APPENDIX J

Shanghai Rapids Field Data Collection

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Hydrology | Hydraulics | Geomorphology | Design | Field Services

TECHNICAL MEMORANDUM

Date:	October 15, 2012
To:	AECOM
From:	Chris Campbell, M.S., Ben Taber, B.S., Chris Bowles, Ph.D., P.E.
Project:	11-1009 – Lower Feather River Corridor Management Plan
Subject:	Shanghai Rapids Field Data Collection

1 INTRODUCTION

In October 2011, cbec prepared a geomorphic assessment of the Lower Feather River (cbec, 2011) indicating the Shanghai Rapids headcut could breach within 10 years. The migration analysis was a preliminary product performed without any up to date or site specific bathymetric and geologic data depicting the actual condition of the Modesto Formation[1] at Shanghai Rapids. Initial breaching evolved episodically and occurred sooner than expected in early January 2012, followed shortly thereafter by failure of a major Yuba City pressurized sewer line in late January (Moffat & Nichol, 2012). The sewer line is buried approximately 5 feet into the Modesto Formation, crosses through what was the projected failure zone, and conveys secondary treated effluent to the settling ponds on the east side of the river during low flows, and discharges it into the river during high flows through a diffuser pipe also embedded in the Modesto Formation.

As summarized in cbec's geomorphic assessment and other documents (Mussetter, 1999; James et al., 2009), the fate of Shanghai Rapids is of particular importance due to the potentially significant hydraulic and geomorphic changes that could ensue following breaching of the rapids. Shanghai Rapids is also an important regional landmark, recognized as a visual amenity and a favorite local fishing spot (RRM, 2002). Chute channel enlargement or full breaching could trigger significant upstream degradation of the river bed. Upstream channel degradation and sediment mobilization could be followed by downstream aggradation, accompanied by bank instability and possibly remobilization of mercury laden sediments (James et al., 2009). These hydraulic and geomorphic changes may result in the loss of salmonid habitat upstream, and a reduction in the frequency of inundation of natural floodplains and

[1] The Modesto Formation is a Pleistocene-age fluvial terrace deposit that is typically less than 8 feet thick and composed of gravel, sand, silt, and clay overlying 5 to 7 feet of poorly sorted gravel (DWR, 1994). The formation is generally considered stable (DWR, 2004) and can inhibit bank erosion and lateral migration (Fischer, 1994), but is moderately erodible when exposed to high shear flow conditions and can gradually erode unevenly and unpredictably.

proposed topographic modifications as part of the Lower Feather River Corridor Management Plan (LFRCMP) to enhance floodplain habitats. The fate of Shanghai Rapids is also important to the Oroville Facilities Federal Energy Regulatory Commission (FERC) relicensing due to the fish passage related flow requirements and conditions identified in the draft Biological Opinion from the National Marine Fisheries Service (NMFS). As it specifically relates to the LFRCMP, partial or full breaching of the Modesto Formation may not affect the baseline and future conditions 100- and 200-year water surface profiles (per the findings from the 1D hydraulic analysis performed by Mussetter Engineering (1999) for the Shanghai Bend levee setback more than a decade ago). However, breaching does have significant implications for the inundation regime associated with ecological flows and smaller, more frequent flood flows because the hydraulic connections to the Three Rivers Levee Improvement Authority (TRLIA) Feather River Setback floodplain and proposed LFRCMP swale complex are located upstream of Shanghai Rapids (i.e., Eliza Bend channel, and State Cut Channel).

As such, field data collection in the vicinity of Shanghai Rapids was performed to better understand the short-term and long-term effects of breaching the Modesto Formation on adult green sturgeon passage, salmonid habitat, river morphology, and proposed LFRCMP features. The data collection activities, methods, and study results are discussed in this Technical Memorandum (TM).

2 METHODS

Data collection in the vicinity of Shanghai Rapids was intended to characterize the current condition of Shanghai Rapids at low flows following the breach in January 2012. Data collection activities included topographic surveys of the exposed Modesto Formation, bathymetric surveys in the Feather River upstream and downstream of the Modesto Formation as well as within the chutes flowing through the Modesto Formation, flow and stage measurements for the purposes of hydrodynamic model calibration, and flow velocity measurements within the main chute as it relates to the swimming velocity of upmigrating adult green sturgeon. The following sections describe the data collection methods.

2.1 TOPOGRAPHY AND BATHYMETRY

The topography of the exposed Modesto Formation was collected using a Trimble Global Navigation Satellite System (GNSS) Real-Time Kinematic (RTK) Global Positioning System (GPS) receiver to provide survey grade horizontal and vertical positioning. The California Surveying Virtual Survey Network (CSVSN; www.csds.com) was used to provide real-time GPS corrections to the receiver for all RTK-GPS applications.

The bathymetry of the river was collected using a SonarMite single beam echosounder integrated with RTK-GPS. This integration was necessary to assign XYZ coordinates to the measured depths. The echosounder was starboard-mounted to a North River jet boat to provide line-of-sight with the boat driver, especially important when navigating the rapids and going over the submerged Modesto Formation.

Figure 1 shows the overall extent of the survey to include those areas surveyed on foot versus by boat as well as limited locations where 2008 Light Detection and Ranging (LiDAR) data (DWR, 2011) was used to fill data gaps. The larger data gaps shown in Figure 1 were locations where data collection was not possible due to highly turbulent water (i.e., excessive air bubbles interfere with acoustic and echosounder technologies) or because they were not accessible by boat or unsafe by wading.

2.2 FLOW AND VELOCITY

Flow and velocity data were measured with a starboard-mounted Acoustic Doppler Current Profiler (ADCP) following USGS guidelines (Mueller & Wagner, 2009). A Teledyne RDI RiverRay ADCP was utilized for this effort and is capable of reporting 3D velocities in automatically sized bins (10 cm minimum with higher resolution/smaller bins in areas with shallower depths) for depths greater than 0.3 meters. The ADCP unit includes a blanking layer at the surface of 0.2 meters below the transducer face (due to ringing effects near the transducer) and a blanking layer at the bottom equivalent to 6% of the side lobe layer plus one depth cell from the bottom for discharge calculations (due to bottom echo return contamination).

The ADCP unit was integrated with RTK-GPS to provide survey grade horizontal and vertical positioning. This integration was necessary to assign XY coordinates to the measured velocities, which is essential for hydrodynamic model calibration with velocity. It was also necessary to integrate the GPS with the ADCP in the event that the bed material was mobilized, which produces errors with the ADCP's bottom tracking routine.

The Teledyne RDI WinRiver II (version 2.08) software running on a Panasonic CF-31 Toughbook was used for ADCP setup, data collection, discharge calculations, and data post processing. Prior to the start of each day, the instrument was configured and pre-measurement field procedures were performed to include compass calibration and water temperature checks.

Per USGS guidelines, when measuring flow in steady conditions, a minimum of four survey transects is standard, two in each direction to overcome direction biases, which are then averaged together for computing flow. If the flow for any transect differs by more the 5% from the mean value, then the number of additional transects needed are dependent upon the absence/presence of a critical data quality problem. In this case, four additional transects should be surveyed and all eight averaged together for computing flow.

Figure 2 shows the location where flow measurements were collected downstream of Shanghai Rapids. This location (FR-6) was selected as it was within a uniform reach of the river and sufficiently downstream of the turbulent flow structure exiting the chute. Point velocity measurements were also collected within the main chute and immediate vicinity to characterize the flow velocities within the chute.

2.3 STAGE

For the purposes of model calibration, continuous stage data were measured with non-vented Solinst Leveloggers. The stage data were barometrically compensated and adjusted vertically based on measured water surface elevations. Figure 2 shows the locations where the loggers were installed. Logger FR-1 was installed upstream of Shanghai Rapids at the historic entrance to Eliza Bend (Old Feather River channel). Loggers FR-2 and FR-3 were installed upstream of Shanghai Rapids to characterize the water level gradient. Logger FR-4 was installed at the head of the Modesto Formation to the right of the chute entrance and away from the influence of the chute entrance. Logger FR-5 was installed on the tail end of the Modesto Formation near the chute exit. Logger FR-6 was co-located where flow measurements were taken.

2.4 SURVEY CONTROL

All RTK-GPS elevation data was corrected by occupying National Geodetic Survey (NGS) control at the start and stop of each day. Table 1 and Figure 3 show the NGS control that was occupied on any given day, which typically coincided with proximity to a boat ramp.

Table 1. NGS survey control

PID	Name	Easting[1]	Northing[1]	Elevation[2]
DH6498	OSWALD	6662988.70	2151336.70	42.4
KS1971	K1435	6674279.18	2173621.18	61.82
KS2036	HPGN D CA 03 GH	6681054.89	2172515.24	62.8

Notes: [1] CA State Plane, Zone 2, NAD 83, feet, [2] NAVD 88, feet

2.5 SEDIMENT SAMPLING

Bed material was sampled at select river miles (RM) with a boat-mounted crane and Ponar dredge sampler. The bed material was sampled to verify existing bed material particle size data that is currently being used in the hydrodynamic and sediment transport model for the LFRCMP. The bed material samples were sent to Cooper Testing Laboratory (www.coopertestinglabs.com) for particle size analysis. Figure 4 shows the eight locations where samples were taken. Seven locations were on the Feather River with one location on the Yuba River and mostly co-located with older sediment sample locations (Ayres, 1997).

3 RESULTS

The following sections present the results of the data collection efforts and discuss the challenges with collecting data at Shanghai Rapids. Detailed interpretation of the data will follow later during hydrodynamic model calibration and validation.

3.1 TOPOGRAPHY AND BATHYMETRY

A majority of the survey data was collected on foot and by boat on 6/22/2012, 6/29/2012, 8/24/2012, and 9/7/2012 with a two-man survey crew. In the intervening period between 6/29/2012 and 8/24/2012, the flows in the river were generally too high, deep and swift over the Modesto Formation to safely wade, and too shallow over the Modesto Formation to collect quality single-beam data using the boat. In an attempt to safely wade portions of the Modesto Formation, we waited for flows to drop below 6,000 cfs. Even then, specific portions of the Modesto Formation, namely the head of the formation on river left, had secondary chutes in the formation that could not be waded safely.

Figure 5 shows the resulting surface model of Shanghai Rapids and vicinity based on the survey data that was collected and as augmented with limited 2008 LiDAR data (DWR, 2011), and breaklines[2] generated in AutoCAD Civil3Din data gaps as informed by field observations. There were significant data gaps in the central portion of the main chute where the pre-January 2012 falls eroded, and in the western lobes due to highly turbulent and aerated water interfering with the echosounder returns. There were also significant data gaps at the head of the formation on river left due to the secondary chutes that could not be waded safely.

Figure 6 shows a longitudinal profile of the river, generally along the thalweg, as drawn from Eliza Bend downstream through the main chute to the flow measurement location 1,400 feet downstream of the end of the Modesto Formation. Figure 5 and Figure 6 show that bed topography upstream of Shanghai Rapids generally ranges from 12 to 27 feet, which is currently controlled by the existing Modesto Formation forming Shanghai Rapids as well as the mapped and unmapped lateral outcroppings of Modesto Formation that underpin portions of the left bank and prevent a lower bed profile. Within the main chute, bed elevations range from 27 feet at the chute entrance, to 19 feet within the chute, to 22 feet at the chute exit due to the presence of submerged remnants of Modesto Formation. Adjacent to the chute, and as exposed during low flows, the intact Modesto Formation has a controlling surface elevation that ranges from 36 feet on the upstream end to 34 on the downstream end. Downstream of Shanghai Rapids, bed elevations in this historically dredged[3] section of the river (James et al., 2009) range from 7 to 19 feet to include the scour hole downstream of the chute exit.

