entrix 2011). Legend abbreviations: WSE = water surface elevation; BFE = bankfull elevation.

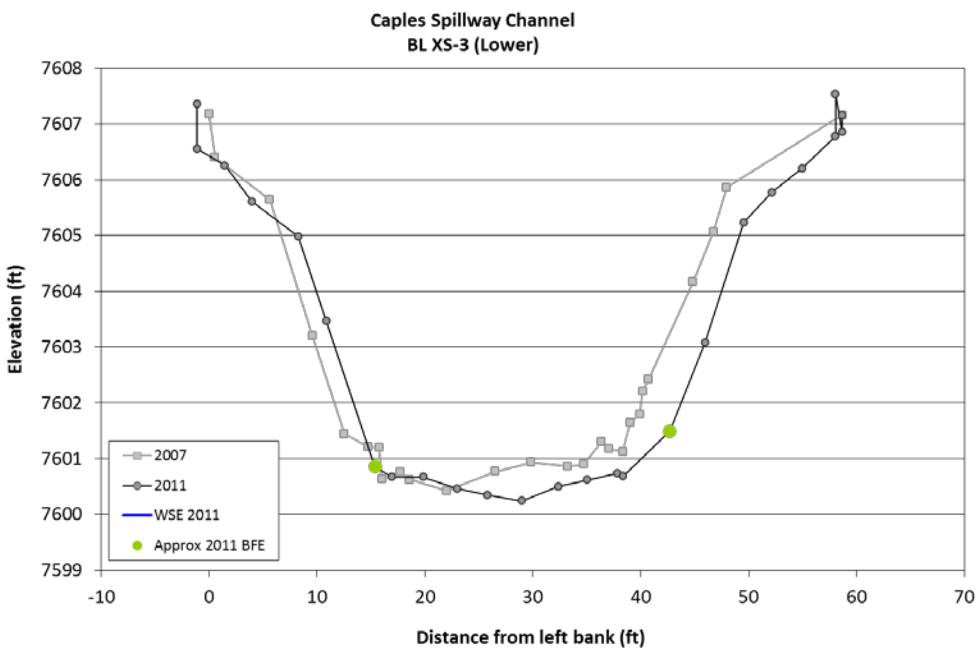


Figure 3-12. Caples Spillway Channel BL XS-3 survey data. Elevation is shown relative to the datum used for the 2007 survey (see Cardno Entrix 2011). Legend abbreviations: WSE = water surface elevation; BFE = bankfull elevation.

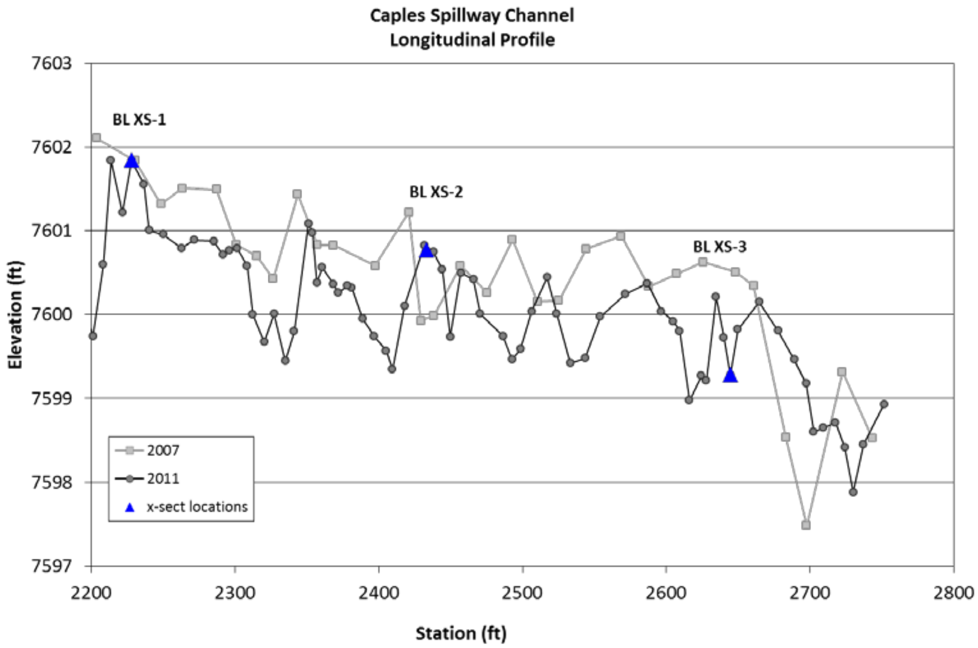


Figure 3-13. Caples Spillway Channel longitudinal profile data. Elevation is shown relative to a datum established for the 2007 survey. Legend abbreviations: WSE = water surface elevation.

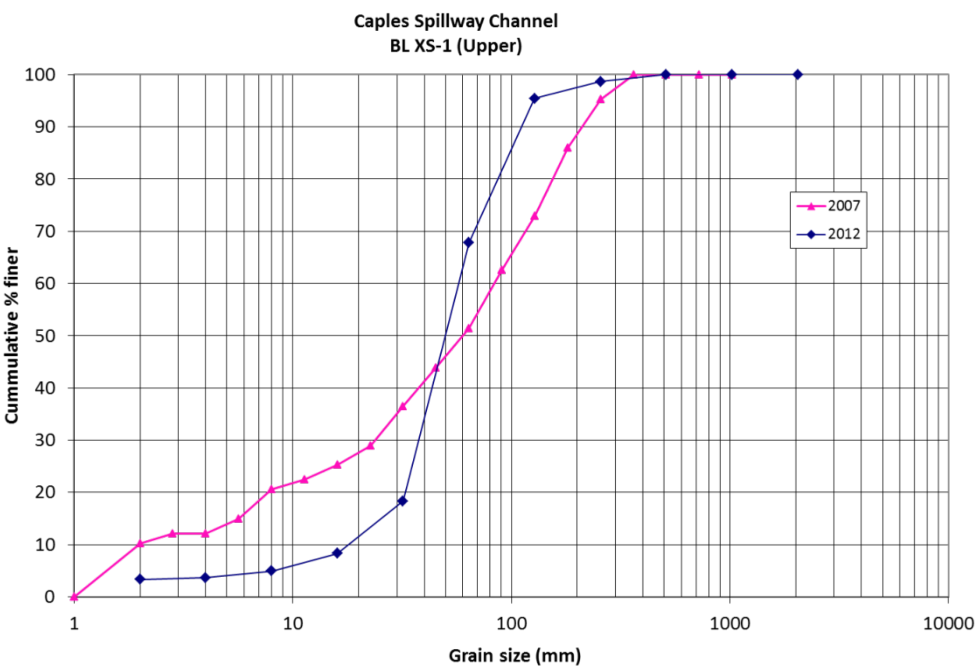


Figure 3-14. Caples Spillway Channel BL XS-1 bed particle size distribution.

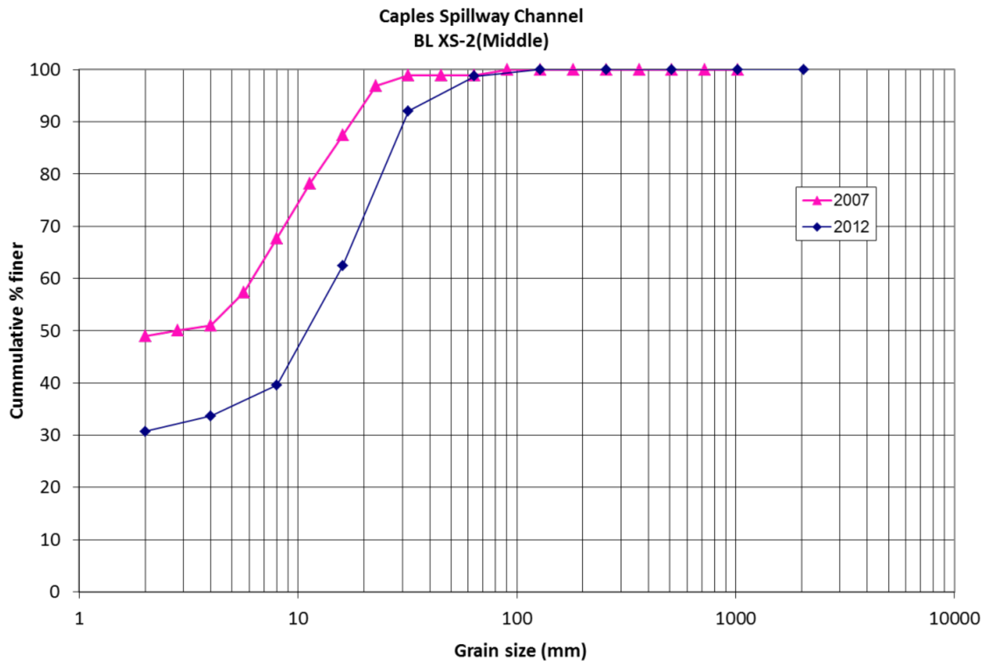


Figure 3-15. Caples Spillway Channel BL XS-2 bed particle size distribution.

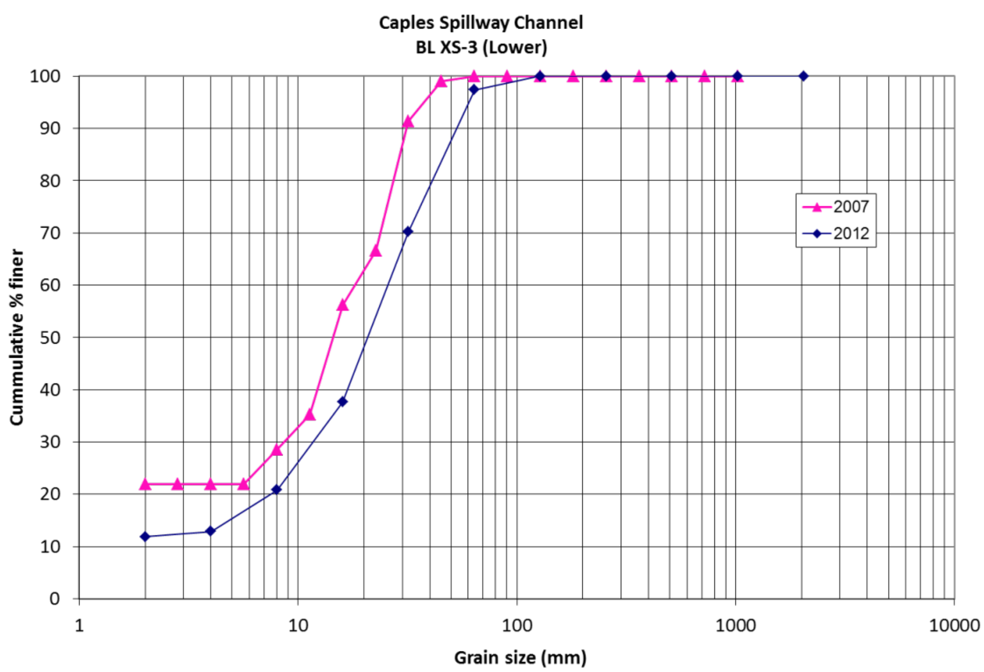


Figure 3-16. Caples Spillway Channel BL XS-3 bed particle size distribution.

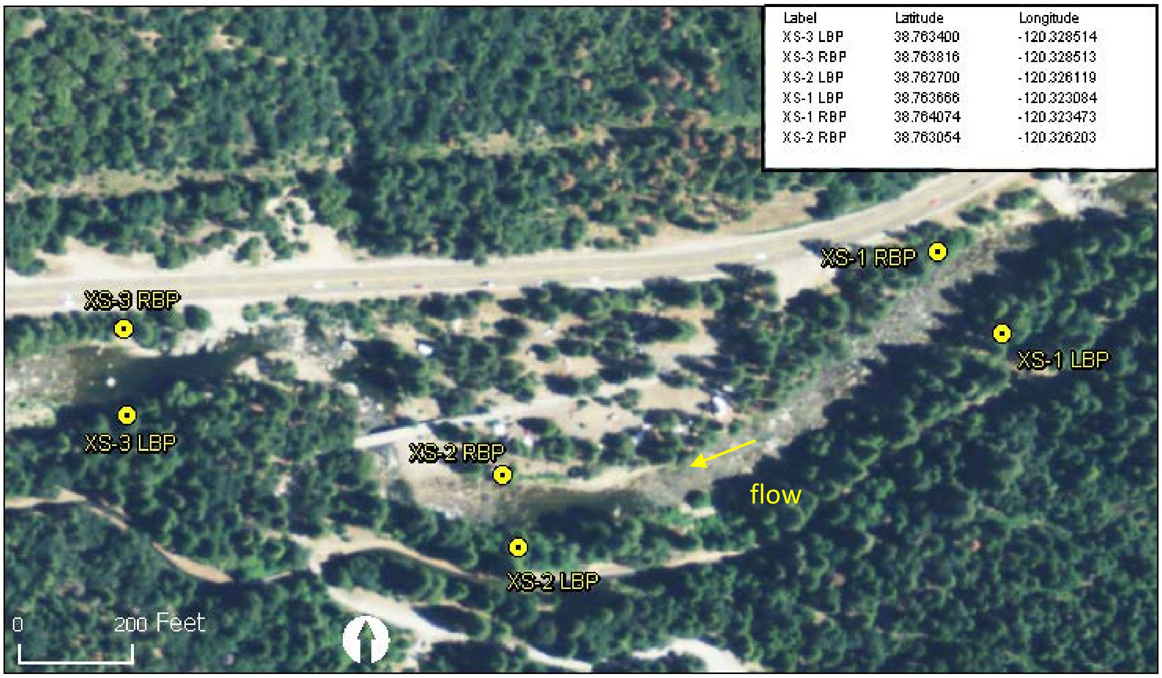


Figure 3-17. Site map of South Fork American River below Kyburz Diversion Dam site showing cross-section endpins and coordinates (in decimal degrees). LBP is left bank pin and RBP is right bank pin.

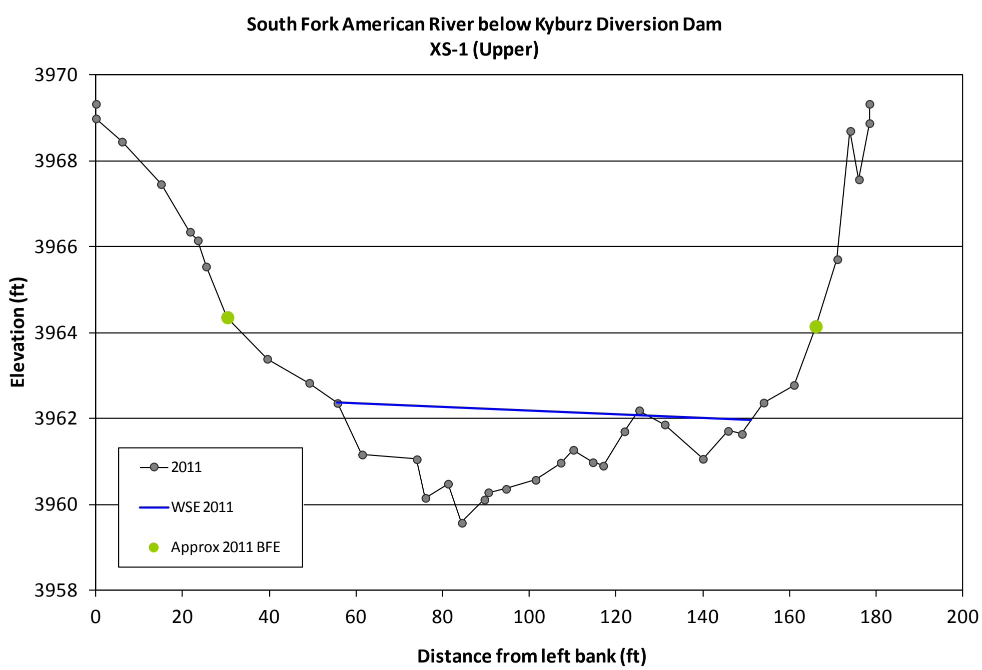


Figure 3-18. South Fork American River below Kyburz Diversion Dam XS-1 survey data. Elevation is an approximation of NAVD88 based on GPS survey. Legend abbreviations: WSE = water surface elevation; BFE = bankfull elevation.