Figure 7 shows a cross section cut across the head of the Modesto Formation to include the main chute and secondary chutes. Figure 5 and Figure 7 show that Modesto Formation on river left includes three secondary chutes in addition to the main chute. The controlling surface of the upstream face of the Modesto Formation is generally at elevation 36 feet, but as low as 34 feet on river left between the secondary chutes. During lows flows (i.e., 2,200 cfs) observed by others (Moffat & Nichol, 2012), the secondary chutes are flowing and there is evidence to suggest that the third secondary chute to the

[2] A breakline is a feature line representing a stream channel, ridge, or some other feature that is preserved within a surface model.

[3] According to James et al., (2009), a dredge channel was present in 1906 that bypassed Eliza Bend, which ultimately resulted in a river avulsion by 1909. The avulsion was subsequently followed by further channel incision and widening forming the present-day position of the river in the vicinity of Shanghai Rapids.

immediate left of the main chute has a similarly positioned knickpoint as the main chute (see Figure A-7). As shown by Figure 6, there is approximately 500 feet at elevation 21 feet between the old sewer pipe crossing and the first lateral outcrop of Modesto Formation. However, it is uncertain how fast the knickpoints will migrate upstream. The rate of upstream migration is dependent on the presence or lack thereof of Modesto Formation between the chute entrance and the first lateral outcrop underlying the mapped bed surface.

3.2 FLOW

Flow measurements were collected on 6/22/2012 and 6/29/2012, coinciding with the primary topographic and bathymetric data collection efforts. While the second flow measurement was not included in the scope of work, in the interest of model calibration and validation and in consideration of the flow range for proposed activation of Old Feather River channel at Eliza Bend, cbec also measured flow on 6/29/2012. A total of eight flow transects were collected on 6/22/2012 and averaged since one of the first four transects varied by more than 5% of the mean value of the first four transects (i.e., 5.4%). A total of four transects were collected on 6/29/2012 whereby the difference from the mean was less than 2%.

Figure 8 shows the time when the flow measurements were made in relation to the real-time monitored flows reported by DWR on the California Data Exchange Center (CDEC) website (cdec.water.ca.gov). Because the reported Feather River flows at Boyds Landing (FBL) are lower than field measured flow, the flows on the Feather River at Gridley (GRL) and the Yuba River at Marysville (MRY) were added together after accounting for approximately 12 hours of river flow travel time from Gridley to Shanghai Rapids. This figure shows that both flow measurements match very closely with GRL+MRY flows when travel time is accounted for. It should be noted that the total flow releases from Oroville below Thermalito are fairly steady, so the small pulses in flows at GRL and further downstream are likely due to other sources (e.g., agricultural drainage and diversions) and may not be fully captured in Figure 8. Hence, these unrecorded inflows and diversions from the river may explain why the 6/29/2012 flow field measurement does not align with the small pulse observed at the GRL gaging station.

Table 2. Flow summary (cfs)

6/22/2012		6/29/2012	
Transect 001	6,123	Transect 001	8,378
Transect 002	6,062	Transect 002	8,277
Transect 003	5,856	Transect 003	8,266
Transect 004	6,453	Transect 004	8,517
Transect 005	5,998		
Transect 006	5,820		
Transect 007	6,227		
Transect 008	6,026		
Average	**6,071**	**Average**	**8,360**

3.3 STAGE

Continuous stage measurements at a 5-minute intervals were collected on 6/22/2012 and 6/29/2012, coinciding with the two flow measurements and the primary topographic and bathymetric data collection efforts. The loggers were deployed at the start of each day prior to making flow measurements and removed at the end of each day. While the second continuous stage measurement was not included in the scope of work, in the interest of model calibration and validation and in consideration of the flow range for proposed activation of Old Feather River channel at Eliza Bend, cbec made the decision to measure continuous stage on 6/29/2012. Figure 9 shows the dates when stage measurements above and below Shanghai Rapids were collected in relation to continuous real-time monitored stage further downstream at the FBL gage.

Spot water surface elevations were collected on 6/22/2012 and 6/29/2012 at the continuous logger locations in order to calibrate the continuous stage measurements. cbec also collected water surface elevations on 7/12/2012 when the flows were approaching 9,800 cfs and on 8/24/2012 when flows were approximately 5,500 cfs and slightly lower than the 6,100 cfs flows on 6/29/2012. Field deployment and acquisition of data was relatively rapid as only spot water surface elevations were measured with an RTK-GPS, generally within the vicinity or opposite bank of the continuous logger locations. Figure 9 and Figure 10 show the time when the spot water surface elevations were measured in relation to the real-time monitored stage further downstream at FBL.

Figure 8 also shows the time when the spot water surface elevations were measured in relation to the real-time monitored GRL+MRY flows when travel time is accounted for. Because the measured flows on 6/22/2012 and 6/29/2012 match very closely to GRL+MRY, the GRL+MRY flows can be used in conjunction with the 7/12/2012 and 8/24/2012 spot water surface elevations as further model validation checks at 9,800 cfs and 5,500 cfs, especially at 9,800 cfs when proposed LFRCMP actions are intended to divert flows into Eliza Bend.

3.4 VELOCITY

Velocity measurements within the chute were collected on 6/22/2012 and 6/29/2012 with an ADCP, coinciding with the two flow measurements and with the primary topographic and bathymetric data collection efforts. There were significant data gaps in the central portion of the main chute due to highly turbulent and aerated water interfering with the ADCP returns. As such, the velocity measurements from the two days were combined and are shown by Figure 11 as depth averaged velocities. This figure shows the following:

- Entrance velocities at the top of the chute were up to 10 fps at the centerline of the chute. Figure A-1 shows the calm (but swift flowing) entrance along the centerline of the chute. To either side of the centerline, converging flows break over the Modesto Formation (perhaps onto submerged shelves), and are highly aerated.
- Main chute velocities were generally 10 to 12 fps (see Figure A-2).

- Secondary chute velocities were up to 10 fps before rejoining the main chute (see Figure A-3 and Figure A-5).
- Main chute velocities downstream of where the secondary chute joins the main chute, and in the vicinity of the standing waves (see Figure A-4), were up to 16 fps.
- Downstream of the standing waves, and where the flows expand in the main chute, core velocities ranged from 8 to 14 fps. Velocities outside of the core ranged from 2 to 8 fps.
- Exit velocities were up to 10 fps as flows reconverged due to the constriction created by the exposed knob and submerged formation (see Figure A-6).

3.5 SEDIMENT

Eight bed material samples on the Feather River and Yuba River were collected on 6/29/2012 and compared to the older data set (Ayres, 1997) that is currently being used in the sediment transport model to understand if the bed material size and gradation has changed over the last 15 years. Figure 4 shows the location of the sediment samples. Table 3 is a summary of the particle size distribution and generally shows that the particle size information is consistent with the older data set (i.e., coarse sand on the Feather River and coarse to very coarse gravel on the Yuba River) and becomes finer in the downstream direction. The one slight deviation is at RM 24.2 where the older d_{50} is 9.78 mm (1997) and the newer d_{50} is 0.56 mm (2012). At this location downstream of Shanghai Rapids and opposite a large sand bar, cbec attempted to sample the bed material with the Ponar dredge sampler, but a vein of coarser material prevented a successful sample after multiple attempts. After repositioning, the sample brought to the surface was sand void of any gravels. It is possible in this historically dredged section of the river that gravelly bed material is overlain by sand deposits.

Table 3. Sediment summary (mm)

River	River Mile	Ayres (1997) Data			cbec Data		
		d_{16}	D_{50}	d_{84}	d_{16}	d_{50}	d_{84}
Yuba	1.4	0.74	12.82	38.97	1.40	17.10	48.93
Feather	8.4	0.27	0.39	0.54	0.35	0.46	0.60
Feather	13.1	0.35	0.48	0.7	0.35	0.50	1.14
Feather	19	0.34	0.59	3.3	0.32	0.42	1.15
Feather	24.2	0.6	9.78	20.64	0.40	0.56	1.50
Feather	25.6	0.41	0.6	8.31	0.40	0.58	1.65
Feather	26.6	0.51	0.86	1.82			
Feather	27				0.38	0.57	1.60
Feather	30	0.37	0.68	1.06	0.45	0.98	1.76

Notes: see Appendix B for Cooper Testing Laboratory data sheets

4 SUMMARY

Data collection in the vicinity of Shanghai Rapids was performed between 6/22/2012 and 9/7/2012 with the intent to characterize the current condition of Shanghai Rapids at low flows following the breach in January 2012. Data collection activities included topographic surveys of the exposed Modesto Formation, bathymetric surveys in the Feather River upstream and downstream of the Modesto Formation as well as within the chute flowing through the Modesto Formation, flow and stage data measurements for the purposes of hydrodynamic model calibration, and flow velocity measurements within the chute. The length of data collection was longer than anticipated primarily due to high flow releases from Oroville Dam that occurred in July and August, which limited the field crew's ability to safely conduct survey activities over the submerged Modesto Formation.

Overall, data collection efforts were successful and the following is a brief summary of those efforts:

- **Topographic and bathymetric surveys** were performed on 6/22/2012, 6/29/2012, 8/24/2012, and 9/7/2012 with a two-man survey crew using RTK-GPS and a single beam echosounder. Significant data gaps included the central portion of the main chute where the pre-January 2012 falls eroded, which formed significant standing waves and highly turbulent conditions. Other data gaps included the head of the formation on river left due to the secondary chutes that could not be waded safely. To fill these data gaps, very low river flows (i.e., less than 2,500 cfs) would be needed to reduce turbulent conditions and safely wade, which typically occur in the winter and early spring. In lieu of these flow conditions, breaklines were generated in AutoCAD Civil3D based on field observations. Bed elevations upstream of Shanghai Rapids are controlled by the Modesto Formation forming Shanghai Rapids, as well as the mapped and unmapped lateral outcroppings of Modesto Formation that underpin portions of the left bank. The intact Modesto Formation has a hydraulically controlling surface elevation that ranges from 34 to 36 feet. However, the main chute and secondary chutes that bisect the head of the Modesto Formation on river left have similarly positioned knickpoints that will continue to migrate upstream. It is uncertain how fast the knickpoints will migrate upstream. The rate of upstream migration is dependent on the presence or lack thereof of Modesto Formation between the chute entrance and the first lateral outcrop of Modesto Formation underlying the mapped bed surface. This could be as short as 50 feet or as long as 500 feet accompanied by at least 5 feet of bed incision.
- **Flow measurements** were collected downstream of Shanghai Rapids on 6/22/2012 and 6/29/2012 per USGS guidelines within a uniform reach of the river sufficiently downstream of the turbulent flow structure exiting the chute. The measured flows of 6,071 cfs and 8,360 cfs were very similar to the real-time flow published by DWR on the CDEC website when the flows on the Feather River at Gridley (GRL) and the Yuba River at Marysville (MRY) were added together after accounting for approximately 12 hours of travel time from Gridley to Shanghai Rapids. Therefore the GRL and MRY flows could be used to support model validation on days when only stage measurements were taken in the river. The Feather River flows downstream of Shanghai Rapids as recorded at the FBL gage underestimate the flow in the river at Shanghai Rapids and should not be used for model calibration and validation.