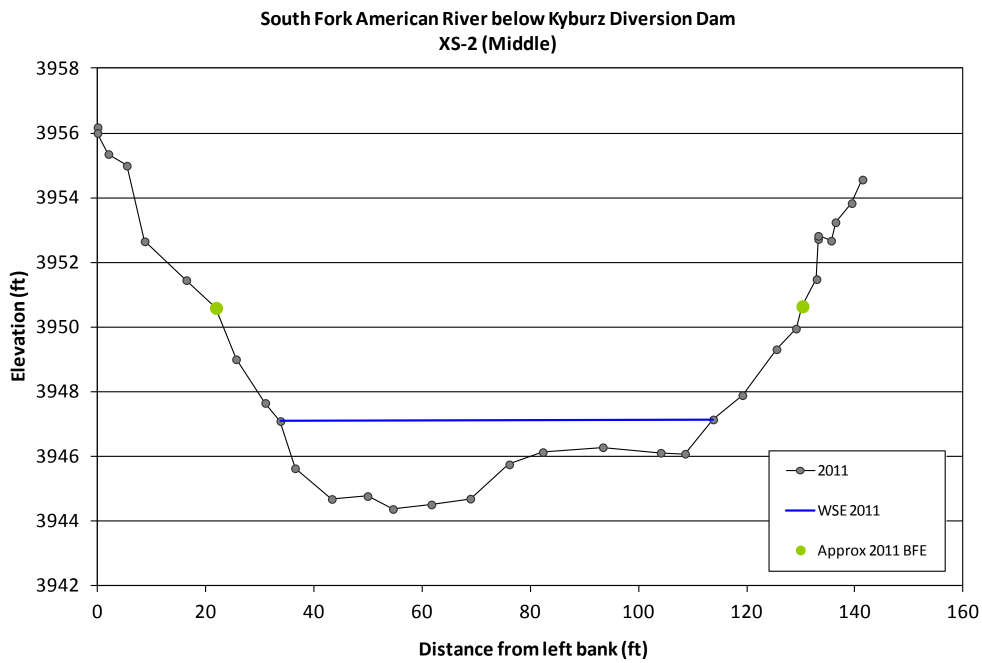


Figure 3-19. South Fork American River below Kyburz Diversion Dam XS-2 survey data. Elevation is an approximation of NAVD88 based on GPS survey. Legend abbreviations: WSE = water surface elevation; BFE = bankfull elevation.

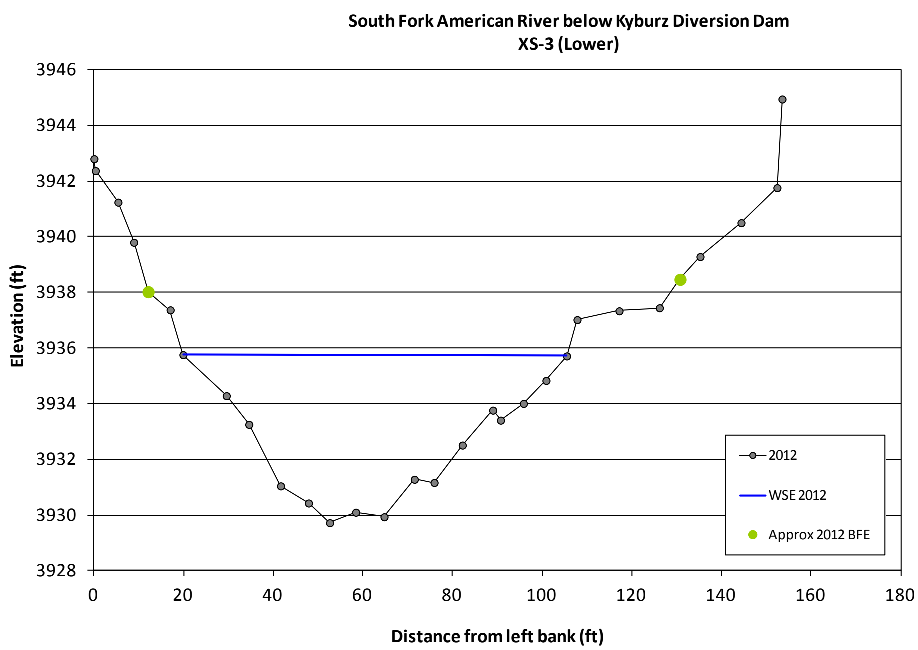


Figure 3-20. South Fork American River below Kyburz Diversion Dam XS-3 survey data. Elevation is an approximation of NAVD88 based on GPS survey. Legend abbreviations: WSE = water surface elevation; BFE = bankfull elevation.

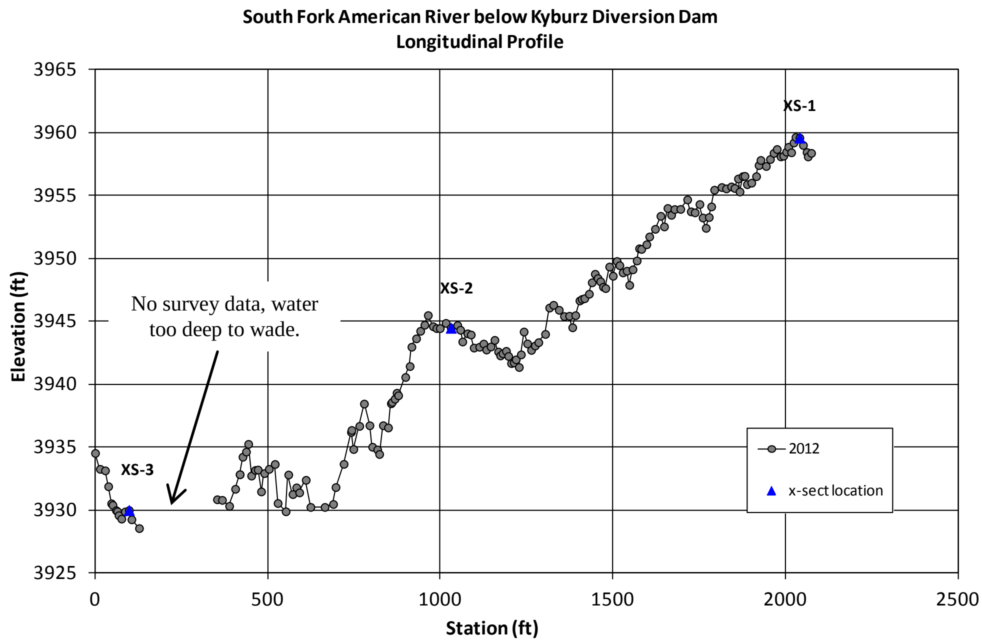


Figure 3-21. South Fork American River below Kyburz Diversion Dam longitudinal profile survey data. Elevation is an approximation of NAVD88 based on GPS survey.

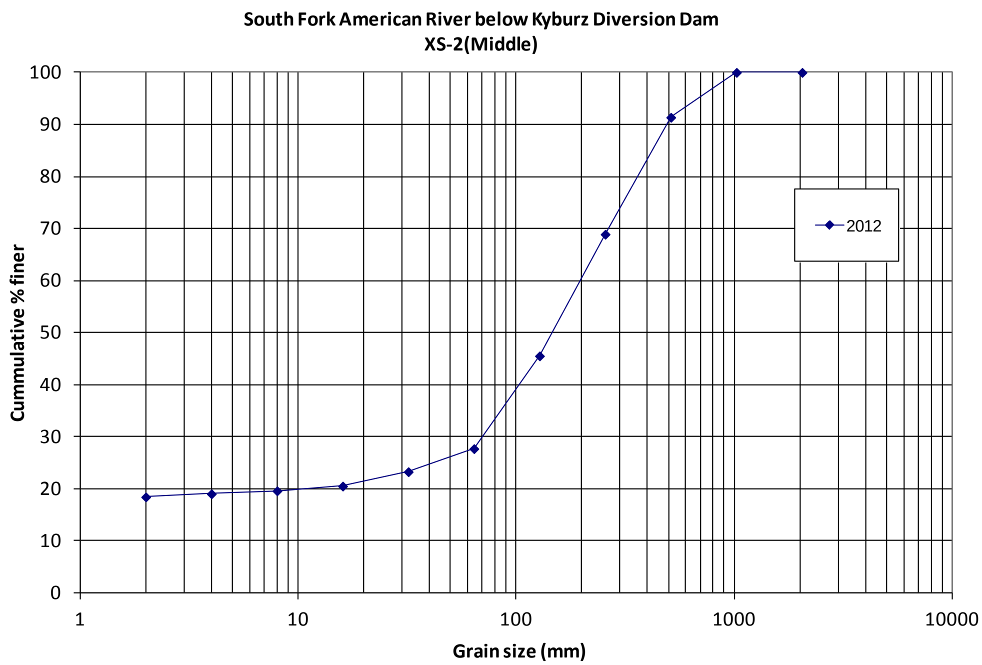


Figure 3-22. South Fork American River below Kyburz Diversion Dam XS-2 bed particle size distribution.

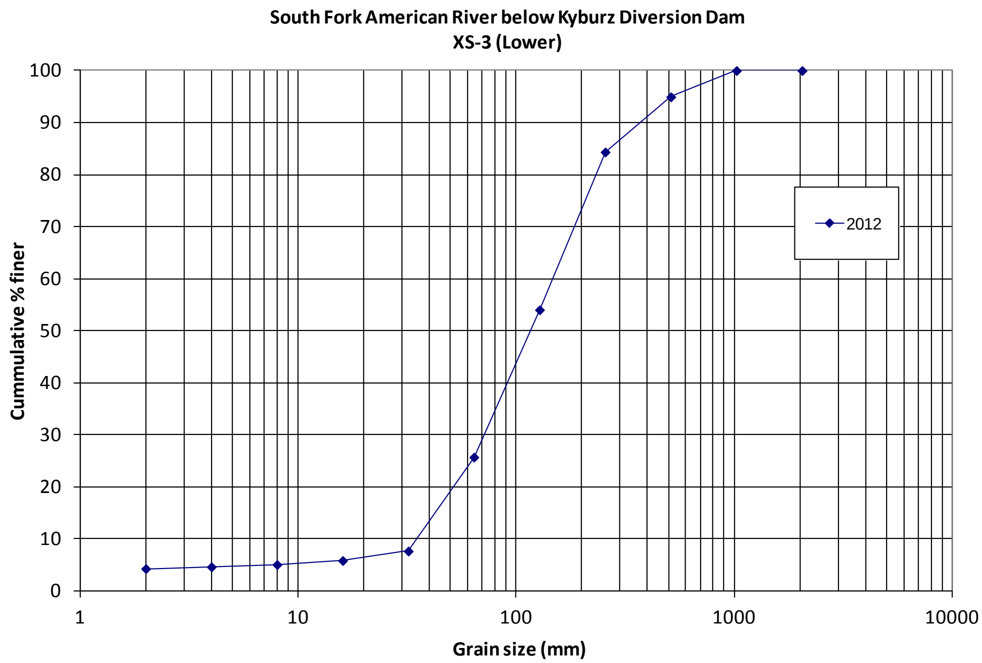


Figure 3-23. South Fork American River below Kyburz Diversion Dam XS-3 bed particle size distribution.

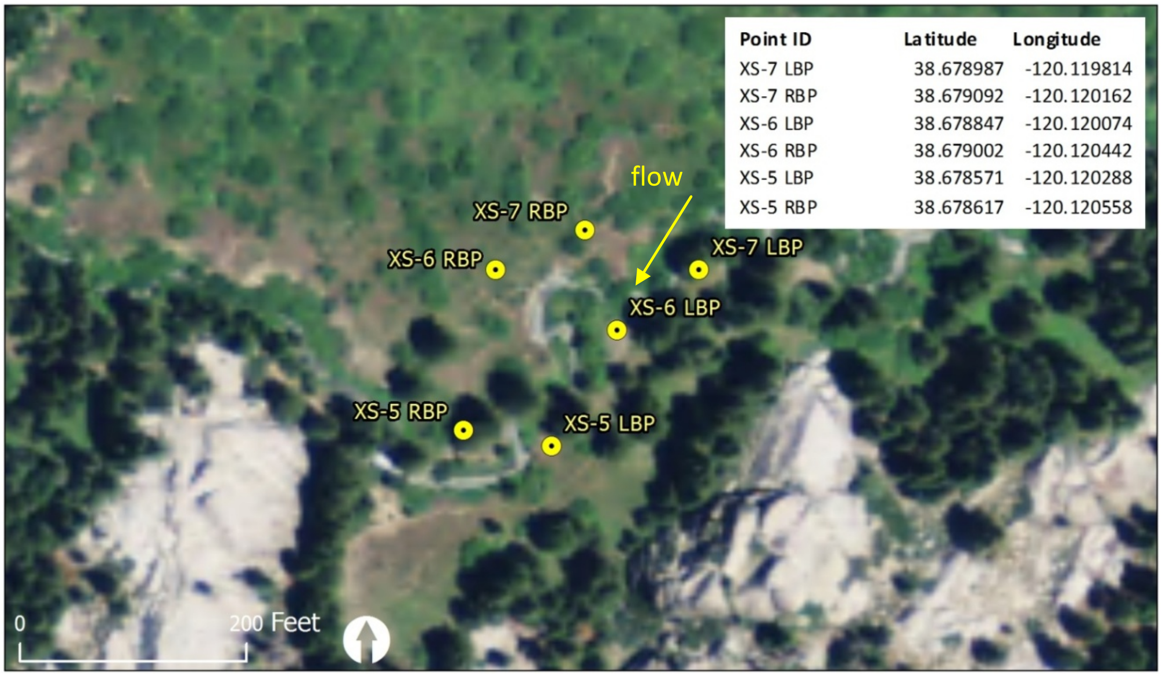


Figure 3-24. Site map of the Oyster Creek below Highway 88 site showing cross-section endpins and coordinates (in decimal degrees). LBP is left bank pin and RBP is right bank pin.