- **Continuous stage measurements** at six locations bounding Shanghai Rapids were collected on 6/22/2012 and 6/29/2012, coinciding with the two flow measurements. These data will be used to support hydrodynamic model calibration and validation at low flows. To calibrate the continuous stage measurements, **water surface elevations** were also collected on 6/22/2012 and 6/29/2012. cbec staff also collected water surface elevations on 7/12/2012 when the flows were approaching 9,800 cfs (i.e., 1,400 cfs greater than the highest measured flow and within the proposed flow range for activating flow into Old Feather River at Eliza Bend) and on 8/24/2012 when flows were approximately 5,500 cfs (i.e., 600 cfs lower than the lowest measured flow). Given that the measured flows were very similar to the real-time flows published by DWR, these two sets of extra water surface elevations can be used to support model validation.
- **Velocity measurements** within the chute were collected on 6/22/2012 and 6/29/2012 with an ADCP. Entrance and exit velocities were up to 10 fps, core chute velocities ranged from 10 to 14 fps, but were as high as 16 fps within the vicinity of the standing waves.
- **Bed material samples** on the Feather River and Yuba River were collected at eight locations on 6/29/2012 and compared to the older data set (Ayres, 1997) that is currently being used in the sediment transport model. The particle size distribution and mean grain size were generally consistent with the older data set and becomes finer in the downstream direction. The newer information should be used in the sediment transport model to represent the current condition.

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6 LIST OF PREPARERS

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Notes: background courtesy of NAIP 2012

Lower Feather River Corridor Management Plan

Shanghai Rapids survey extents

Project No. 11-1009	Created By: CRC	**Figure 1**

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9/26/2012

Notes: background courtesy of NAIP 2012

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Lower Feather River Corridor Management Plan

Flow and stage monitoring locations

Project No. 11-1009	Created By: CRC	**Figure 2**

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9/21/2012

Notes: background courtesy of Bing Maps

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Lower Feather River Corridor Management Plan

Survey control and boat ramp access

Project No. 11-1009	Created By: CRC	**Figure 3**

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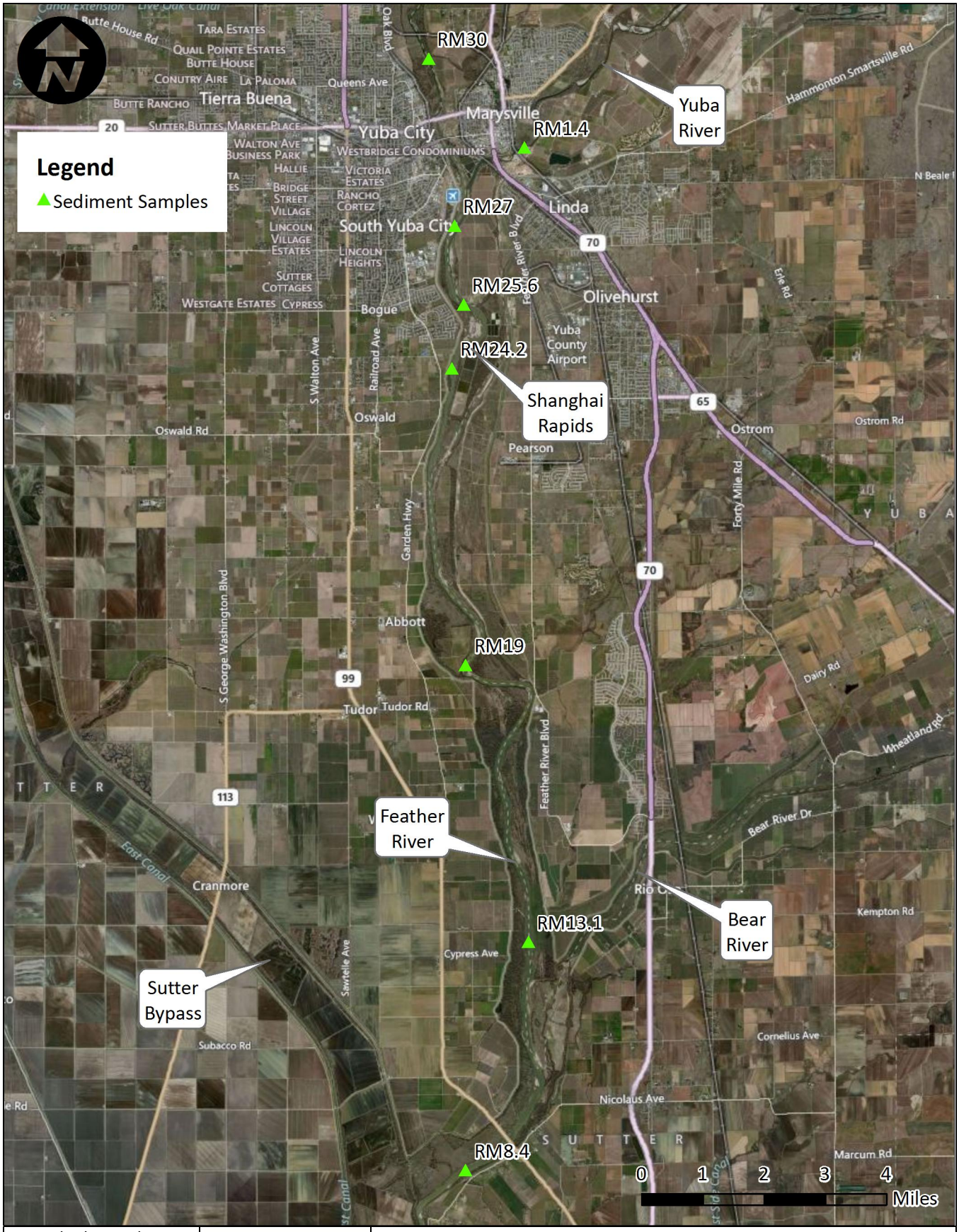
9/21/2012



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Lower Feather River Corridor Management Plan

Sediment sample locations

Project No. 11-1009	Created By: CRC	**Figure 4**

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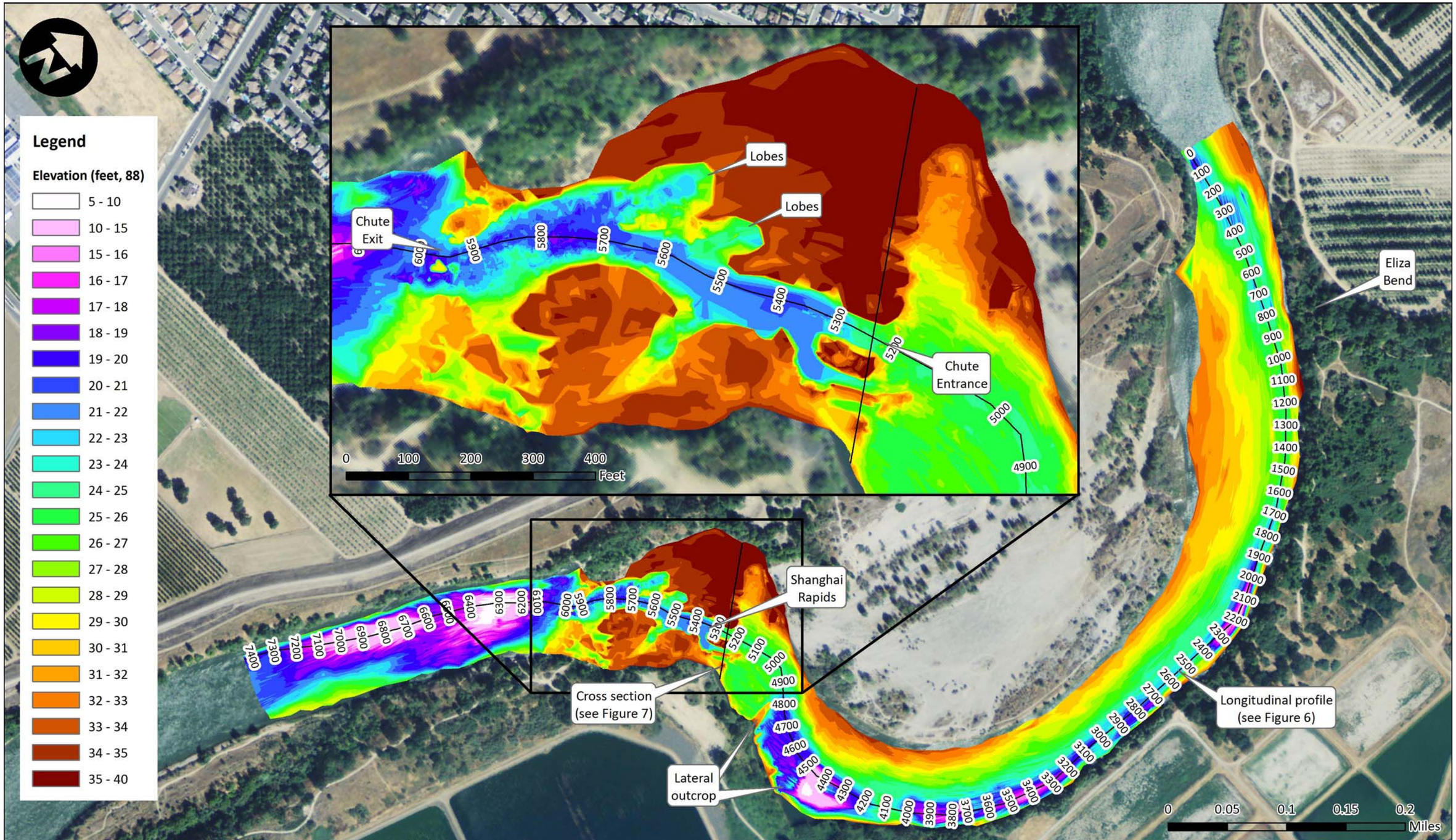
9/21/2012



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Lower Feather River Corridor Management Plan