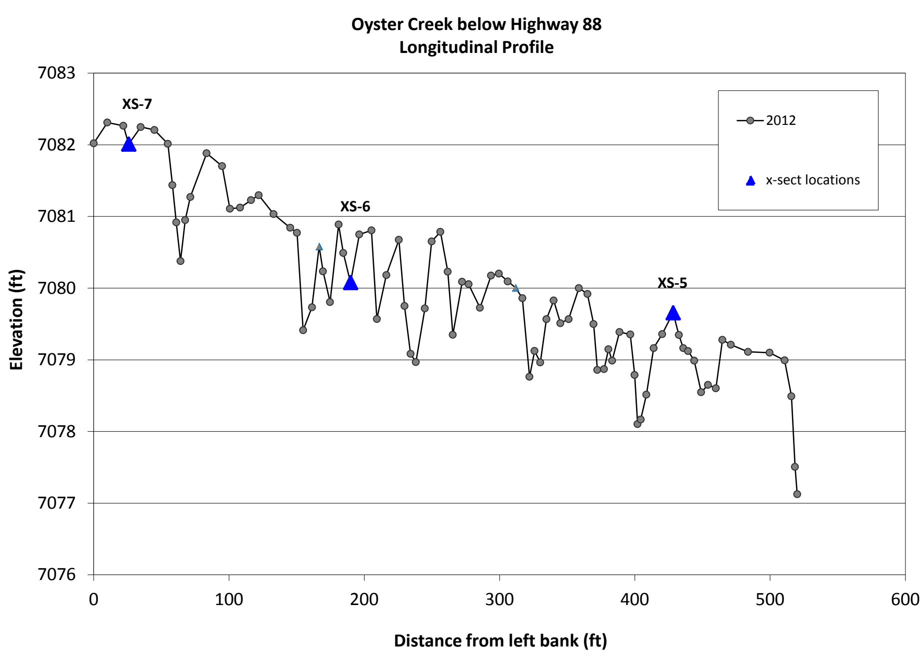


Figure 3-25. Oyster Creek below Highway 88 XS-5 longitudinal profile survey data. Elevation is shown relative to the datum used for the 2007 survey (see Blue Line Consulting 2009).

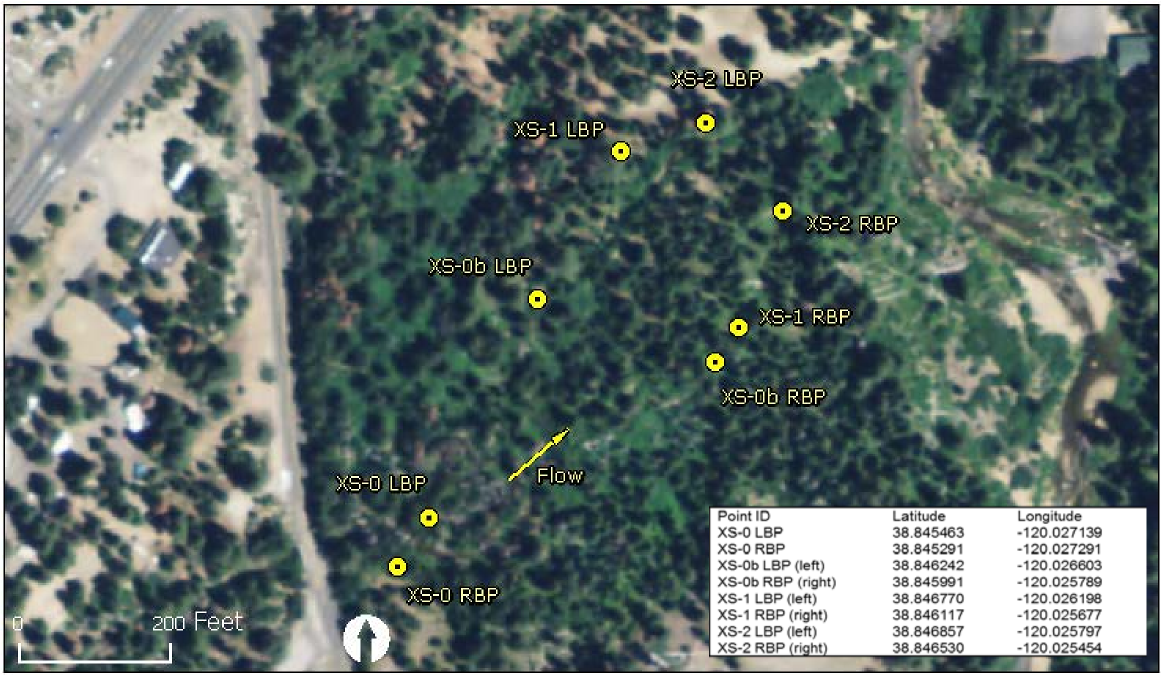


Figure 3-26. Site map of Lower Echo Creek site showing cross-section endpins and coordinates (in decimal degrees). LBP is left bank pin and RBP is right bank pin.

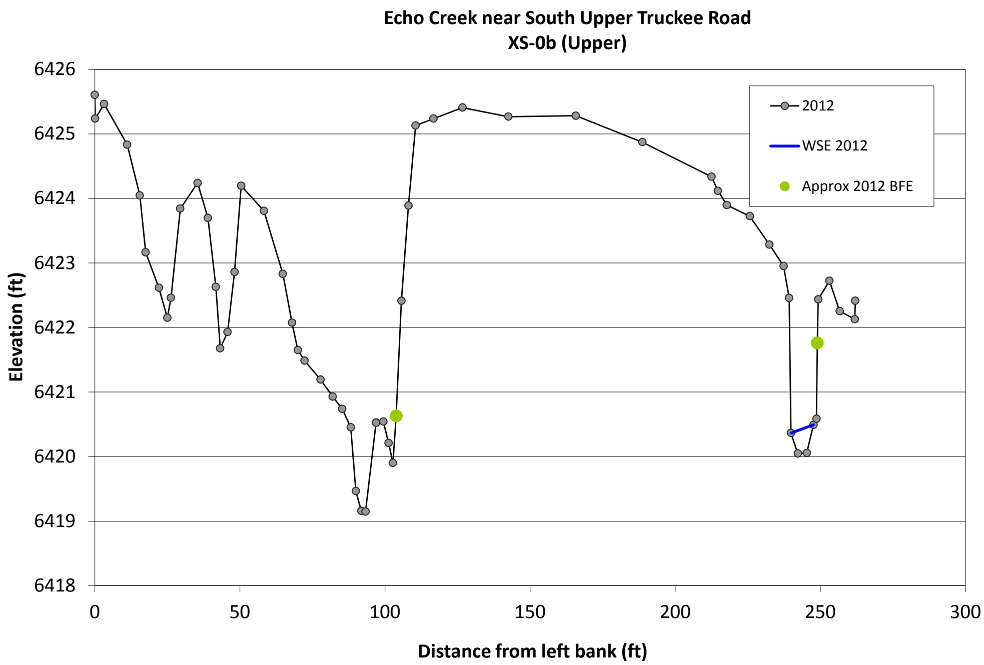


Figure 3-27. Lower Echo Creek XS-0b survey data. Elevation is an approximation of NAVD88 based on GPS survey. Legend abbreviations: WSE = water surface elevation; BFE = bankfull elevation.

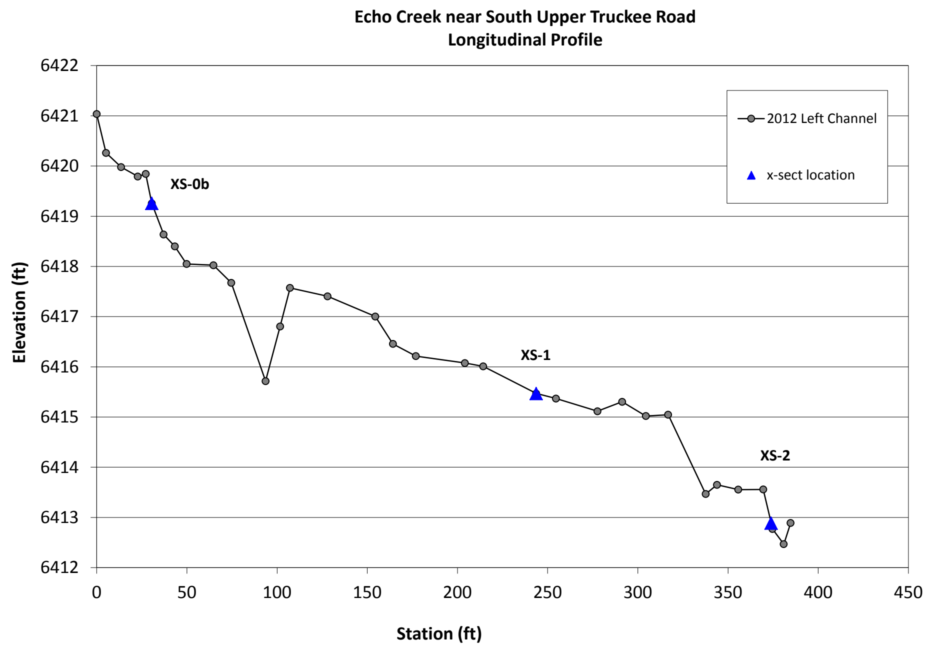


Figure 3-28. Lower Echo Creek left channel longitudinal profile survey data. Elevation is an approximation of NAVD88 based on GPS survey.

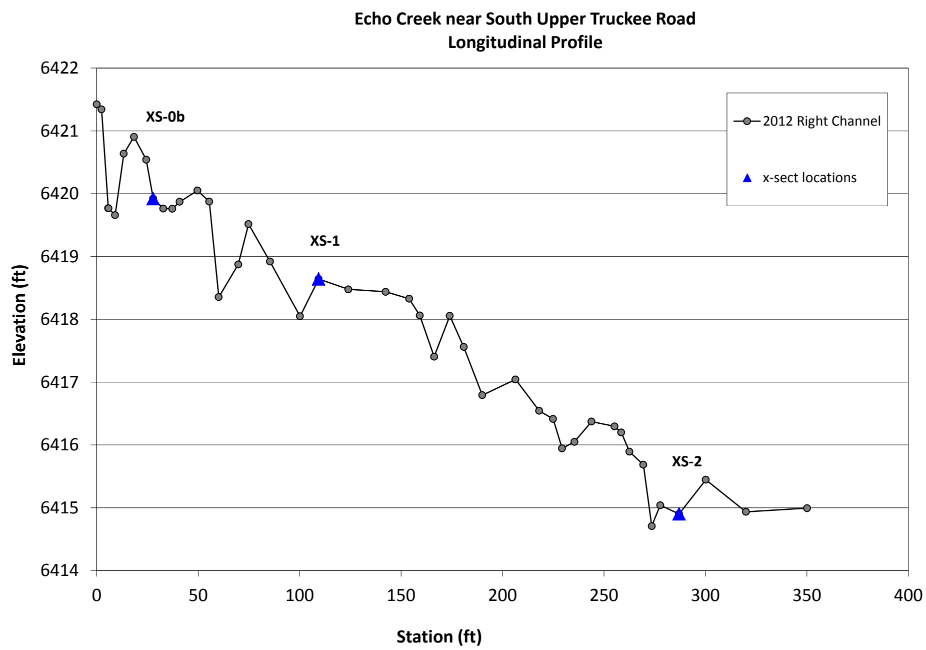


Figure 3-29. Lower Echo Creek right channel longitudinal profile survey data. Elevation is an approximation of NAVD88 based on GPS survey.

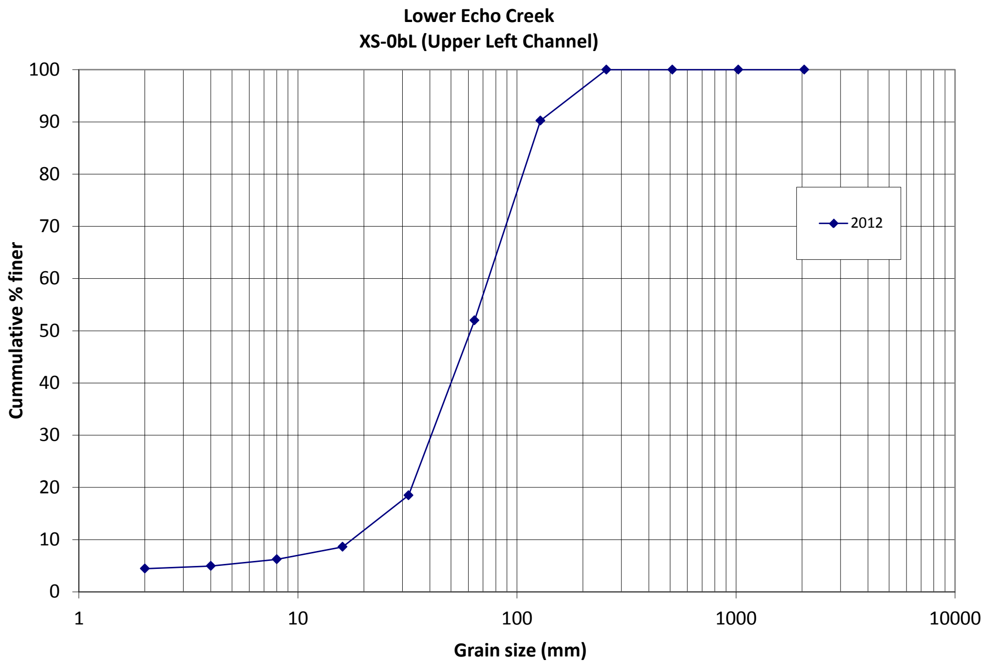


Figure 3-30. Lower Echo Creek XS-0b left channel bed particle size distribution.

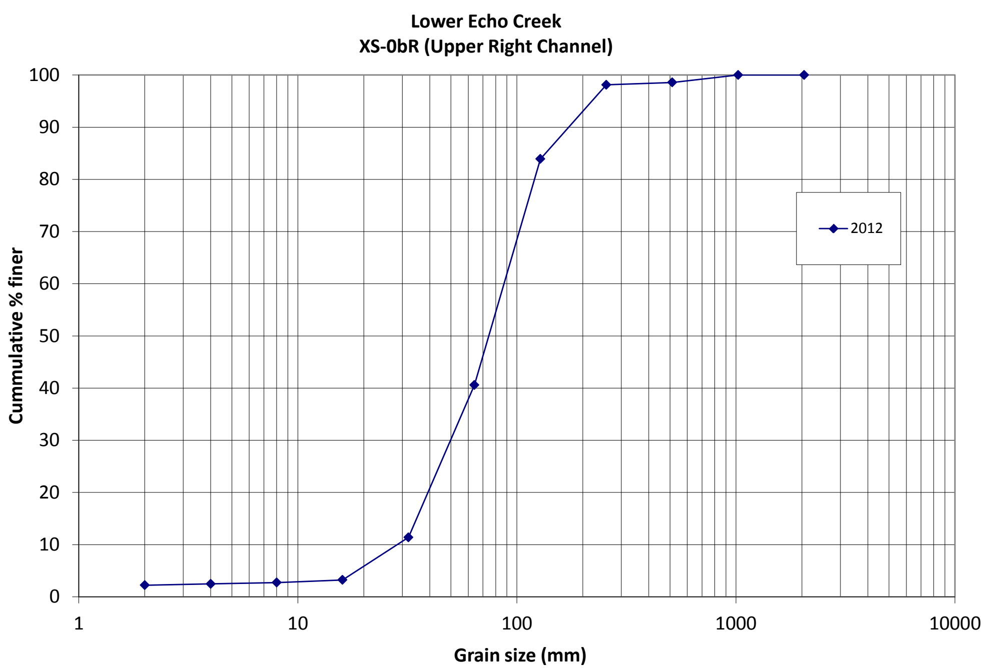


Figure 3-31. Lower Echo Creek XS-0b right channel bed particle size distribution.