Shanghai Rapids surface model

Project No. 11-1009	Created By: CRC	**Figure 5**

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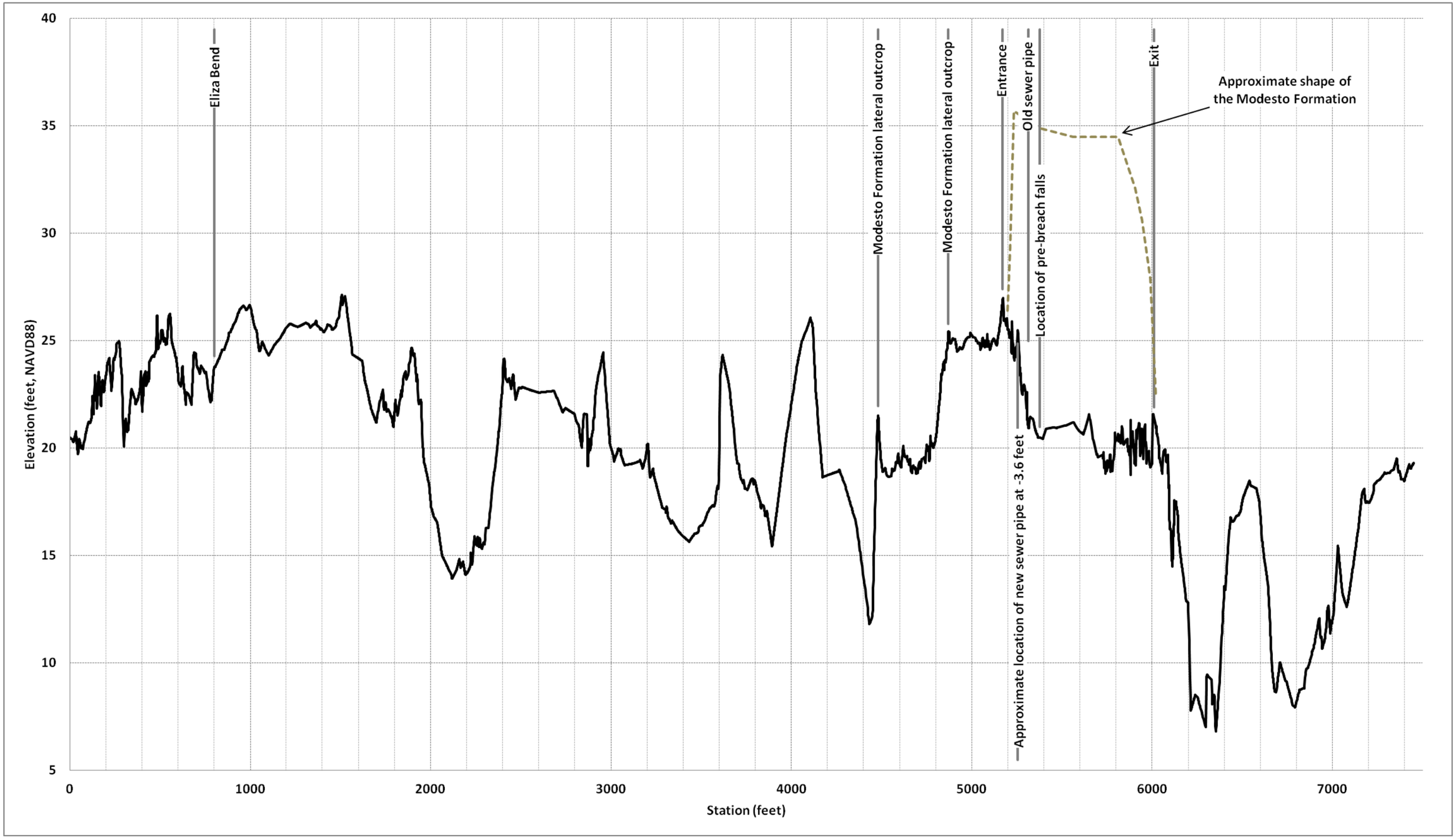
9/26/2012



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Lower Feather River Corridor Management Plan

Shanghai Rapids longitudinal bed profile

Project No. 11-1009	Created By: CRC	**Figure 6**

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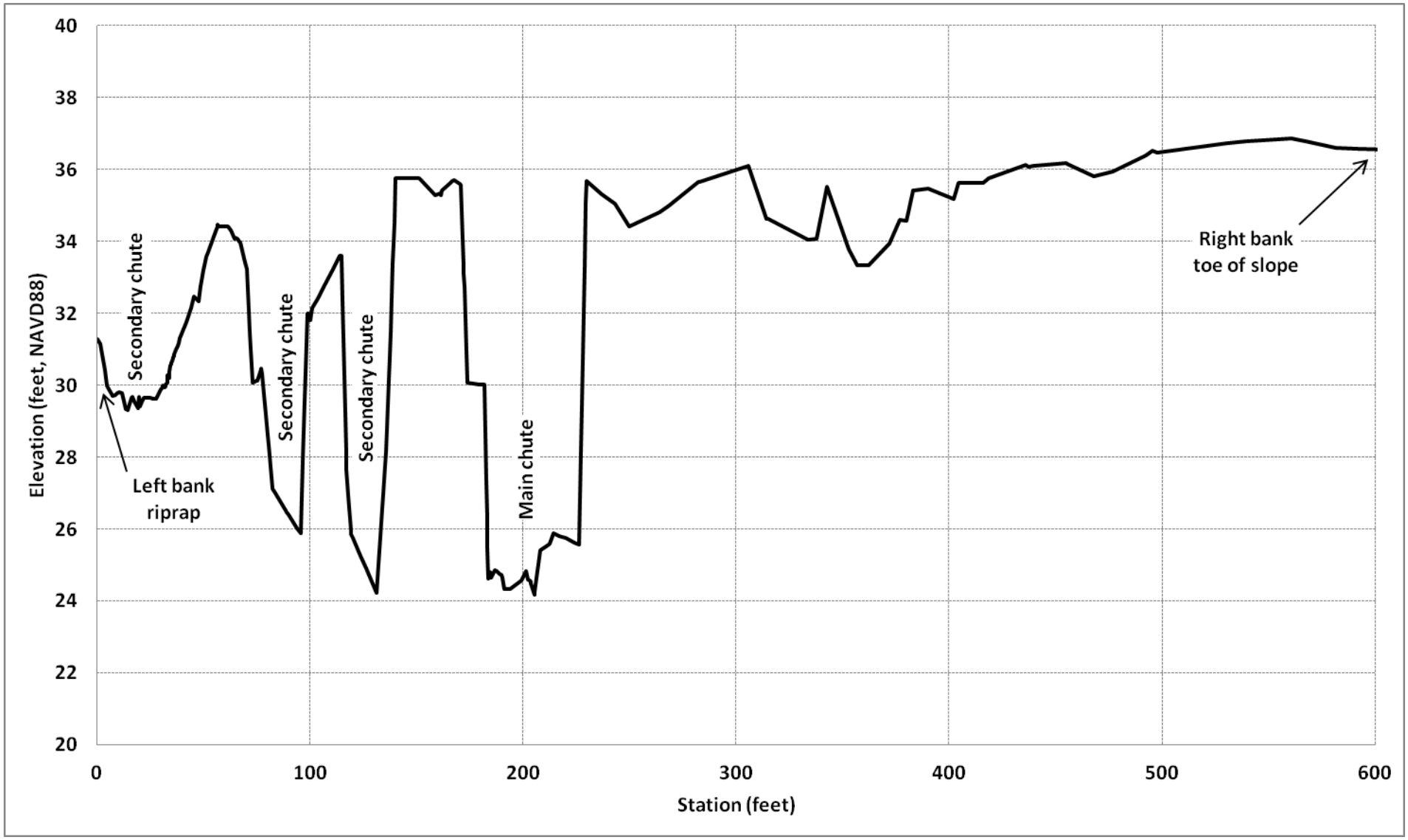
9/25/2012



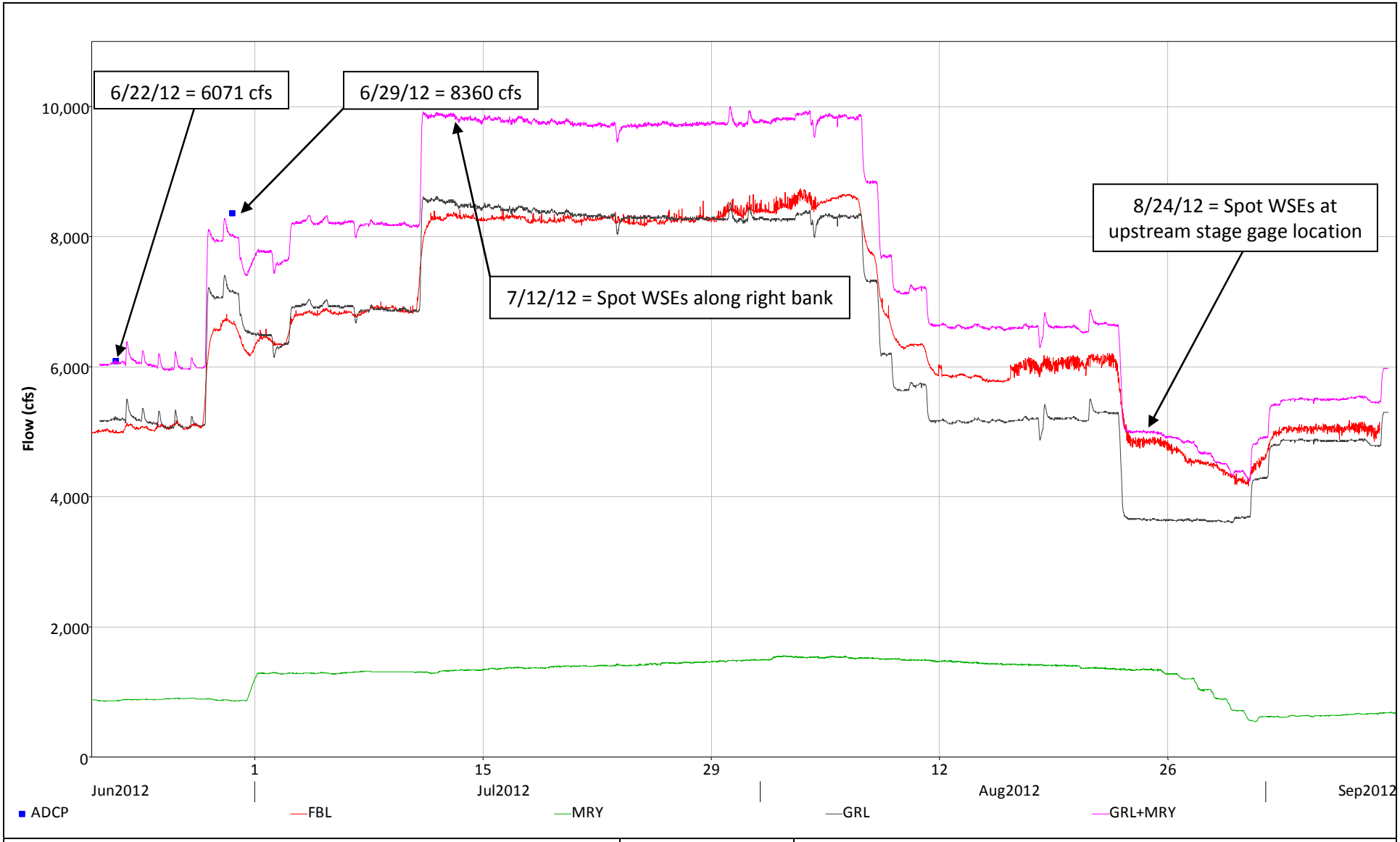
Notes:

Lower Feather River Corridor Management Plan

Cross section at head of Modesto Formation

Project No. 11-1009	Created By: CRC	**Figure 7**

R:\Projects\11-1009_Feather_R_CMP\Reporting\Shanghai\Figures\Fig7_Xsec.docx
10/15/2012



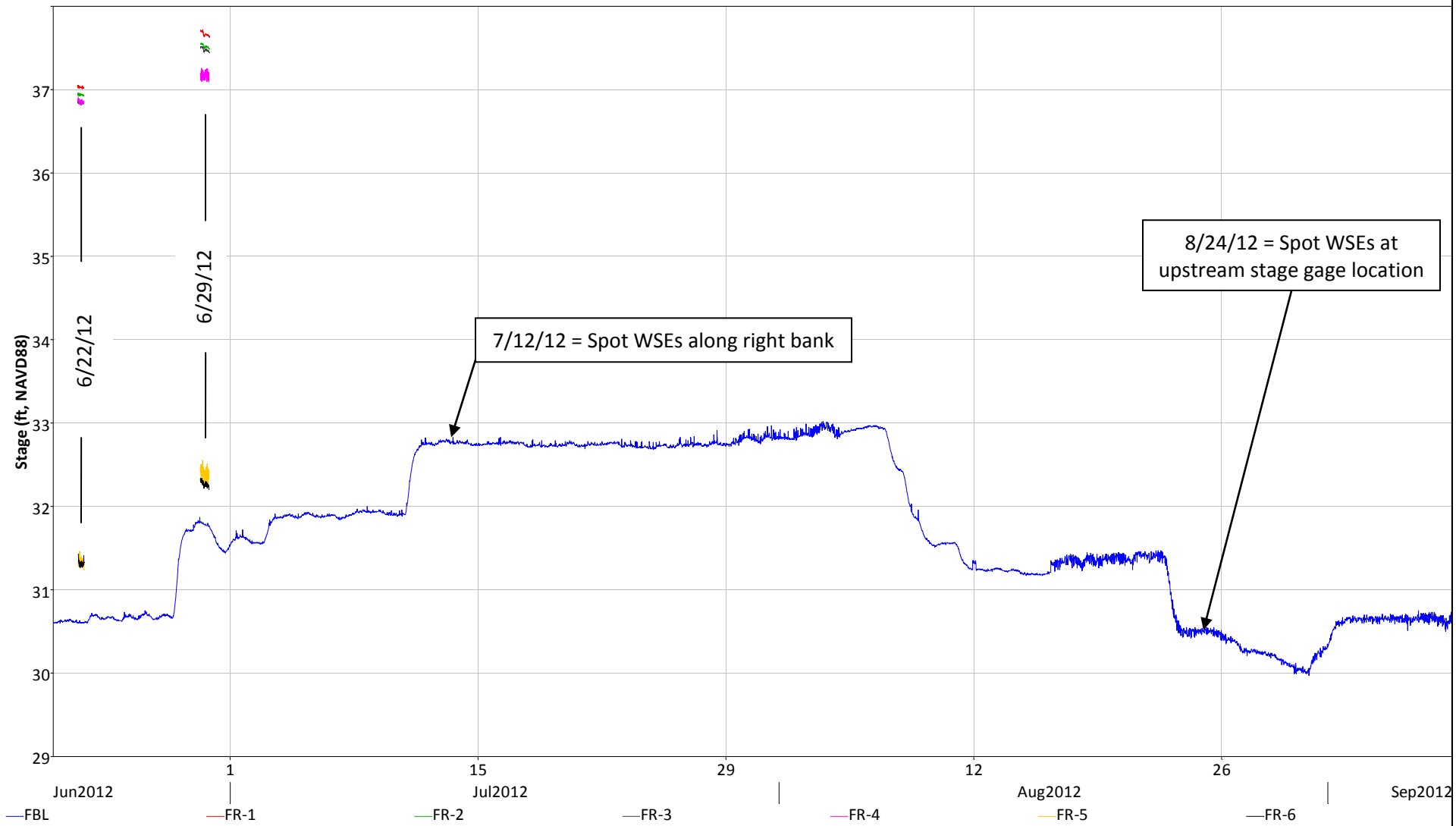
Sources: CDEC; this study
Notes: GRL = Feather River @ Gridley; MRY = Yuba River @ Marysville; FBL = Feather River @ Boyds; GRL+MRY includes 12 hr routing adjustment for GRL; ADCP refers to measured flows (this study)

Lower Feather River Corridor Management Plan

Measured Flow data

Project No. 11-1009	Created By: CRC	**Figure 8**

R:\Projects\11-1009_Feather_R_CMP\Reporting\Shanghai\Figures\Fig8_Measured_Flow_Data.docx
10/15/2012



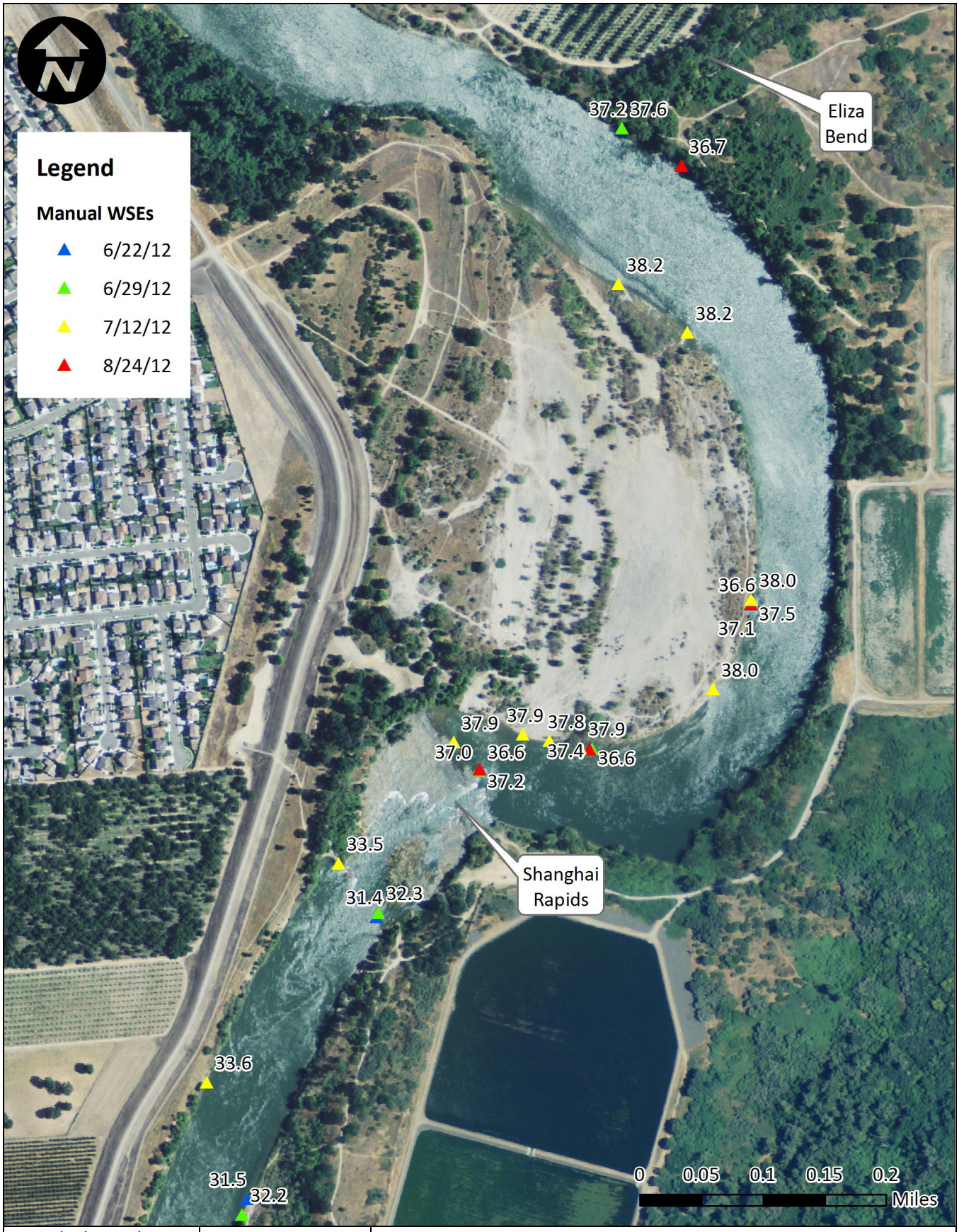
Sources: CDEC; this study
Notes: FBL = Feather River @ Boyds; FR-1 to FR-6 refer to the leveloggers (this study)

Lower Feather River Corridor Management Plan

Continuous stage data

Project No. 11-1009	Created By: CRC	**Figure 9**

R:\Projects\11-1009_Feather_R_CMP\Reporting\Shanghai\Figures\Fig9_Continuous_Stage_Data.docx
9/26/2012



Notes: background courtesy of NAIP 2012

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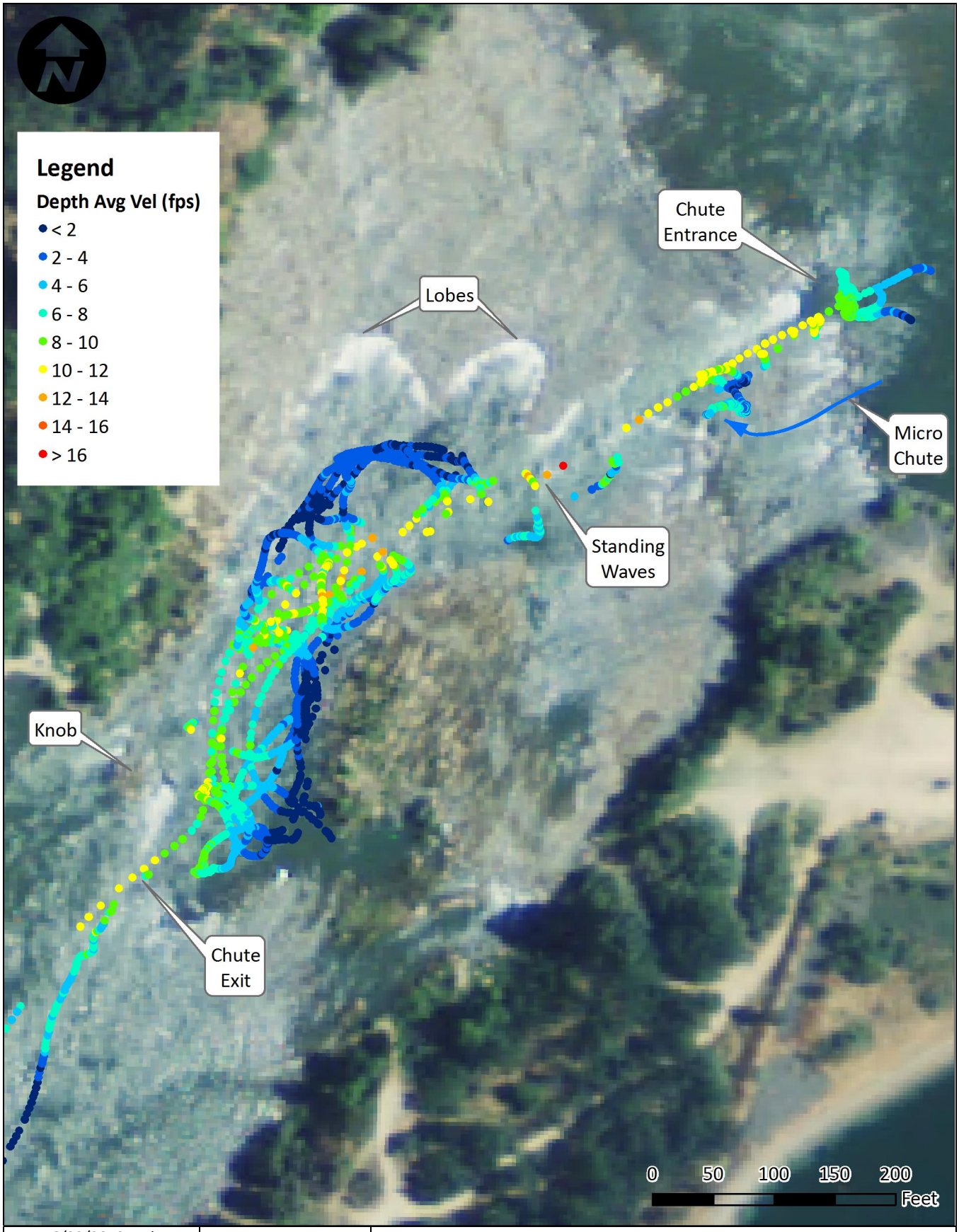
Lower Feather River Corridor Management Plan

Water surface elevations for calibration

Project No. 11-1009	Created By: CRC	**Figure 10**

R:\Projects\11-1009_Feather_R_CMP\Reporting\Shanghai\Figures\Fig10_Point_Stage.docx
9/21/2012



Data: 6/22/2012 and 6/29/2012 Notes: background courtesy of NAIP 2012	cbec eco engineering	*Lower Feather River Corridor Management Plan* **Depth average ADCP velocities**		
		Project No. 11-1009	Created By: CRC	**Figure 11**

R:\Projects\11-1009_Feather_R_CMP\Reporting\Shanghai\Figures\Fig11_Point_Velocities.docx
9/21/2012

APPENDIX A
REPRESENTATIVE SITE PHOTOS

Date: 6/22/2012
Notes: entering chute at Shanghai Rapids, looking downstream

Lower Feather River Corridor Management Plan

Shanghai Rapids chute entrance at ~6,100 cfs

Project No. 11-1009	Created By: CRC	**Figure A-1**

R:\Projects\11-1009_Feather_R_CMP\Reporting\Shanghai\AppA\FigA-1_Entrance_062212.docx
9/21/2012

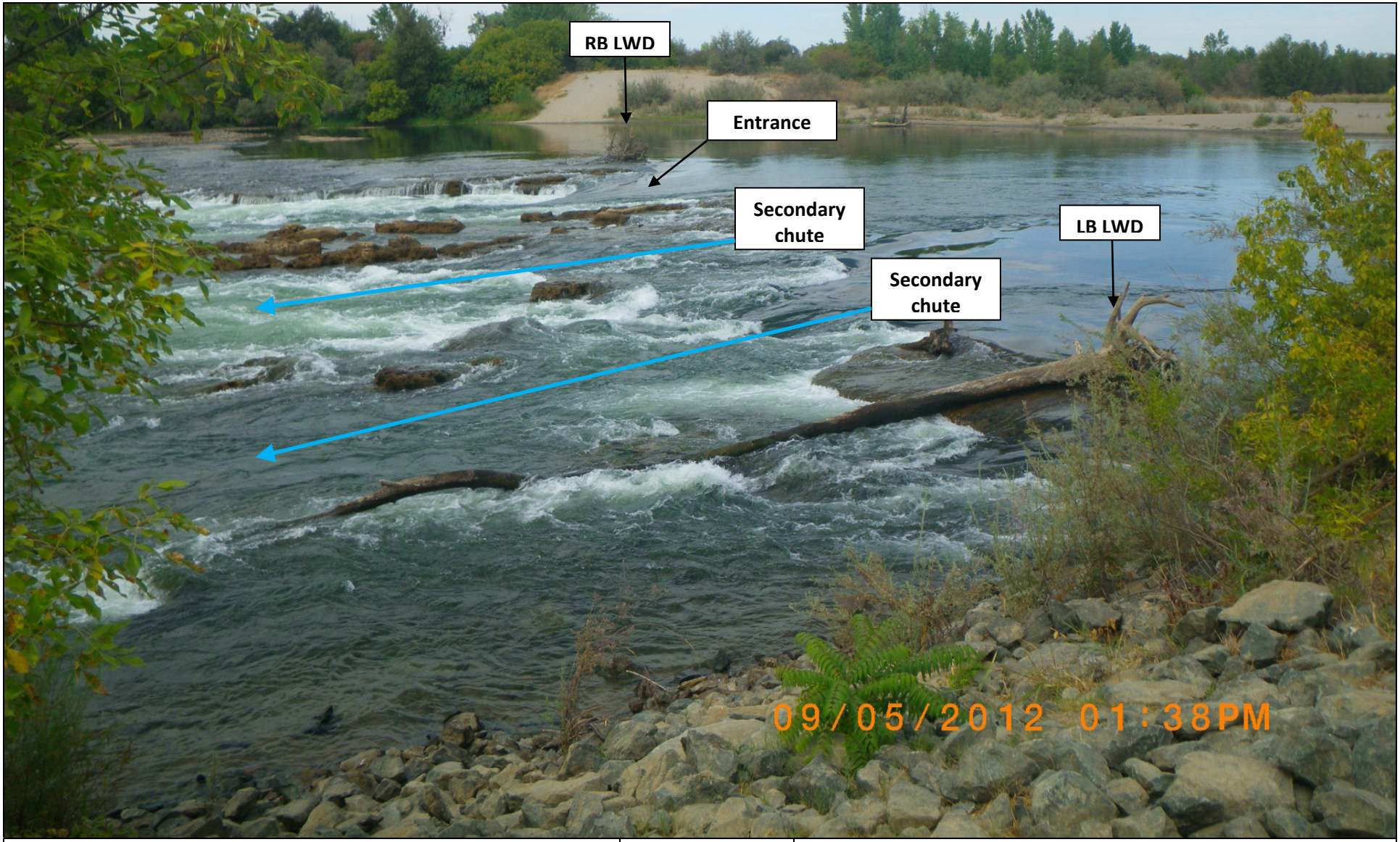
Date: 9/7/2012
Notes: left bank of chute entrance looking upstream

Lower Feather River Corridor Management Plan

Shanghai Rapids chute entrance at ~5,500 cfs

Project No. 11-1009	Created By: CRC	**Figure A-2**

R:\Projects\11-1009_Feather_R_CMP\Reporting\Shanghai\AppA\FigA-2_Entrance_Lk_Up_090712.docx
9/21/2012



Date: 9/5/2012
Notes: left bank looking to right bank across head of formation

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Lower Feather River Corridor Management Plan

Shanghai Rapids head of formation at ~5,500 cfs

Project No. 11-1009	Created By: CRC	**Figure A-3**

R:\Projects\11-1009_Feather_R_CMP\Reporting\Shanghai\AppA\FigA-3_Entrance_LB_090512.docx
10/15/2012

Date: 9/5/2012
Notes: mid-chute on left bank looking upstream at entrance

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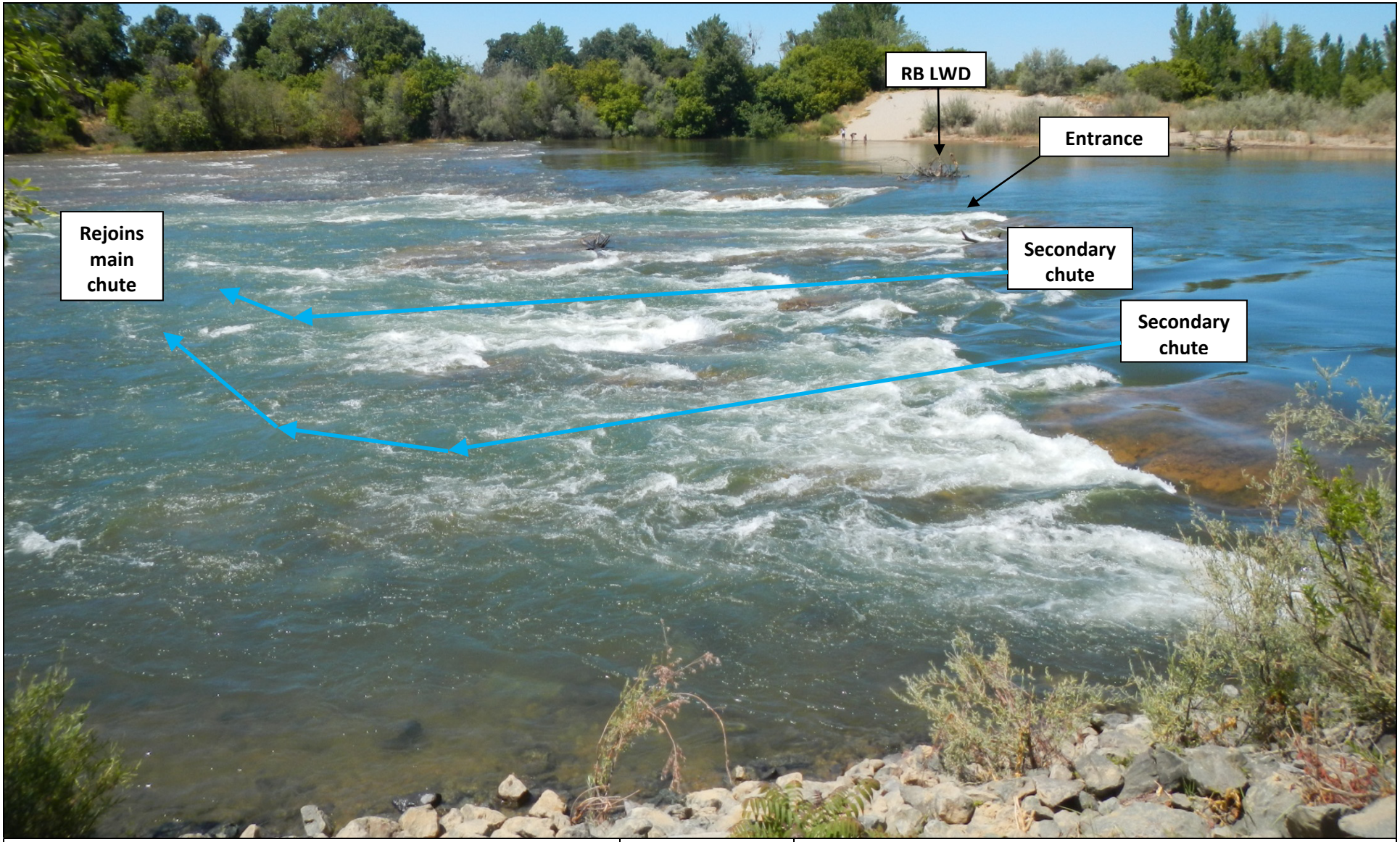
Lower Feather River Corridor Management Plan

Shanghai Rapids mid-chute ~5,500 cfs

Project No. 11-1009	Created By: CRC	**Figure A-4**

R:\Projects\11-1009_Feather_R_CMP\Reporting\Shanghai\AppA\FigA-4_Mid-Chute_Lk_Up_090512.docx
9/21/2012



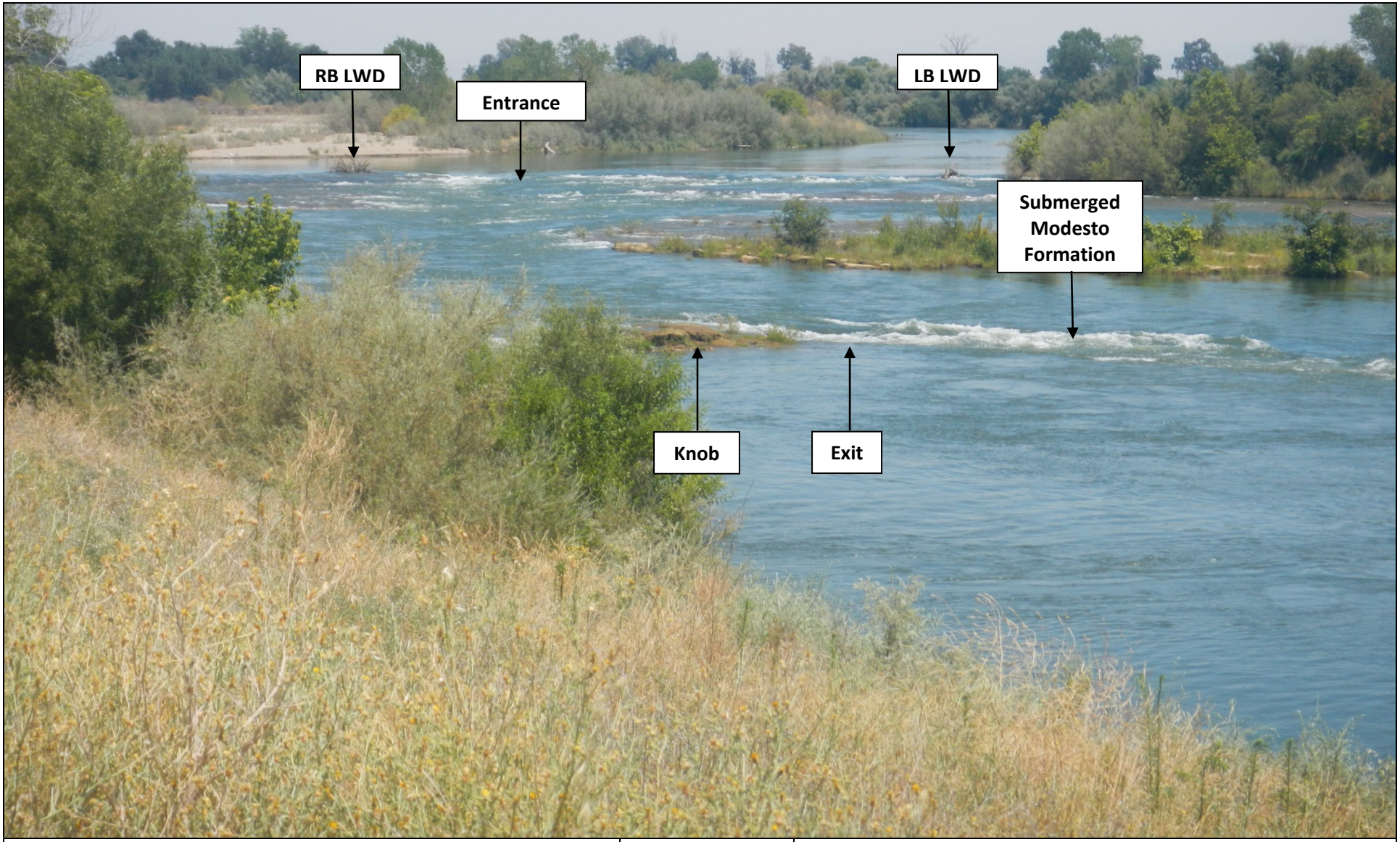
Date: 6/29/2012
Notes: left bank looking to right bank across head of formation

Lower Feather River Corridor Management Plan

Shanghai Rapids head of formation at ~8,400 cfs

Project No. 11-1009	Created By: CRC	**Figure A-5**

R:\Projects\11-1009_Feather_R_CMP\Reporting\Shanghai\AppA\FigA-5_Entrance_LB_062912.docx
10/15/2012



Date: 7/12/2012
Notes: right bank below formation looking upstream at chute entrance

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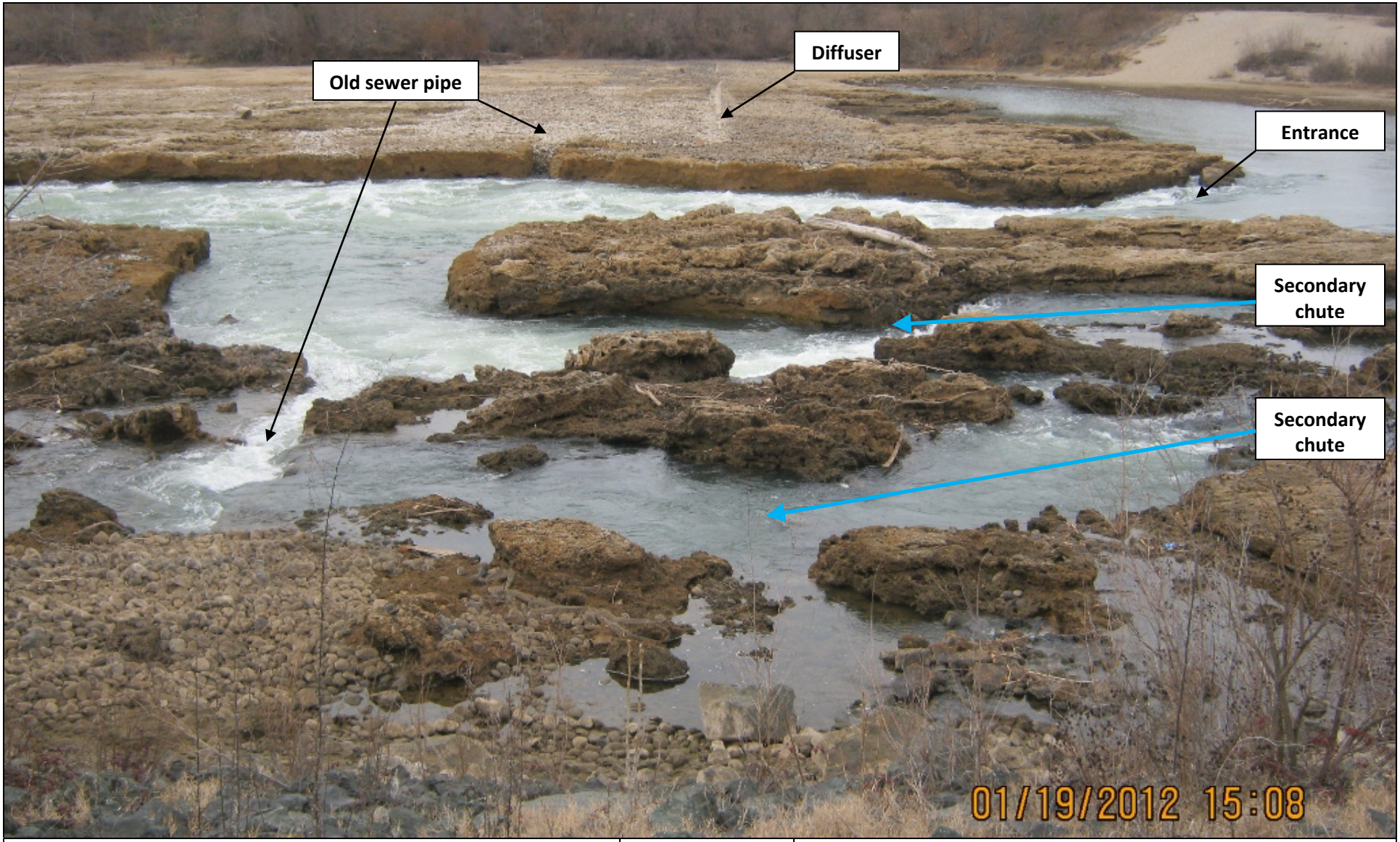
Lower Feather River Corridor Management Plan

Shanghai Rapids at ~9,800 cfs

Project No. 11-1009	Created By: CRC	**Figure A-6**

R:\Projects\11-1009_Feather_R_CMP\Reporting\Shanghai\AppA\FigA-6_Downstream_Lk_Up_071212.docx
9/21/2012



Date: 1/19/2012
Source: Moffatt & Nichol
Notes: left bank looking to right bank across head of formation; after the breach in early January 2012 and before the sewer line failure on January 30, 2012

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Lower Feather River Corridor Management Plan

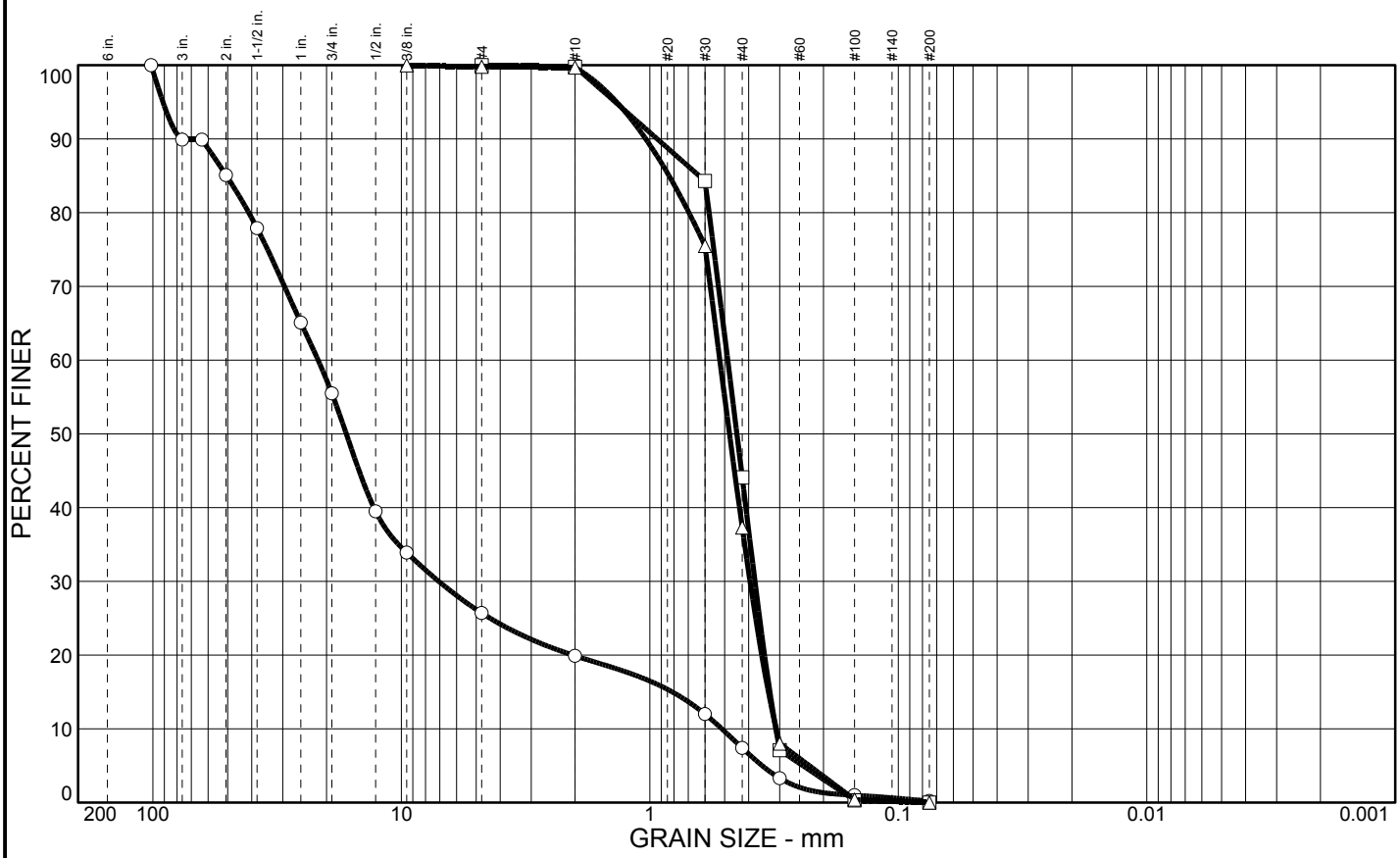
Shanghai Rapids head of formation at ~2,200 cfs

Project No. 11-1009	Created By: CRC	**Figure A-7**

R:\Projects\11-1009_Feather_R_CMP\Reporting\Shanghai\AppA\FigA-7_Low_Flows_011912.docx
10/15/2012

APPENDIX B
COOPER TESTING LABS DATASHEETS

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○	10.1	64.2	25.5	0.2					
□			100.0	0.0	0.0				
△		0.2	99.8	0.0	0.0				

SIEVE inches size	PERCENT FINER ○	□	△
4	100.0		
3	89.9		
2.5	89.9		
2	85.1		
1.5"	77.9		
1"	65.1		
3/4"	55.5		
1/2	39.5		
3/8"	33.9		100.0
	GRAIN SIZE		
D_{60}	21.6	0.486	0.523
D_{30}	7.07	0.378	0.395
D_{10}	0.513	0.311	0.310
	COEFFICIENTS		
C_c	4.50	0.94	0.96
C_u	42.15	1.56	1.69

SIEVE number size	PERCENT FINER ○	□	△
#4	25.7	100.0	99.8
#10	19.9	99.8	99.7
#30	12.0	84.3	75.5
#40	7.4	44.1	37.3
#50	3.3	7.1	8.0
#100	1.0	0.3	0.4
#200	0.2	0.0	0.0

SOIL DESCRIPTION

○ Brown Poorly Graded GRAVEL w/ Sand

□ Brown Poorly Graded SAND

△ Brown Poorly Graded SAND

REMARKS:

○ Total dry weight= 19.75lbs.

□ Total dry weight= 17.36lbs.

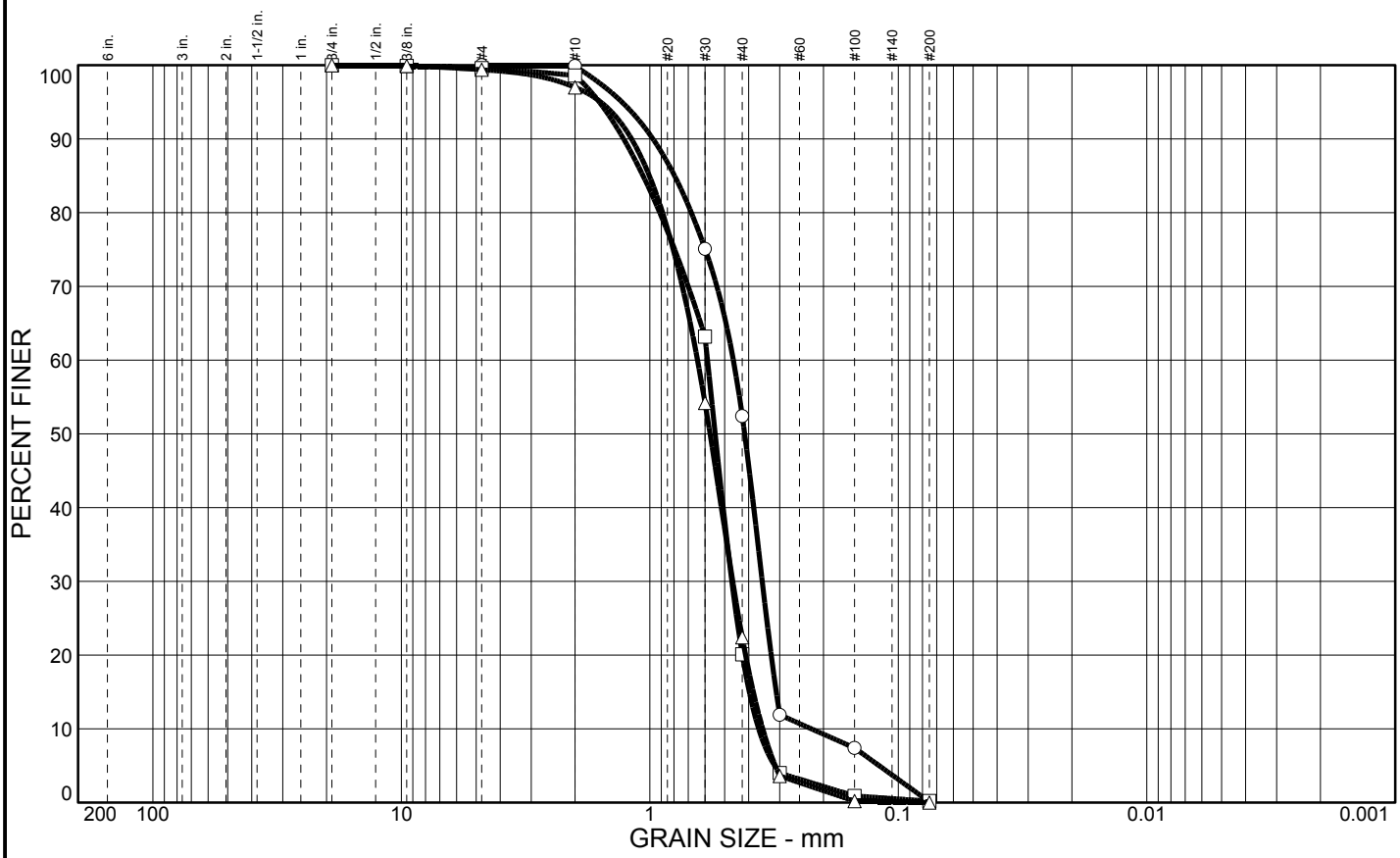
△ Total dry weight= 9.79lbs.

○ Source: RM-1.4 YUBA (BAR)
□ Source: RM-8.4
△ Source: RM-13.1

COOPER TESTING LABORATORY

Client: CBEC
Project: Feather_R_CMP - 11-1009
Project No.: 670-012
Figure

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			99.9	0.1					
□		0.4	99.4	0.2					
△		0.6	99.4	0.0	0.0				

SIEVE inches size	PERCENT FINER ○	□	△
3/4"		100.0	100.0
3/8"		99.9	99.9
GRAIN SIZE			
D_{60}	0.461	0.587	0.643
D_{30}	0.353	0.468	0.464
D_{10}	0.224	0.365	0.351
COEFFICIENTS			
C_c	1.21	1.02	0.95
C_u	2.06	1.61	1.83

SIEVE number size	PERCENT FINER ○	□	△
#4	100.0	99.6	99.4
#10	99.9	98.6	97.0
#30	75.1	63.2	54.2
#40	52.4	20.1	22.4
#50	11.9	4.0	3.6
#100	7.4	0.9	0.2
#200	0.1	0.2	0.0

SOIL DESCRIPTION

○ Brown Poorly Graded SAND

□ Brown Poorly Graded SAND

△ Brown Poorly Graded SAND

REMARKS:

○ Total dry weight= 3.84lbs.

□ Total dry weight= 7.02lbs.

△ Total dry weight= 12.46lbs.

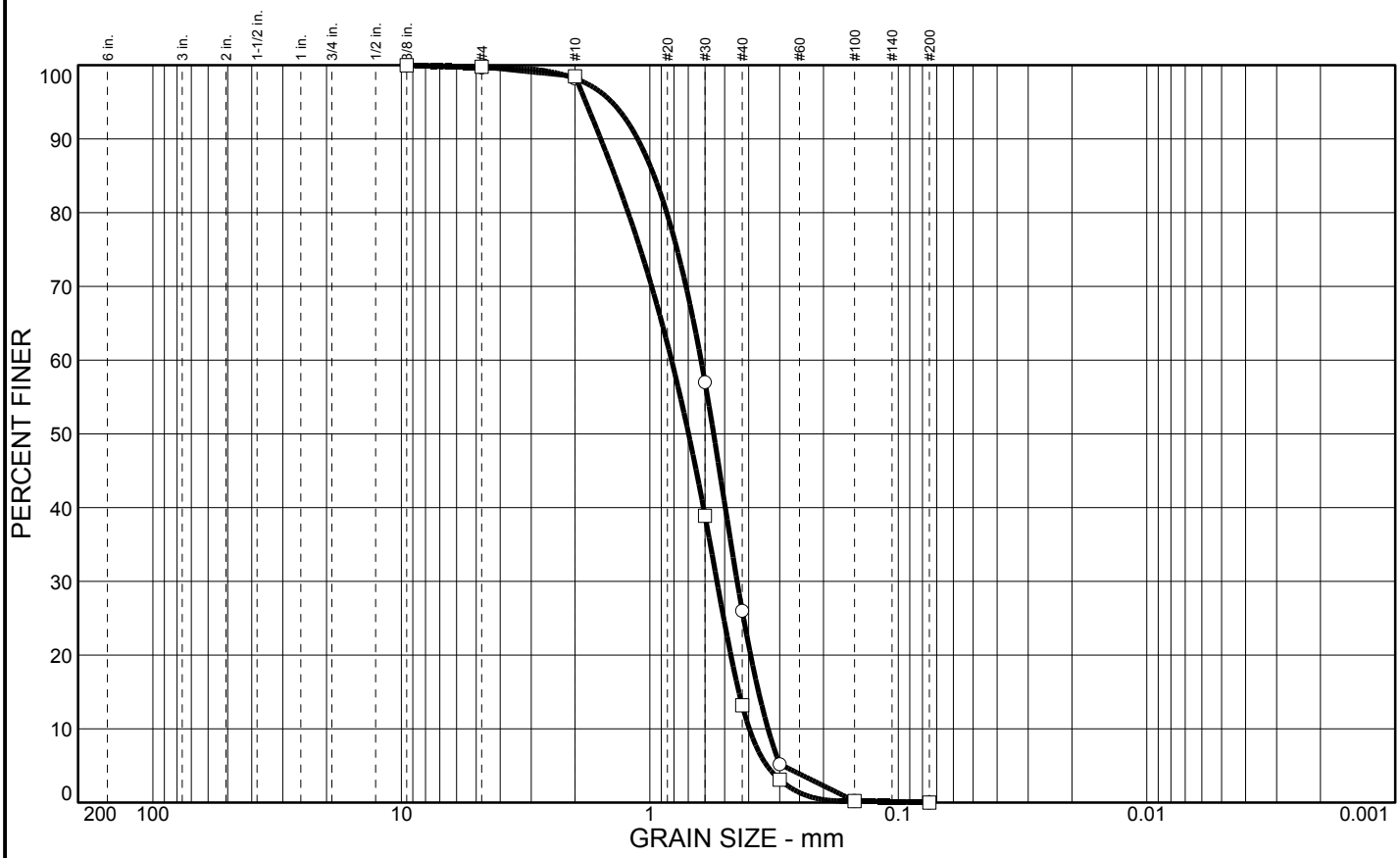
○ Source: RM-19
□ Source: RM-24.2
△ Source: RM-25.6

COOPER TESTING LABORATORY

Client: CBEC
Project: Feather_R_CMP - 11-1009
Project No.: 670-012

Figure

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		0.3	99.7	0.0	0.0				
□		0.2	99.8	0.0	0.0				

SIEVE inches size	PERCENT FINER ○	PERCENT FINER □	
3/8"	100.0	100.0	
	GRAIN SIZE		
D_{60}	0.622	0.818	
D_{30}	0.446	0.537	
D_{10}	0.335	0.398	
	COEFFICIENTS		
C_c	0.95	0.89	
C_u	1.86	2.06	

SIEVE number size	PERCENT FINER ○	PERCENT FINER □	
#4	99.7	99.8	
#10	98.2	98.5	
#30	57.0	38.9	
#40	26.0	13.2	
#50	5.2	3.1	
#100	0.2	0.2	
#200	0.0	0.0	

SOIL DESCRIPTION

○ Brown Poorly Graded SAND

□ Brown Poorly Graded SAND

REMARKS:

○ Total dry weight= 2.87lbs.

□ Total dry weight= 15.94lbs.

○ Source: RM-27

□ Source: RM-30

COOPER TESTING LABORATORY

Client: CBEC

Project: Feather_R_CMP - 11-1009

Project No.: 670-012

Figure