Appendix A

Site Photos

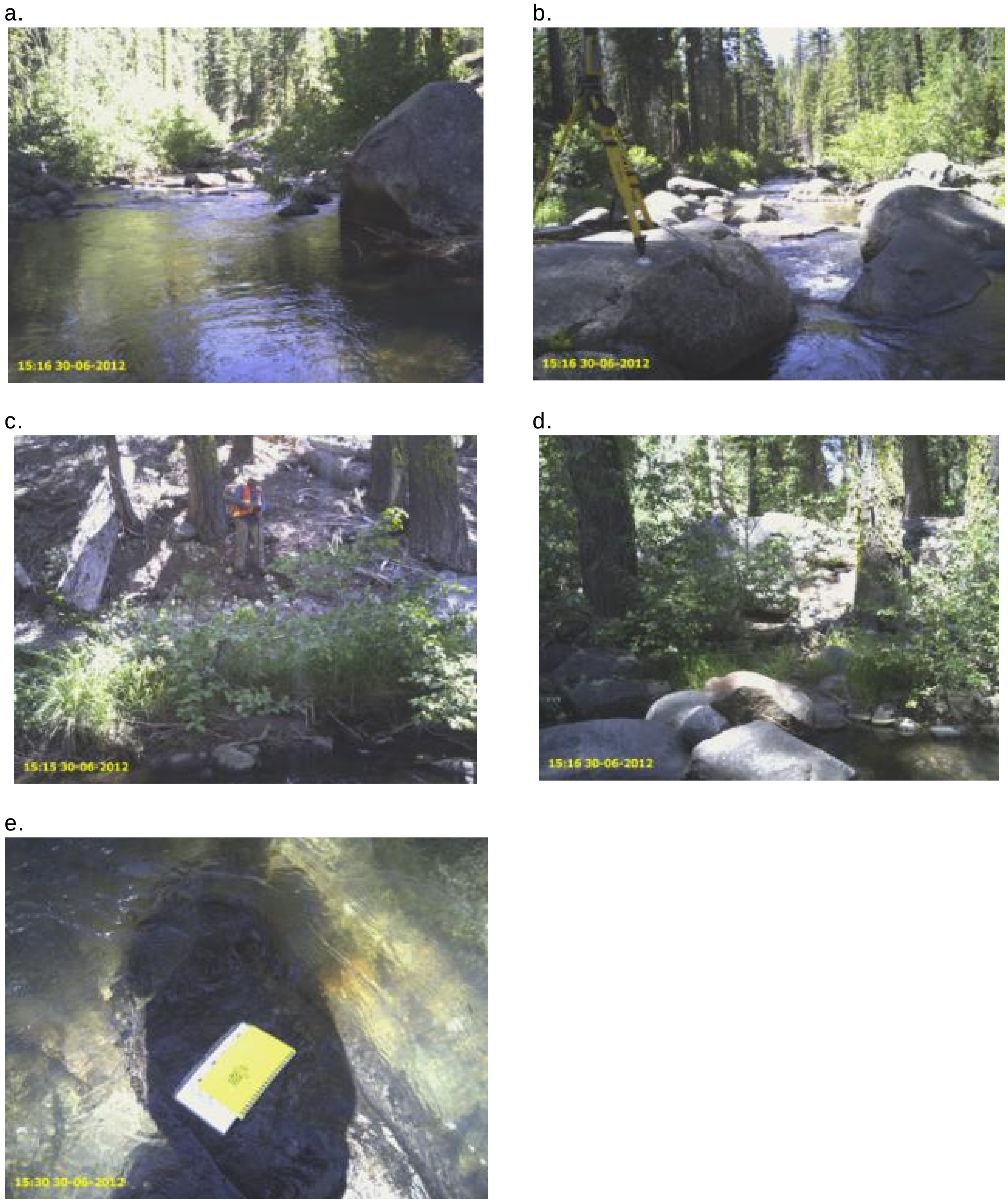


Figure A-1. Forgotten Flat, XS- 1 (Upper): (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; (e) looking at the bed.

a. b.

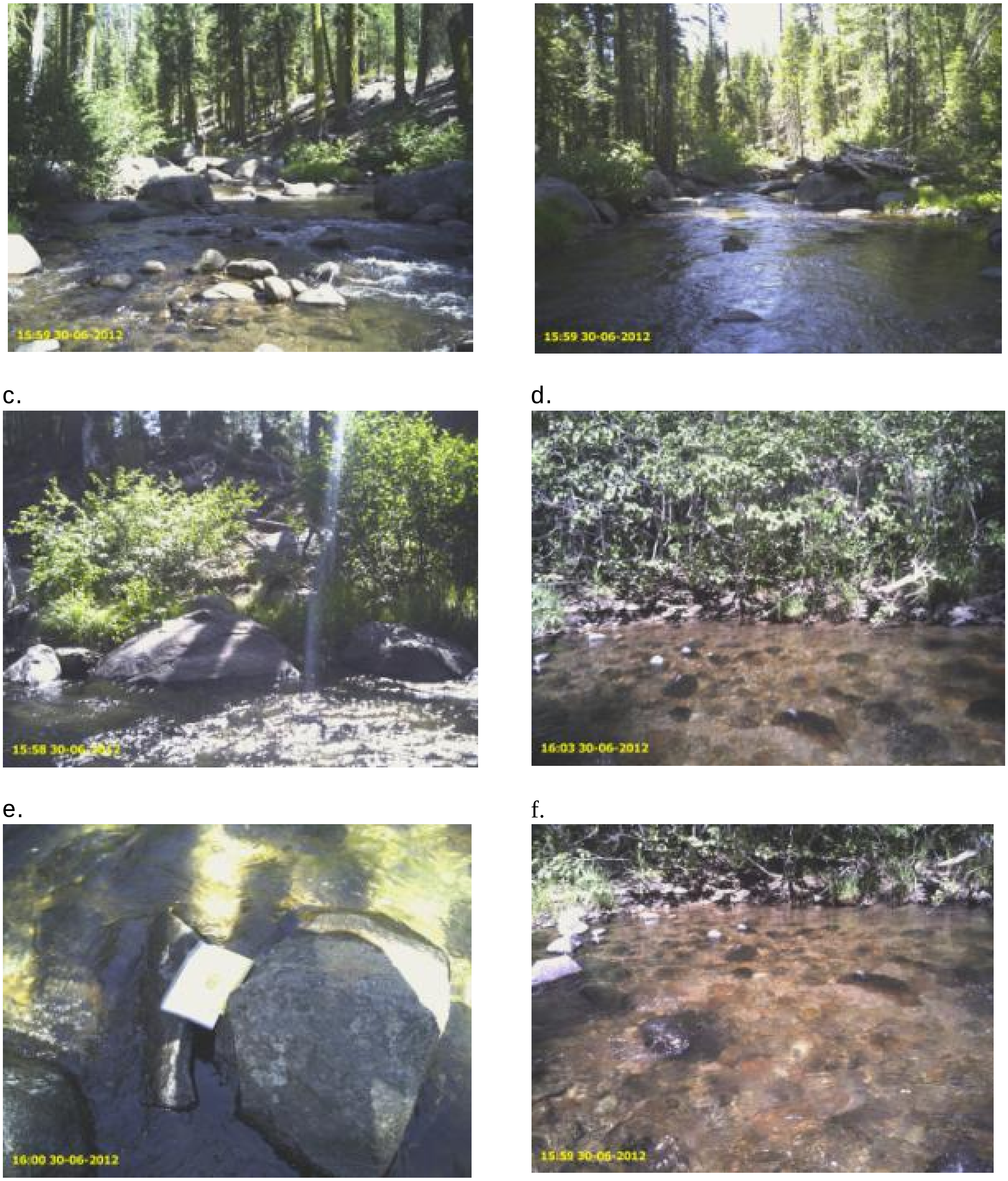


Figure A-2. Forgotten Flat, XS-2 (Mid): (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e-f) looking at the bed.

Figure A-3. Forgtten Flat, XS-3 (Lower): (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank.

a.

b.

c.

d.

e.

Figure A-4. Caples Spillway Channel, BI XS-1 (Upper): (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

a.

b.

c.

d.

e.

Figure A-5. Caples Spillway Channel, BI XS-2 (Mid): (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

Figure A-6. Caples Spillway Channel, BI XS-3 (Lower): (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

a.

b.

c.

d.

Figure A-7. Sand Flat, XS-1 (Upper): (a) looking upstream; (b) looking at the left bank; (c) looking at the right bank; and (d) looking at the bed.

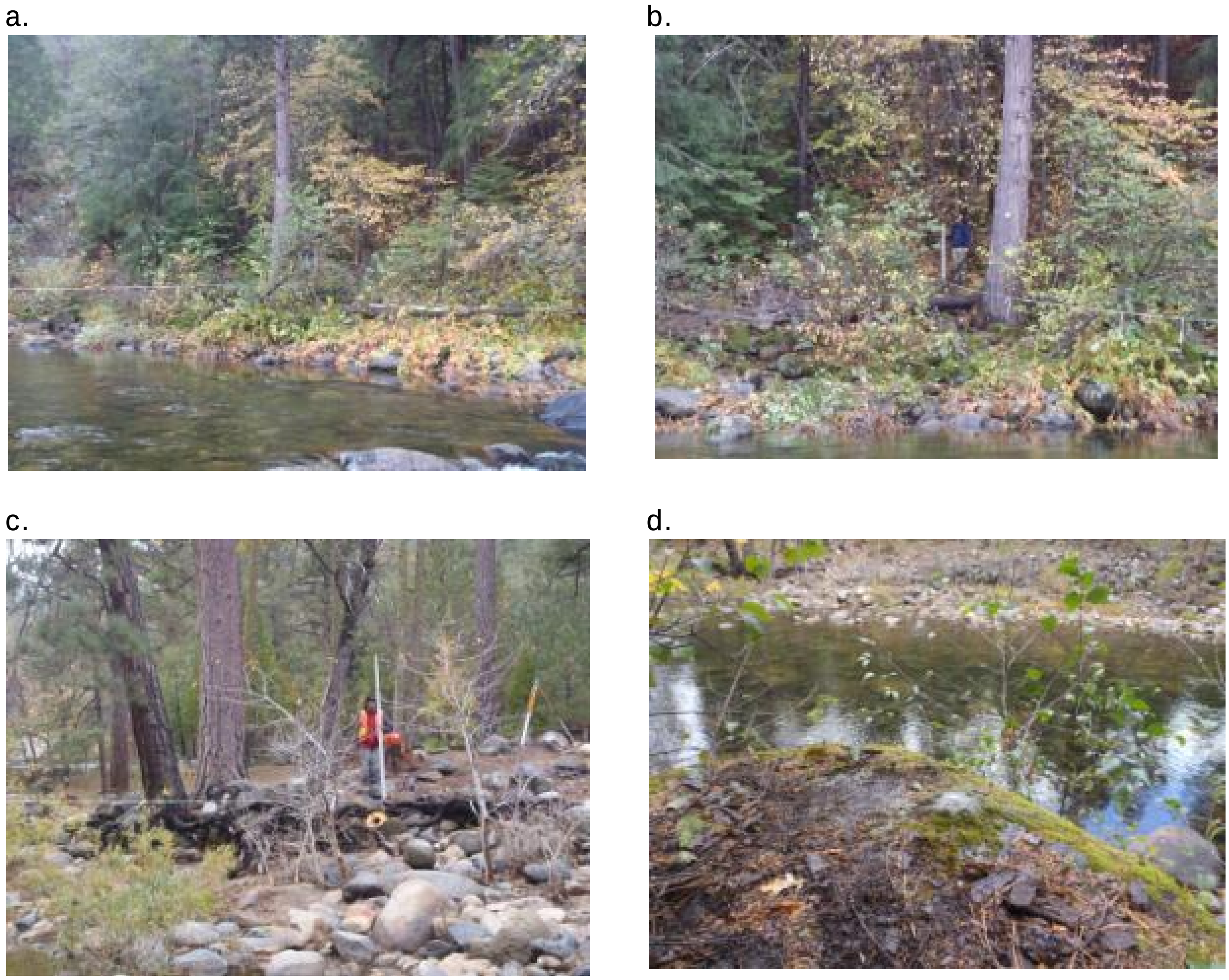


Figure A-8. Sand Flat, XS-2 (Mid): (a) looking upstream; (b) looking at the left bank; (c) looking at the right bank; and (d) looking at the bed.

a. b. c. d. e.

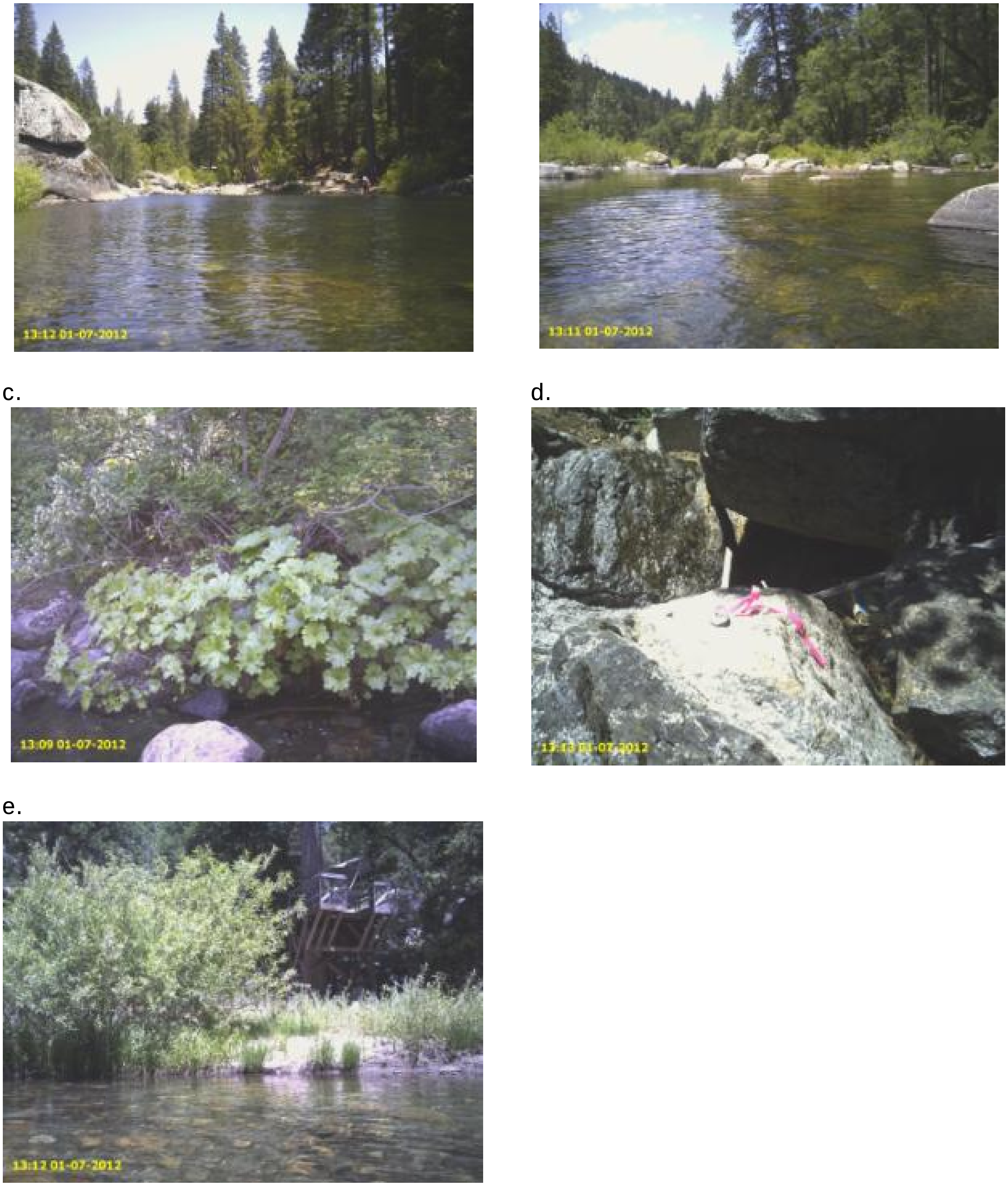


Figure A-9. Sand Flat, XS-3 (Lower): (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

a.

b.

c.

d.

e.

Figure A-10. Echo Creek, XS-0b at Left Channel: (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

Figure A-11. Echo Creek, XS-0b at Right Channel: (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank