Bobcat Flat RM 43 Phase II As-Built Monitoring Final Report

June 24, 2013

Bobcat Flat RM 43 Phase II
As-Built Monitoring Final Report

(Including Phase I Monitoring and Analysis)

Prepared for:

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1 INTRODUCTION

Bobcat Flat is located within the Dredger Tailing Reach of the lower Tuolumne River, approximately 43 river miles (RM) upstream of the Tuolumne River confluence with the San Joaquin River, and 10 miles east of Waterford, California (Figure 1). Bobcat Flat is owned by the Friends of the Tuolumne, Inc. (FOT), a non-profit organization, and is comprised of three parcels totaling 334.09 acres adjacent to 1.6 miles of the Tuolumne River. Bobcat Flat was acquired through three land purchases between 2000 and 2010: with funding provided by CALFED, the City and County of San Francisco, and FOT privately raised funds. FOT purchased Bobcat Flat for the purpose of long-term restoration and preservation.

Restoration of Bobcat Flat is a multi-phased project initiated in 2003 to restore morphologic function and habitat for target species within the Dredger Tailing Reach of the Tuolumne River. To date, two restoration projects (Phase I and Phase II) have been designed, permitted, and constructed (Figure 2). A portion of the Phase II project was not constructed in 2011 due to limited funding (Figure 2). However, this portion of the Phase II project was designed and permitted and is ready for construction should funds become available. Phase I and Phase II construction:

1. Phase I was constructed between August 22 and September 21, 2005, funded by grants from CALFED (USFWS) to FOT and the California Department of Water Resources (DWR) to Turlock Irrigation District (TID).
2. Phase I restoration included excavating 10.5 acres of remnant dredger tailings, sorting excavated tailings, and placing approximately 11,000 yd^3 of coarse sediment from these tailings into the river channel as constructed riffles and bars.
3. Phase II was constructed between August 22 and September 30, 2011, with funding from United States Fish and Wildlife Service, Anadromous Fish Restoration Program.
4. Phase II restoration included excavating approximately 24,300 yd^3 of remnant dredger tailings, restoring 6.4 acres of floodplain, and enhancing off-channel wetlands. Excavated material was sieved and coarse sediment less than 1/4 inch and greater than 5 inches removed for use in floodplain, river, and wetland restoration. Approximately 17,500 yd^3 of coarse sediment (ranging in size between 1/4 inch and 5 inches) was placed into the mainstem channel partially filling remnant in-channel gravel pits and constructing alternating bars and riffles (Figure 2).

1.1 Background

Beginning with the Gold Rush in 1848, the Tuolumne River has been extensively modified by resource extraction (e.g., water for irrigation, gold mining, and aggregate mining) and land use practices (e.g., agriculture, ranching, and urbanization). Streamflow regulation began with construction of Wheaton Dam (1871) and La Grange Dam (1893), intensified in the 1920s with the construction of several large reservoirs in the basin, and culminated in 1971 with construction of the New Don Pedro Project, which more than tripled the storage capacity in the basin. During the early twentieth century, the Tuolumne River channel and floodplain around RM 43 were dredged for gold. The gold dredges excavated channel and floodplain alluvial deposits to the depth of bedrock (up to 25 feet) and often realigned the river channel into a chaotic series of multiple channels. After recovering the gold, the dredges deposited the remaining tailings back onto the floodplain, creating large, cobble-armored windrows that replaced the alluvial deposits and floodplain soils. By the end of the gold mining era, most of the floodplain adjacent to the project site had been converted to dredger tailings. In the 1960s, some of the tailings were excavated to provide construction material for New Don Pedro Dam. Following removal of the dredger tailings, Davis-Grunsky Act funds were used in the early 1970s to reconstruct a defined channel through the chaos of multiple channels. Unfortunately, only the reach upstream of Basso Bridge (RM 47.5) was completed, leaving Bobcat Flat severely damaged. The remaining tailings are barren, unproductive surfaces with exposed coarse sediment/cobble and little or no soil layer.

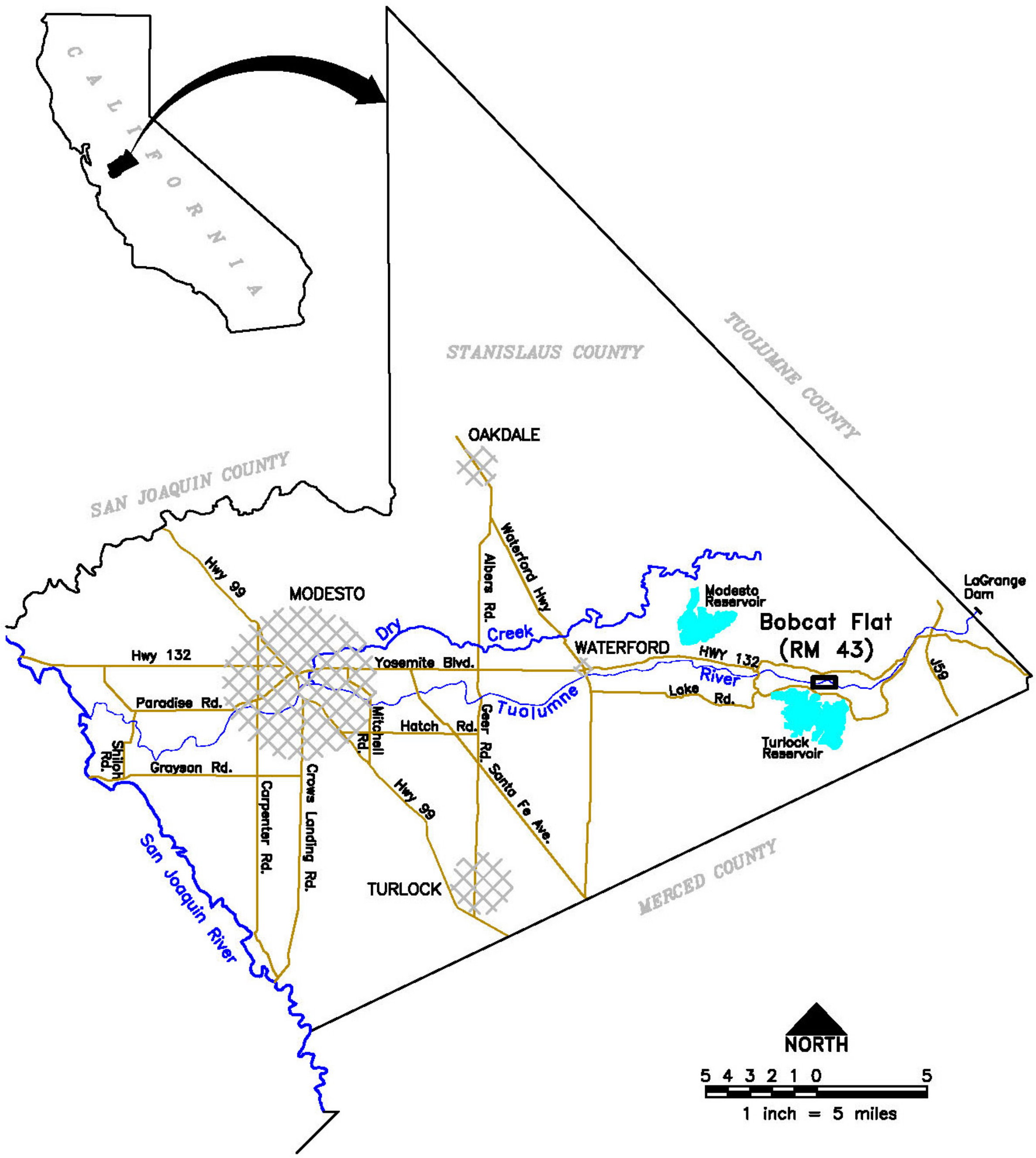

Figure 1. Bobcat Flat (RM 43) location map.

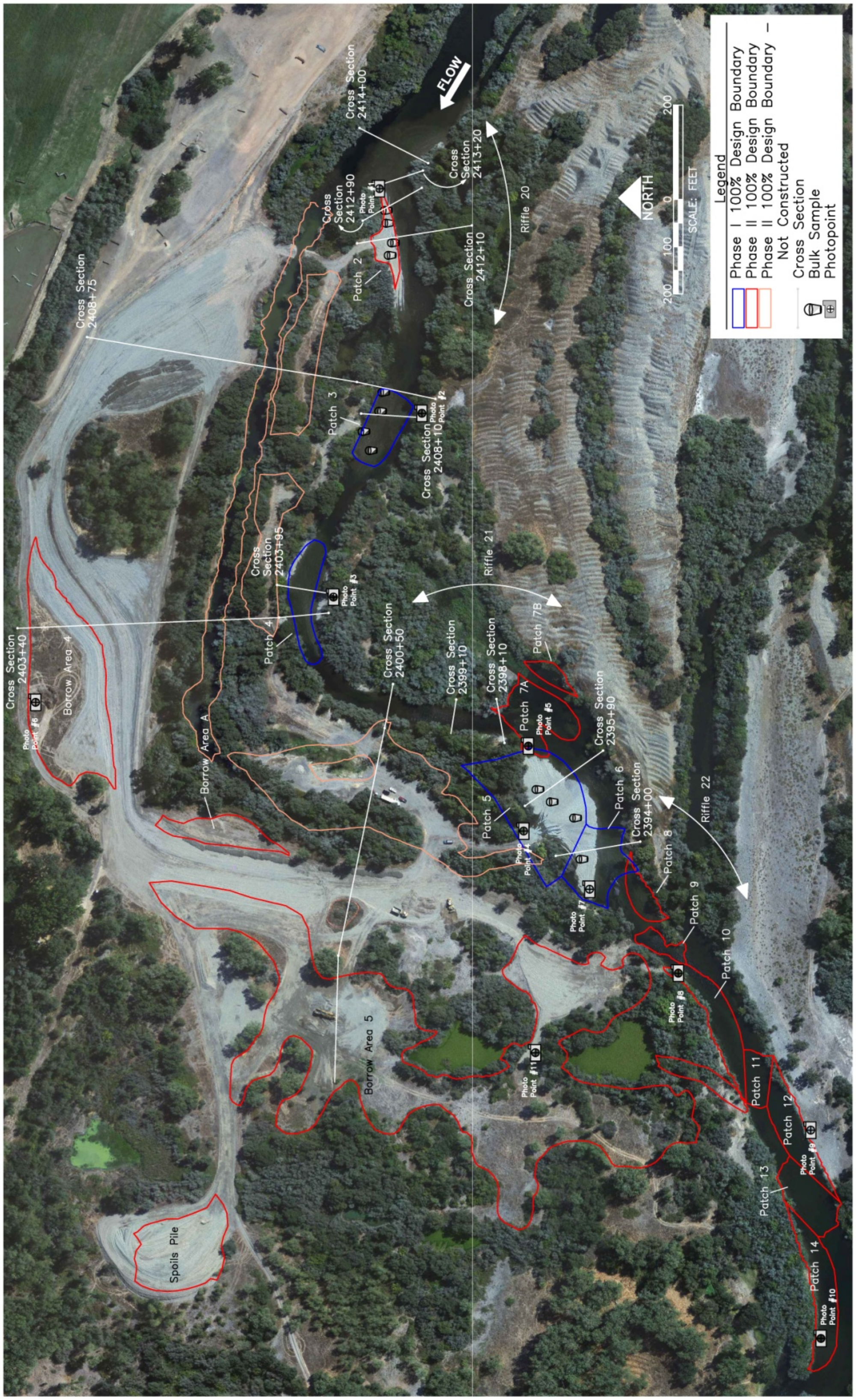

Figure 2. Bobcat Flat site map showing Phase I and Phase II construction boundaries and monitoring locations.

The Tuolumne River has also been extensively mined for aggregate. Large-scale aggregate mining began in the 1940s and continues today. Historically, aggregate mines extracted sand and gravel directly from the active river channel, creating large, in-channel pits. These in-channel pits range in depth from 8 feet to depths greater than 30 feet and can be more than 0.5 miles long (M&T 2000). One of these pits, Special Run Pool 3, is within the Bobcat Flat property boundary. This pool hosts fish species, such as largemouth and smallmouth bass, which prey on juvenile salmonids migrating to the Pacific Ocean (M&T 2000). The 1996 flood destroyed levees, gravel mining infrastructure, and mainstem connectivity, leading CALFED, AFRP, and DWR 4-Pumps project to begin funding design and restoration projects within the Gravel Mining Reach of the Tuolumne River. This funding enabled design and construction of the first two phases of Bobcat Flat restoration efforts.

Gold dredging and in-stream gravel mining converted the channel morphology from natural pool-riffle sequences to "lake-cascade" (or pool-steep riffle) morphology (Figure 3). This conversion greatly reduced low gradient riffles that provided Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*) spawning and rearing habitats and productive benthic macroinvertebrate (BMI) sources, and replaced them with high gradient riffles separated by long pools. Many of these steep riffles have slopes greater than 1% (0.01) during spawning flows (150–300 cfs), creating unsuitably high velocities. The Gravel Mining Reach now provides only a small proportion of its total spawning and rearing habitat and BMI production capacity compared to riffles upstream of Basso Bridge (Figure 4). Additionally, the lack of coarse sediment recruitment below La Grange Dam, combined with the reduction of high flows needed to mobilize sediment and help restore channel morphology, prevents recovery of the natural channel morphology. The degraded channel conditions within the Bobcat Flat Reach will not likely recover natural channel and floodplain features and habitats without mechanical intervention. Restoring a more natural distribution of slope and channel morphology throughout the entire reach greatly improved spawning and rearing habitat as shown with the Phase I construction and subsequent monitoring (M&T 2006, M&T 2008). Replenishing salmonid spawning gravel and coarse sediment supply would reduce large remnant dredger and gravel mining pools that support detrimental predators and improve salmonid rearing habitat, BMI production, and other aquatic habitats in this reach.

1.2 Bobcat Flat Construction Projects and Monitoring to Date

FOT has completed two phases of Bobcat Flat construction to date:

1. Phase I, constructed between August 22 and September 21, 2005, restored 10.5 acres of floodplain and placed 11,000 yd^3 of coarse sediment into 2,400 feet of mainstem river channel as constructed riffles and bars.
2. Phase II, constructed between August 22 and September 30, 2011, restored 6.4 acres of floodplain, converted two gravel pits into off-channel wetlands, and placed 17,500 yd^3 of coarse sediment into 2,000 feet of mainstem river channel as constructed riffles and bars.

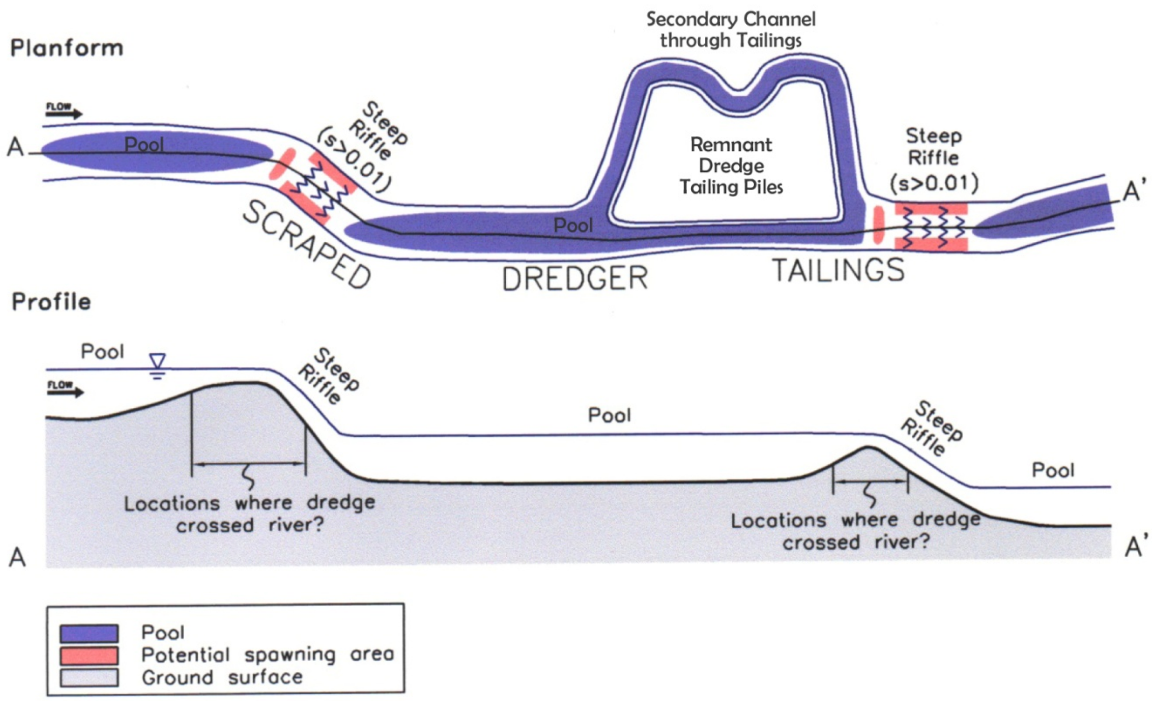

Figure 3. Post-dredger mining planform and longitudinal profile showing the impacts of mining on the channel.

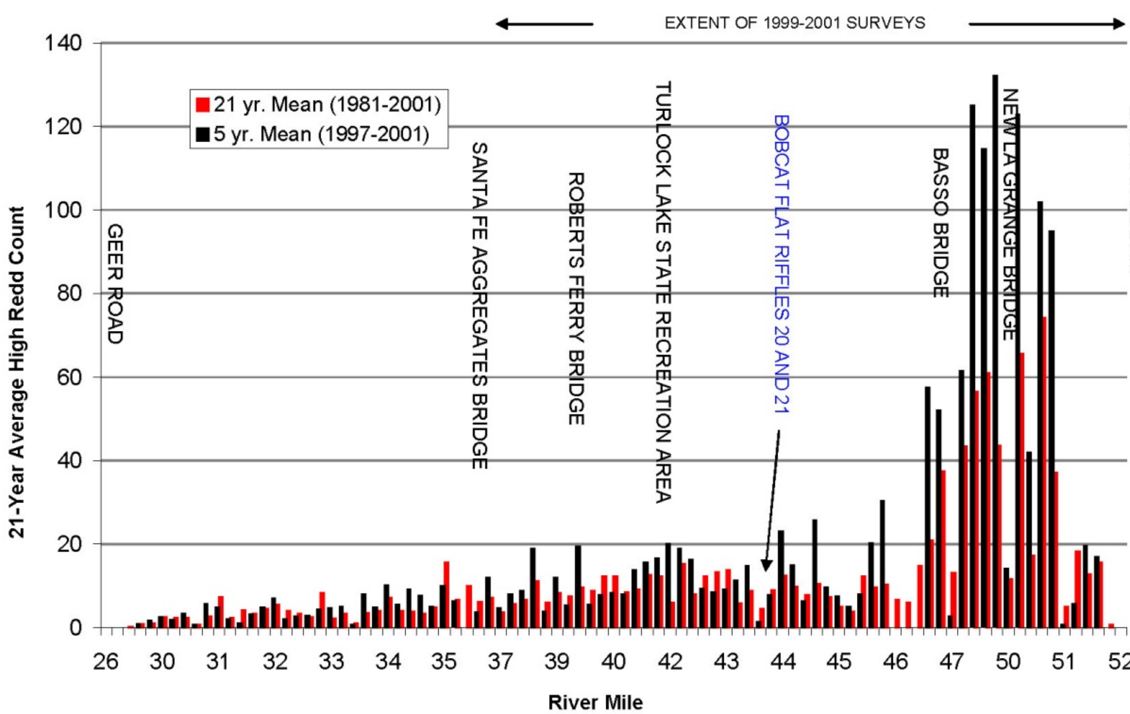

Figure 4. Reduced spawning availability as a result of in-channel dredge mining (M&T 2000).

Monitoring of the Phase I and Phase II project areas began in May of 2003 and included:

1. Bobcat Flat monitoring in 2003 and 2005, and 2005 Phase I construction were documented in the Phase I As-Built Monitoring Final Report (M&T 2006a).
2. The September 2006 monitoring effort was done to capture the effects of high flows in excess of 6,000 cfs. September 2006 monitoring results were entered, checked for accuracy, and archived for future use.
3. May 2008 monitoring was done to document the effects of high sediment loading from erosion within the Peaslee Creek watershed on the Bobcat Flat Phase I project area. September 2006 and May 2008 monitoring results were reported in: Monitoring the Impacts on the Tuolumne River from Peaslee Creek Erosion and Runoff Events of January 2008 (M&T 2008).
4. Bobcat Flat monitoring in 2009, 2011, and 2012, and 2011 Phase II construction are documented in this report.

Figure 5 provides a timeline of Bobcat Flat monitoring dates (black) and construction phases (red) between 2003 and 2012.

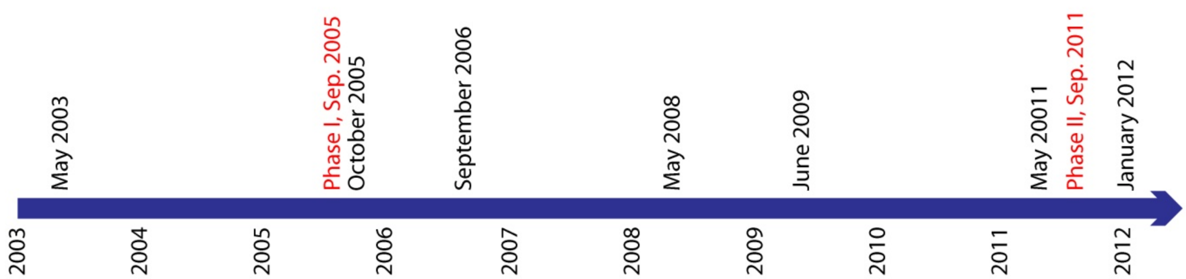

Figure 5. Bobcat Flat monitoring (black) and construction (red) activities between May 2003 and January 2012.

1.3 Phase II As-Built Monitoring Report Goals and Objectives

Phase II as-built monitoring and reporting goals and objectives include:

1. Phase II design and as-built comparisons
   - Floodplain and in-channel construction
   - Coarse sediment sieving and cleaning
   - Gravel pit enhancement
   - Riparian planting
2. Phase II pre-construction and as-built site conditions
   - Topography (planform, channel profiles, and cross sections)
   - Bed texture (pebble counts and bulk samples)
   - Visual assessments (photopoints)
3. Additional monitoring of Phase I project areas to address AFRP reviewer comments within the Phase II proposal
   - Topography (planform, channel profiles, and cross sections)
   - Bed texture (pebble counts and bulk samples)
   - Visual assessments (photopoints)

2 PHASE II DESIGN AND IMPLEMENTATION

Planning and design of the Bobcat Flat Phase II restoration project began in the spring of 2009, and was completed May 24, 2011. Project designs and hydraulic analysis, including the 100-year flood assessment, were overseen and/or conducted by:

Domenichelli and Associates
1101 Investment Blvd., Suite 115
El Dorado Hills, CA 95762

Construction began August 22, 2011, and ending September 30, 2011. All construction activities were performed by:

Sean Warren Smith
180 Brannan Street, Suite 220
San Francisco, CA 94107

Construction oversight and management was performed by FOT board members:

Friends of the Tuolumne, Inc.
C/O Dave and Allison Boucher
1900 NE 3rd Street, Ste. 106-314
Bend, OR 97701

2.1 Phase II Project Goals and Objectives

Preliminary Phase II project goals and objectives were developed as part of FOT's proposal to AFRP. During the proposal process, AFRP provided comments and suggestions to the Phase II project goals and objectives. The resulting Phase II projects goals and objectives include:

1. Introduce coarse sediment to supplement existing degraded spawning habitat for Chinook salmon and steelhead and create new riffles and spawning habitat in reaches where none currently exist;
2. Excavate and sort coarse sediment from existing dredger tailing surfaces restoring floodplain function and connectivity to the river;
3. Restore riparian species on restored floodplains through natural recruitment and plantings;
4. Reduce predatory species habitat by partially filling remnant dredger channels and/or in-channel gravel pits to post-dam channel morphology;
5. Reduce predatory species habitat by partially filling off-channel gravel pits that have been incorporated into floodplain restoration; and
6. Implement an experimental design that will test specific components of the project implementation and effectiveness that will yield useful information for other gravel augmentation programs in the Central Valley (see "additional monitoring", Section 4 of this report).

2.2 Phase II Existing Site Topography and Bathymetry and Design Overview

This section provides the pre-construction topographic and bathymetric basis for the 100% civil design and monitoring within the Phase II project footprint and provides a brief summary of the 100% civil designs.

2.2.1 Existing Site Topography and Bathymetry

Pre-construction bathymetry and topography were compiled from several surveys, including:

- A May 2005 Del Terra, Inc. bathymetric survey of the Tuolumne River between Old La Grange Dam and the 7-11 Haul Road Bridge;
- A September 2005 LiDAR flight between Old La Grange Dam and the confluence with the San Joaquin River flown and post-processed by Sanborn and checked by Del Terra Inc.;
- An October 2005 as-built survey of the Phase I project conducted by McBain and Trush, Inc. (M&T) and Del Terra, Inc.;
- A May 2009 spot check of existing 2005 topography at Borrow Area 4 and 5 and bathymetry survey within Duck Slough and at Riffle 22 and Riffle 23 conducted by Domenichelli and Associates, Inc. and M&T; and
- A 2011 pre-construction bathymetric survey of the Tuolumne River that extended from Patch 1 to Patch 14 and included Duck Slough. Conducted by USFWS, under the direction of Mark Gard.

The three 2005 surveys and the 2009 Duck Slough supplemental bathymetry were combined to produce a Digital Terrain Model (DTM) of existing conditions dated June 2009. The 2009 DTM was used as the baseline topography in preparation of the 100 % Phase II civil designs. The 100% designs were completed prior to the 2011 USFWS pre-construction survey data becoming available.

To provide more accurate Phase II as-built assessment, the 2011 USFWS DTM was pasted into the June 2009 topography to form the baseline existing topography used to evaluate pre- and post-construction cut/fill volumes. The primary purpose of the 2011 USFWS bathymetric survey was to provide pre-construction topography to use in a 2-D hydrodynamic model to evaluate existing salmonid habitat.

2.2.2 Floodplain Implementation Overview

The following equipment was used to excavate, grade, and haul material as part of the Phase II construction:

- 2,000 Gallon Valew water truck was used to meet air quality standards.
- CAT D6N XL was used to grade the borrow areas to floodplain design elevations and convert gravel pits to off-channel wetlands;
- CAT D350E heavy haul dump was used to haul excavated coarse sediment from borrow areas to the screen plant and from the screen plant to the river;
- GRADALL XL5200 was used to excavate material from areas around drip lines and areas difficult to reach with the CAT D6N XL (Figure 2); and
- Two Kawasaki front-end loaders, models 90 ZV-2 and 95 ZV-2, were used to place material into the heavy haul dump and screen plant, and to construct all in-channel features.

On-site borrow areas in addition to the Phase I stockpile provided the coarse sediment necessary for off-channel wetland (converted gravel pits) and all in-channel construction. Coarse sediment borrow areas are shown in Appendix A, 100% Design Sheet 3, and Figure 2. Borrow areas were used in the following order: (1) Borrow Area 4, (2) Borrow Area A, (3) Borrow Area 5, and (4) Phase I Stockpile. Borrow Area A was added to offset reduced volume from Borrow Area 5 as a result of drip line boundaries and reduced excavation area (Figure 2). Borrow Areas 1-3 and Duck Slough construction areas (Figure 2, Appendix A) were not implemented as part of Phase II due to limited funding. Funding limitations and Phase II order of implementation was documented in the Bobcat Flat River Mile 43 Phase II Restoration Final Design Document (M&T 2011). Should funding become available, the unconstructed portion of the Phase II project could be implemented any time prior to the expiration of the 5-year permit window. Table 1 lists each of the borrow areas, estimated volume from the 100% designs, and actual volume of material excavated from each site. See Section 3 for as-built monitoring and methods used to calculate actual excavation and fill volumes.

Phase II floodplain construction objectives included:

- Restoration of floodplain function;
- Restored floodplains that encompass the off-channel wetlands (converted gravel pits), allowing high flows to pass through them and drain into the mainstem river;
- Connectivity of floodplain surfaces to the contemporary flow regime;
- Provide as-built surfaces suitable for riparian plantings and natural recruitment; and
- Provide high flow refugia for salmonids.

Table 1. Estimated coarse sediment cut volumes from the 100% civil design and actual volumes from pre-construction topography and as-built topography. See Section 3 of this report for a description of as-built topography.

Coarse sediment source	**Estimated unprocessed coarse sediment**	**Estimated coarse sediment between 0.25 in and 5 in**	**Estimated coarse sediment greater than 5 in or less than 0.25 in**	**Actual unprocessed coarse sediment**	**Estimated coarse sediment between 0.25 in and 5 in**	**Estimated coarse sediment greater than 5 in or less than 0.25 in**
Borrow Area 4	8,000 yd^3	5,600 yd^3	2,400 yd^3	6,800 yd^3	5,050 yd^3	1,750 yd^3
Borrow Area A	N/A	N/A	N/A	1,100 yd^3	820 yd^3	280 yd^3
Borrow Areas 5	17,300 yd^3	12,110 yd^3	5,190 yd^3	11,300 yd^3	8,400 yd^3	2,900 yd^3
Phase I Stockpile	12,000 yd^3	8,400 yd^3	2,880 yd^3	5,100 yd^3	3,800 yd^3	1,300 yd^3
Total	**37,300 yd^3**	**26,110 yd^3**	**11,190 yd^3**	**24,300 yd^3**	**18,070 yd^3**	**6,230 yd^3**

2.2.3 Riparian Planting Overview

The California Environmental Quality Act (CEQA) permit required the replacement (mitigation) of trees damaged or removed during the Phase II construction. CEQA mitigation requires a 3:1 replacement of all trees less than 4 inches in diameter at breast height (DBH). During Phase II construction, 12 red willow (*Salix laevigata*) and 5 yellow willow (*S. lutea*) under 4 inches DBH were damaged or removed. No other tree species were impacted. Therefore, CEQA requires that at least 36 red willow and 15 yellow willow be planted within the Phase II construction area. To improve floodplain species and structural diversity, additional species were included in the revegetation design.

In April 2012, 198 cuttings of four native willow one and cottonwood species were taken from plants on site in roughly equal proportions (Figure 6). Species included red willow, yellow willow, black willow (*S. gooddingii*), arroyo willow (*S. lasiolepis*) and Fremont cottonwood (*Populus fremontii*). The cuttings were identified, stripped of vegetation and limbs, soaked in water filled barrels overnight (at minimum), and the tips painted with color codes for later identification.

The cuttings were then planted on approximately four acres of excavated floodplain. A small piece of equipment commonly known as a Bobcat was used for planting. It was equipped with a pneumatic jack-hammer-like attachment that drove a 4-inch diameter, 4-ft long well casing into the rocky ground. When the casing was withdrawn, the cutting was inserted down into the hole created. The cuttings were planted in rows at least 20 feet apart with planting on each row a minimum of 15 feet apart.

Figure 6. Riparian planting beginning with the gathering of cuttings (left photo), soaking the cuttings in barrels overnight (middle photo), and planting of cuttings (right photo).

2.2.4 Coarse Sediment Sieving and Washing Overview

Approximately 24,300 yd^3 of coarse sediment was excavated from three borrow areas and existing stockpile (Figure 2 and Table 1). The excavated coarse sediment was processed and sorted using a CEC 6 ft x 16 ft, 3-Deck Screen Plant with an 8 x 8 in square top screen (converted to a 4 x 4 in square screen). An Auto-Prime Water Pump with Deutz Diesel & Custom Light Weight Portable Water Tower, and two 2-inch Multiquip, Inc. Portable Water Pumps (Figure 7).

Coarse sediment excavated onsite was cleaned prior to being placed in-stream. The CEQA document for this project stipulated that two methods of cleaning the rock be evaluated: (1) a “wet wash method”; and (2) a “dry screen method”. The “wet wash method” combined a powerful water jet spray directed at the coarse sediment as it passes through the screening process. The theory behind the approach is that agitation of the rock on the screens combined with water spray will loosen the fine sediments adhering to the material and be washed off its surface by the water. The “dry screen method” used the same screen agitation to loosen fine soils adhering to the coarse sediment without the application of a water spray. Loosened fine sediments simply fall away from the coarse sediment.

Evaluation of the end product produced by each cleaning method by a FOT representative determined the dry screen method yielded a cleaner end product than the wet cleaning method. Reasons for superior performance of the dry screening may be related to the clay soil particles that coated the unprocessed material. Application of water turned the clay into pasty glue that prevented it from being dislodged from the surface of the coarse sediment during agitation on the screens. The dry screen method was therefore selected for use to clean the coarse sediment prior to placing in the river.

The processed coarse sediment was sorted into three categories:

1. Coarse sediment greater than 5 inches was used to provide a skeletal layer between existing clay hardpan in Patches7A through 14. Oversized material was also mixed with native material scraped from the near vertical banks of the gravel pits to construct off-channel wetlands with gently sloping banks and benches within the constructed floodway.

2. Coarse sediment less than ¼ inch was spread over areas outside constructed floodplain surfaces and planted with native grasses.

3. Coarse sediment between ¼ and 5 inches was used in the construction of riffles, dunes, and point bars (Figure 2). Approximately 18,070 yd^3 of coarse sediment between ¼ and 5 inches was estimated to be available from borrow sources (Table 1). In total approximately 17,500 yd^3 of ¼ to 5-inch coarse sediment was placed in 10 patches. These 10 coarse sediment patches provide a desirable particle size distribution for spawning and rearing salmonids and are expected to be mobilized by the contemporary flow regime (Figure 2).

Figure 7. Gravel processing plant.

2.2.5 In-Channel Implementation Overview

The 100% design for the coarse sediment augmentation phase included placement of up to 17,000 yd^3 of coarse sediment in 10 discrete patches within the project reach (Appendix A, Figure 2). Mainstem Tuolumne River in-channel coarse sediment augmentation work was completed as described in the 100% design document (M&T 2011) using one of two front-end loaders, a Kawasaki model 90 ZV-2 and a Kawasaki model 95 ZV-2. A variety of coarse sediment placement methods were developed and presented in the Tuolumne River Coarse Sediment Management Plan (CSMP, M&T 2004a). Phase II in-channel coarse sediment augmentation project areas included:

- Patch 2, a high flow coarse sediment recruitment pile originally placed in 2005 as part of Phase I construction was scoured away by the 2006 and 2011 high flow events. The purpose of the Phase II project was to replenish the Patch 2 recruitment pile. Approximately 1,000 yd^3 of coarse sediment were added to Patch 2, providing a near term coarse sediment supply for the mainstem Tuolumne River downstream of Riffle 20 (Figure 2, Table 2).
- Patches 7A, 7B, and 8 completed the re-scaling of a historic in-channel gravel pit begun as part of the Phase I project (Patches 5 and 6) and extended Riffle 21 downstream (Figure 2). The primary objectives included: (1) filling the remaining coarse sediment storage void (it was assumed that most of the coarse sediment transported through Riffle 21 was settling into the gravel pit directly downstream); (2) reduce low flow channel widths to more contemporary channel geometry; and (3) reduce predatory fish habitat (i.e. largemouth and smallmouth bass).
- Patches 9-14 restored an alternating point and transverse bar sequence to a portion of channel that had been dredged and scoured to clay hardpan. This portion of the design intended to mimic natural alluvial features and immediately improve habitat for all life stages of salmonids and reduce predatory fish habitat.

Table 2. Estimated coarse sediment fill volumes from the 100% civil design and actual volumes from pre-construction topography and as-built topography.

Coarse sediment augmentation site	Design estimated placed coarse sediment	Design estimated placed coarse sediment with 25% contingency	Actual placed coarse sediment
Patch 2	500 yd^3	625 yd^3	1,000 yd^3
Patch 7A and 7B	2,700 yd^3	3,375 yd^3	4,300 yd^3
Patch 8	300 yd^3	375 yd^3	1,200 yd^3
Patches 9–14	10,100 yd^3	12,625 yd^3	11,000 yd^3
Total	**13,600 yd^3**	**17,000 yd^3**	**17,500 yd^3**

3 PHASE II AS-BUILT DOCUMENTATION

Phase II as-built monitoring documented changes between 100% civil designs, pre-construction, and post-construction site conditions. Phase II pre-construction conditions used monitoring data collected between 2006 and 2011 (Table 3). Apart from pre-construction topography (Section 2), methods used to collect pre-construction monitoring data prior to 2011 are documented in the Phase I As-Built Monitoring Final Report (M&T 2006a), and Monitoring the Impacts on the Tuolumne River from Peaslee Creek Erosion and Runoff Events of January 2008 (M&T 2008). As-built monitoring of the Phase II project was conducted between January 18 and August 27, 2012, and included floodplain and bar topography, channel bathymetry, pebble counts, bulk sediment samples, cross sections, long profiles, and photopoints. The Phase II as-built monitoring also verified earthwork volumes, provided as-built ground surface elevations, and established a baseline condition for future monitoring. Documenting the Phase II post-construction site conditions should allow future evaluation of:

1. Alternative sediment placement methods;
2. Sediment mobility, routing, and transport;
3. Changes to channel morphology; and
4. Long term suitability of gravel for Chinook salmon spawning.

Additional Phase II project monitoring of pre- and post-2011 construction site conditions is being conducted by USFWS and includes:

1. Chinook salmon juvenile rearing and adult spawning 2-D modeling of existing and as-built site conditions; and
2. Benthic macroinvertebrate (BMI) species richness and abundance monitoring.

USFWS 2-D modeling results and invertebrate monitoring were not available at the time of this report.

Future monitoring of the Bobcat Flat Phase II project will be dependent on available funding. To address comments received in the Phase II project proposal, monitoring of select Phase I project areas (Figure 2) was done and is reported on in Section 4 of this report.

Table 3. Summary of Bobcat Flat monitoring parameters, methods, and dates.

Monitoring Parameter	**Method**	**Phase I Pre-project**			**Phase I As-Built**	**Post-Phase I Project Monitoring and Phase II Pre-Project**			**Phase II As-Built**
		2003	**2004**	**2005**	**2005**	**2006**	**2008**	**2011**	**2012**
Channel Cross Section	Level and Total Station surveys	•			•	•			
Channel Profile	Level and Total Station surveys	•			•	•			
	Acoustic bathymetry survey			•					
Channel Bathymetry (bed topography)	Total Station (1-ft contour DTM)				•	•		•	•
	Acoustic bathymetry survey							•	•
Bed Texture	Pebble counts	•			•	•	•		•
	Bulk samples				•	•	•		•
Bed Mobility Thresholds	Marked rock experiments				•	•			
Floodplain Topography	Total Station survey (1-ft contour DTM)	•						•	•
	Kinematic GPS survey (1-ft contour DTM)				•				
	LiDAR survey (2-ft contour DTM)				•				
River Stage and Shallow Groundwater Table Fluctuations	2 staff plates installed along river channel				•				
	5 staff plates installed in dredger ponds	•	•						
Photopoints	Digital camera	•	•	•	•	•	•	•	•
BMI Sampling	California Stream Bioassessment Protocol						•		
Habitat Assessment	Direct habitat mapping Chinook spawning	•			•	•	•	•	•
	Direct habitat mapping salmonid rearing							•	
	Aerial photo mapping redd locations		•		•				
	River 2-D Chinook spawning[1]							•	•
	River 2-D Chinook spawning[1]							•	•

[1] USFWS will be preparing a Phase II pre- and post-construction 2-D hydrodynamic model to evaluate salmonid rearing and spawning habitat.

3.1 As-Built Topography

As-built topography was surveyed using a combination of methods between January 18 and August 27, 2012. Floodplains (Borrow Areas 4, 5, and A), Phase I stockpile area, and Patches 2 and 14 were surveyed by Domenichelli and Associates, M&T, and FOT, while Patches 7A through 13 were surveyed by USFWS (Figure 8).

3.1.1 Methods

As-built channel morphology was documented using Total Station surveys and Real-Time Kinematics (RTK) Global Positioning System (GPS) surveys; an Acoustic Doppler Current Profiler (ADCP), in combination with the RTK-GPS, was used to capture mainstem bathymetry. All survey data coordinates are oriented to the NAD 83, California State Plane, Zone III, ft. coordinate system and NAVD 88, ft. vertical datum. AutoCAD Civil 3D 2012 was used to compile 2012 ADCP, RTK-GPS and Total Station surveys into a single as-built digital terrain model (DTM). The as-built DTM was then pasted into the 2011 pre-construction digital DTM to form a final post-construction DTM (Figure 8).

AutoCAD Civil 3D, 2012 was then used to create a map of the topographic difference between the 2011 pre-construction DTM and the 2012 post-construction DTM (Figure 9).

3.1.1 Results

The resulting topographic differencing from the 2011 Phase II construction shows the cut/fill surface, in 1-foot vertical colored increments (Figure 9). The greatest excavation depth occurred within the existing stockpile area (12 to 14 ft) and Borrow Area 4 (5 to 6 ft) while the greatest fill areas occurred within Project Areas 7A and 14 (10 to 12 ft). The cut/fill volumes are summarized in Table 1 and Table 2. Figure 9 also shows a few areas of cut between Patches 7A and 7B. Since no material was removed from the channel, the difference was determined to be a result of the 2005 bathymetry data used for this portion of the pre-construction topography. Flows in excess of 6,000 cfs in 2006 and 2011 (Figure 10) are most likely the cause of this topographic difference.

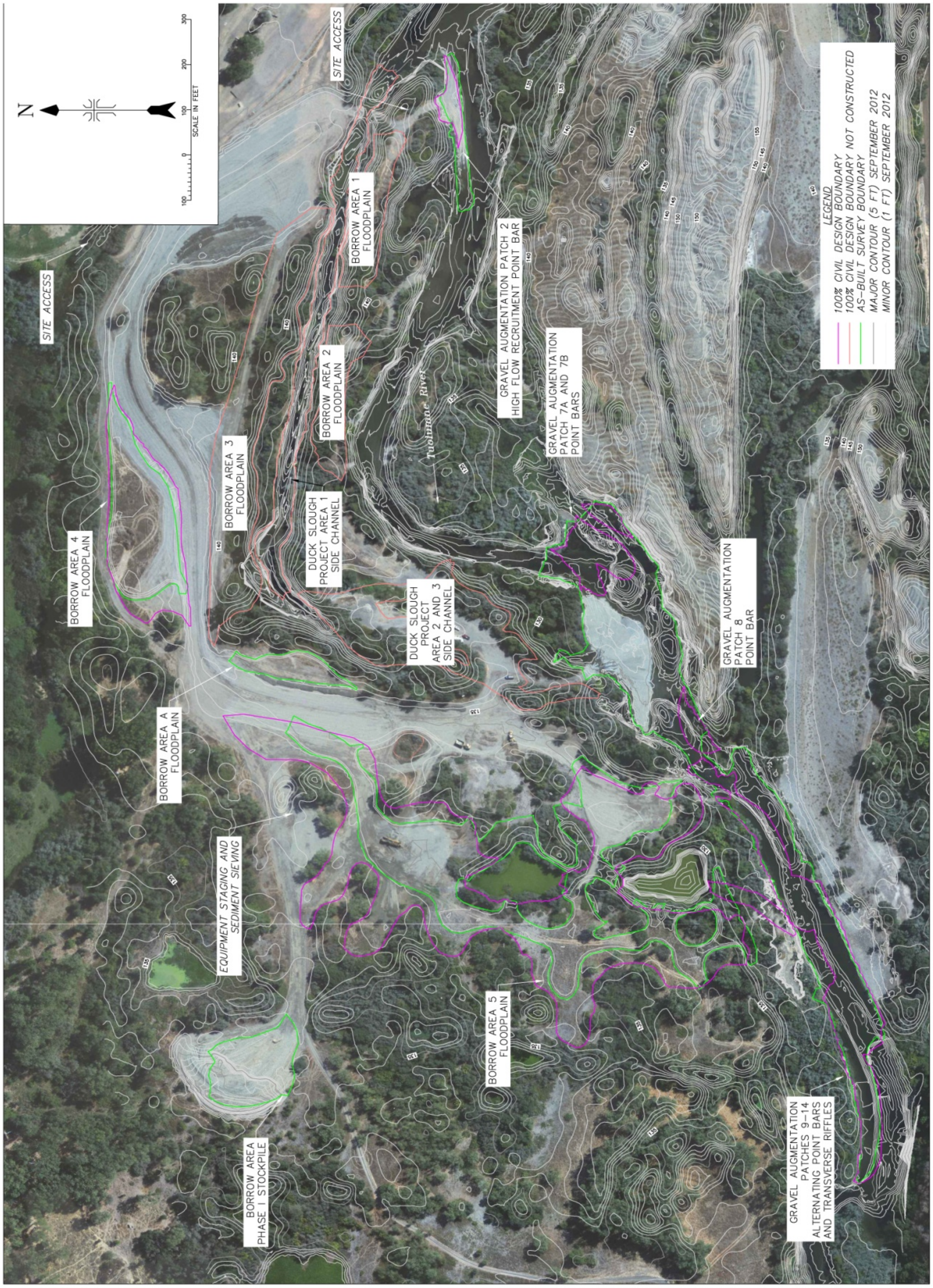

Figure 8. Bobcat Flat site as-built contour map showing Phase I patch boundaries and Phase II 100% design and as-built boundaries.

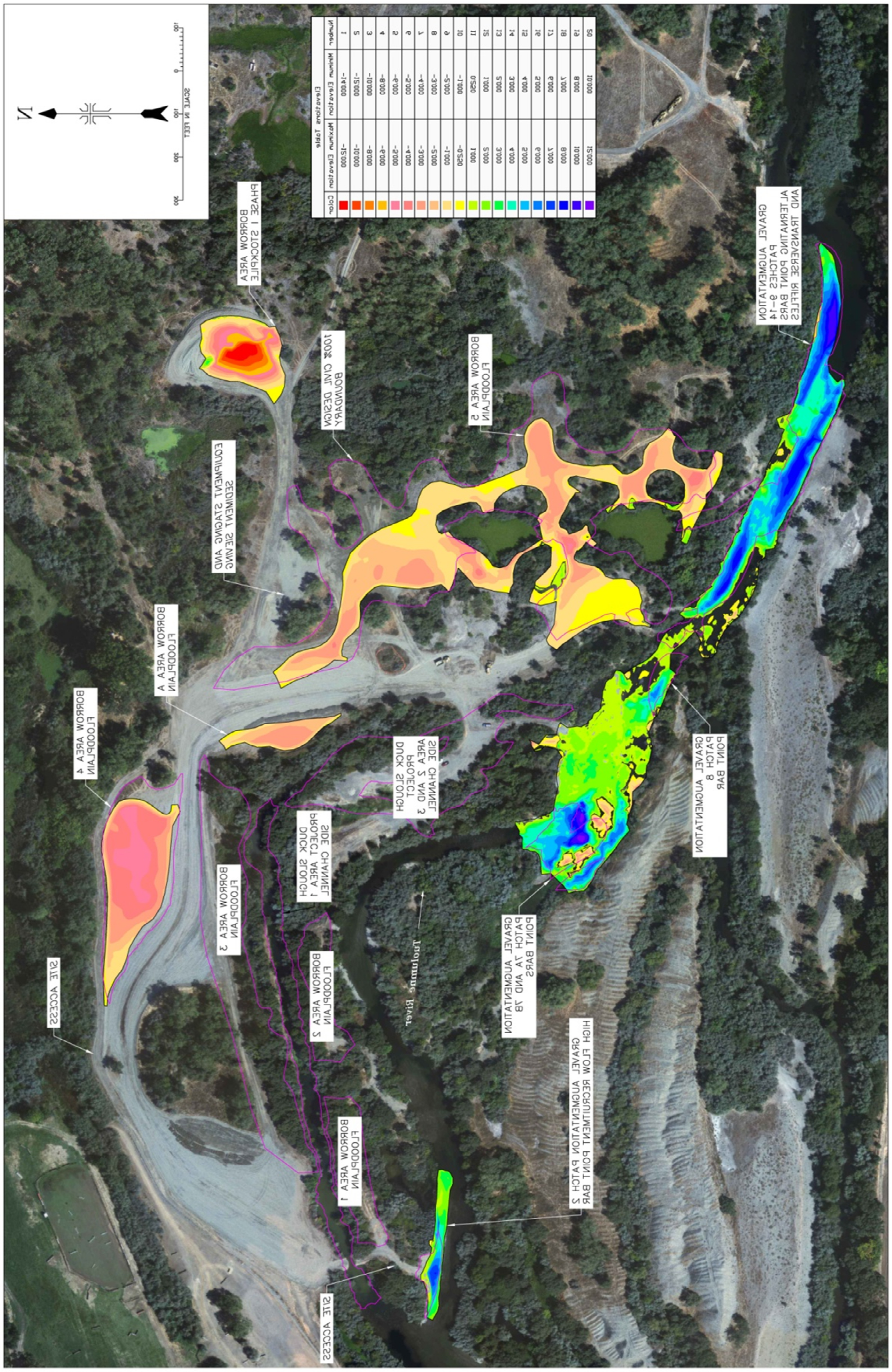

Figure 9. Planform map showing as-built topographic differencing between pre-construction and as-built topography and 100% design boundary and as-built boundary overlaid on the 2005 aerial photograph.

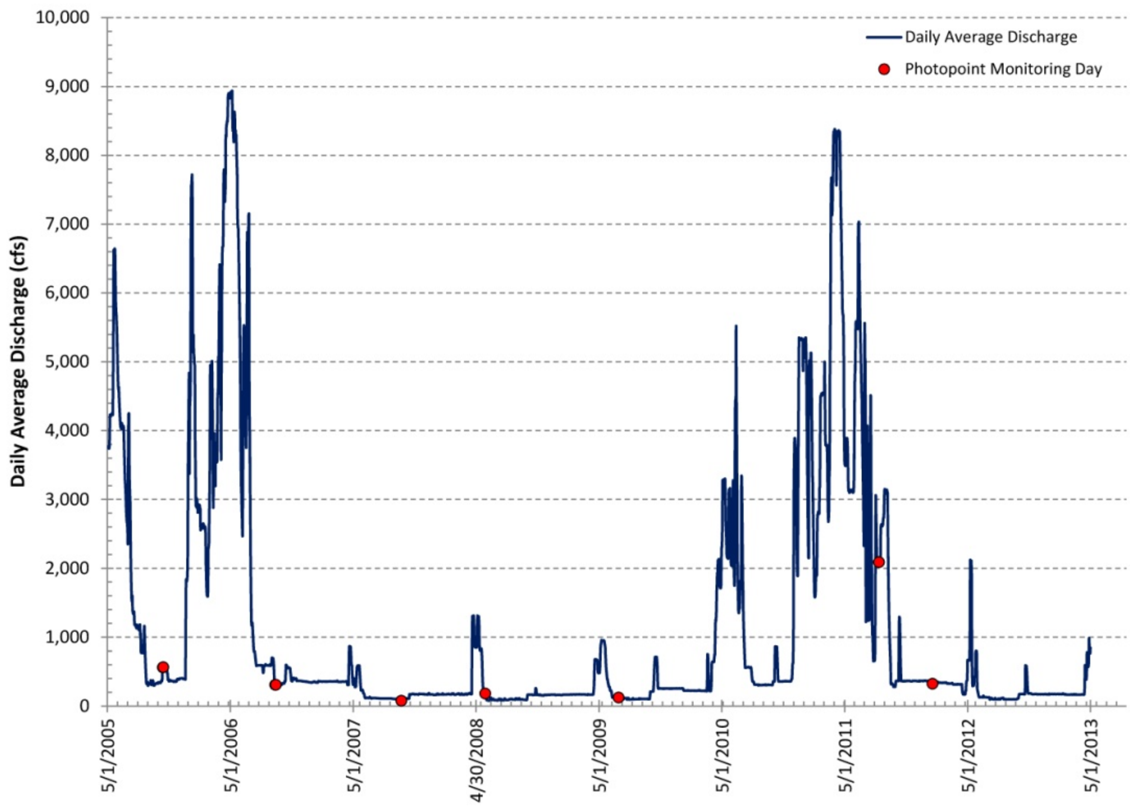

Figure 10. Daily average flow between May 1, 2005, and May 1, 2013, showing two years (WY 2005 and 2010) when daily average flow exceeded 6,000 cfs.

3.2 Cross Sections and Longitudinal Profiles

Monumented cross sections provide a way to accurately measure elevation changes to channel geometry and river stage as a result of high flow events and/or construction activities. A total of 13 cross sections were established during the Phase I project (Figure 2, M&T 2006a). As part of the Phase II as-built monitoring, three Phase I cross sections were resurveyed. Cross sections 2394+00, 2395+90, and 2412+10 were surveyed to document changes in channel geometry between 2006 and pre- and post- Phase II construction. Two additional Cross Sections, 2403+95 and 2408+10, were surveyed to document long term changes at Patches 3 and 4 as discussed in Section 4.

In addition to cross section monitoring, three longitudinal profiles were monitored: the first between Patch 6 and Patch 14, the second through Borrow Area 5, and the third through Riffle 21 (Figure 2). Ground surface elevations were pulled from existing, 100% Design, and Phase II as-built DTM's using AutoCAD Civil 3D.

3.2.1 Methods

Cross sections 2394+00, 2395+90, and 2412+10 were surveyed as part of the Phase II as-built monitoring to document pre- and post- Phase II construction channel geometry (Figure 2). At cross sections 2394+00 and 2395+90, 2006 surveys documented pre-Phase II construction channel geometry; at cross section 2412+10, a May 2011 USFWS DTM provided the pre-Phase II channel geometry. Phase II as-built cross section monitoring was done by stringing a tape between the left bank and right bank cross section pins and documenting ground surface elevations at points along the tape using an Engineers Level or Total Station. Data were then entered or downloaded into Microsoft Excel, checked for accuracy, and results plotted.

3.2.2 Results

Results for the three cross sections and longitudinal profiles surveyed as part of the Phase II as-built monitoring are shown in Figure 11 through Figure 16. Cross section 2412+10 surveys between 2003 and 2012 (Figure 11) show deep scour along the right bank as a result of high flows between 2006 and 2011. Cross section surveys justify Patch 2 as an ideal location for a coarse sediment recruitment location to supply coarse sediment to downstream patches. Cross sections 2394+00 (Figure 12) and 1395+90 (Figure 13) shows changes to Patches 5 and 6 as a result of Phase II construction activities. At cross section 2394+00 no change between 2005 and 2012 to the thalweg elevation even though Patch 6 provided the access route to Patch 8. This is important as any increase in the riffle control elevation at Patch 6 would have impacted upstream riffle function.

Phase II design riffle control elevation difference between Patches 9 and 13 was approximately 0.5 feet (M&T 2011). A grade check of the riffle control elevation at Patch 9, prior to construction, showed that 2011 high flows had increased the riffle control elevation to design grade therefore, no additional coarse sediment was added to Patch 9. Patches 6 through 13, Pre- and post-construction longitudinal profiles were pulled from DTM's with a 1-foot contour accuracy therefore, riffle crest elevations in Figure 14 are approximate. However, photopoint monitoring (Section 3.3) indicates no backwater effects on upstream riffles from downstream riffle crests. Figure 14 and Figure 16 capture some of the microtopographic features (dunes) incorporated into Riffle 21 and Patches 11 and 13. These constructed dunes provide immediate habitat benefits for juvenile salmonids (CMC 2001, CMC 2002, and DWR 2006).

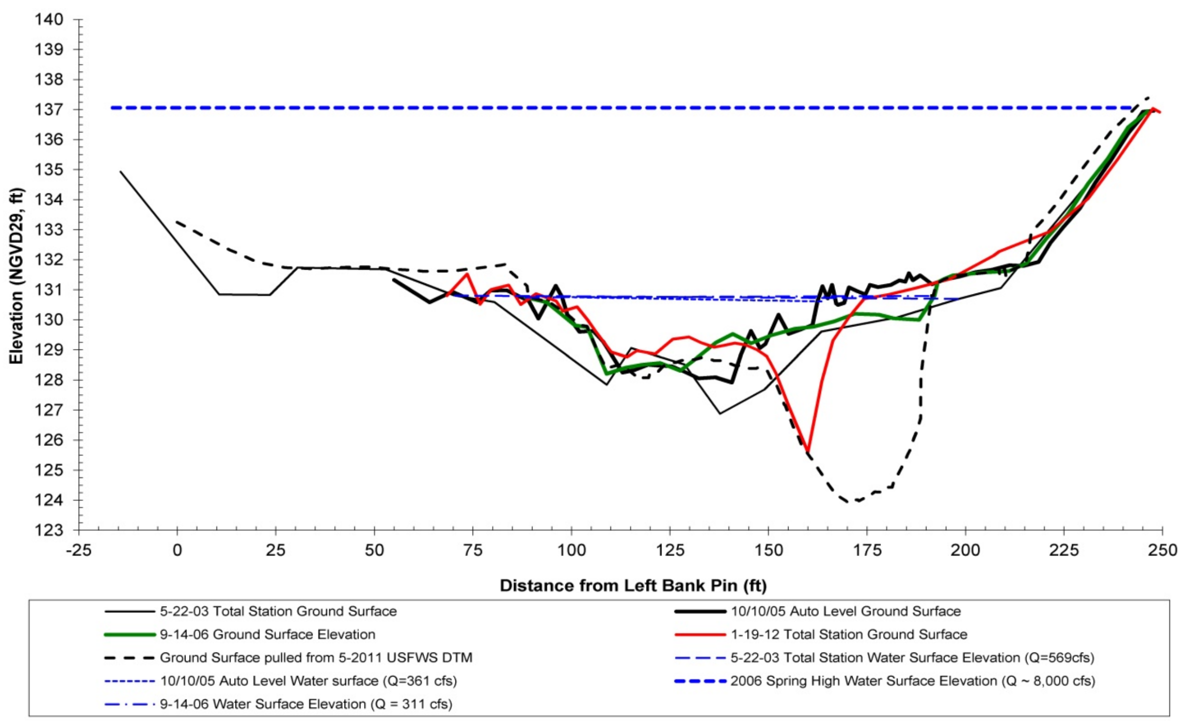

Figure 11. Cross section 2412+10 showing 2003 existing site conditions, Phase I as-built topography 2006 and 2011 site conditions, and Phase II as-built topography.

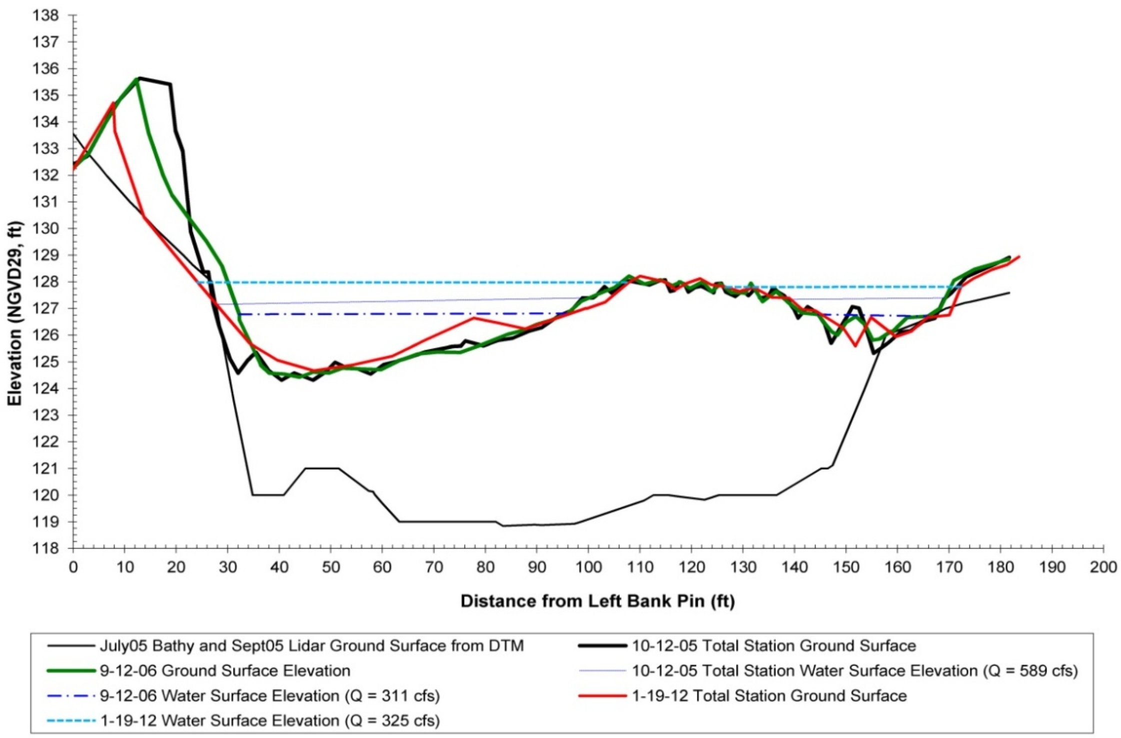

Figure 12. Cross section 2394+00 showing little to no change to Patch 6 as a result of Phase II construction activities. Patch 6 was used to provide access to Patch 8 and was graded post-construction to reduce compaction impacts from heavy equipment driving over the riffle.

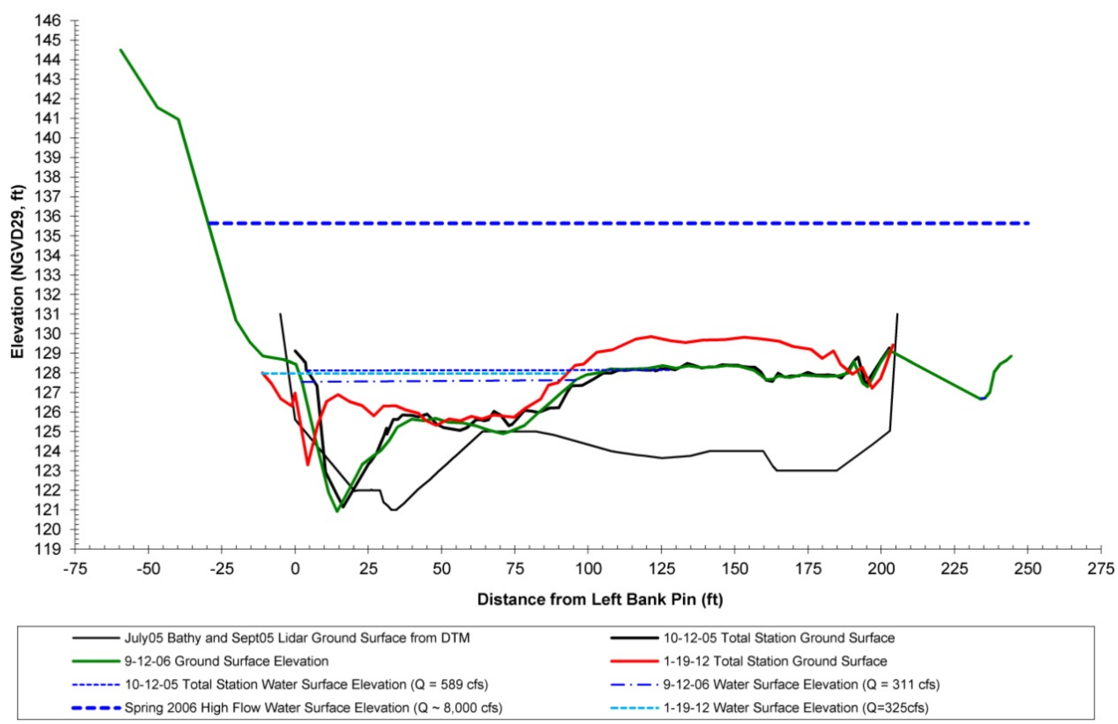

Figure 13. Cross section 2395+90 showing the continued development of the natural riffle across from Patch 5 and the 1-2 feet of material spread out over Patch 5 after Patches 7A, 7B, and 8 were completed.

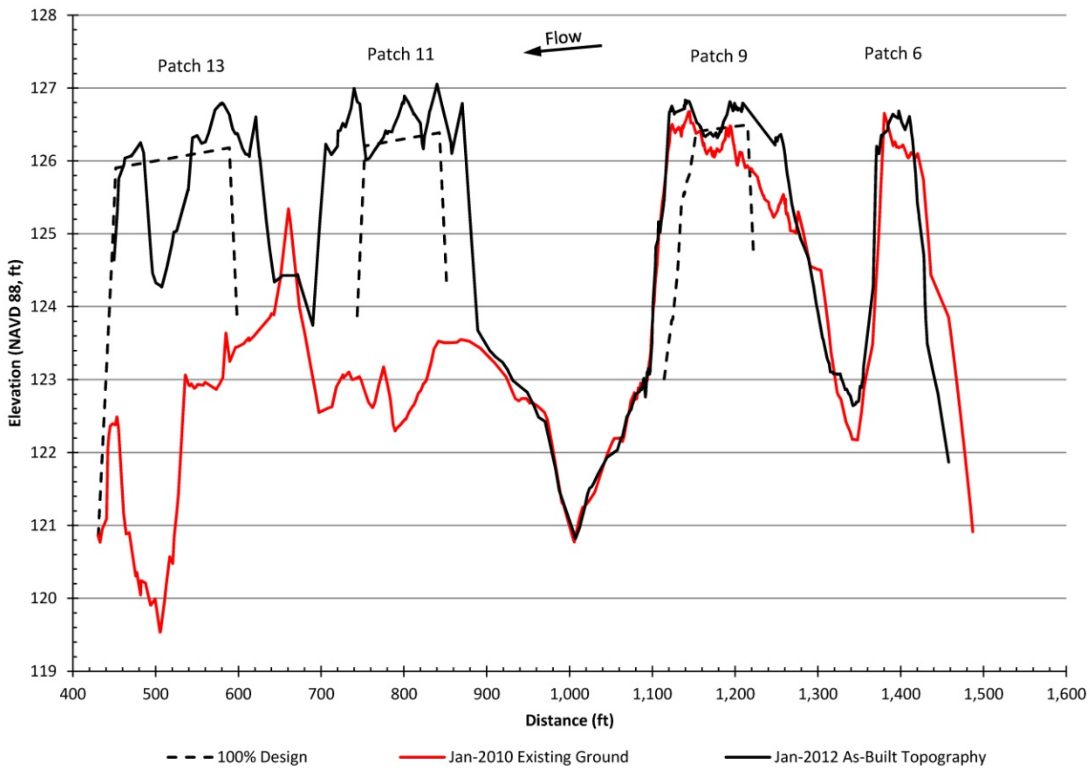

Figure 14. Longitudinal profile between Patch 6 and Patch 14 comparing existing, final design, and as-built conditions.

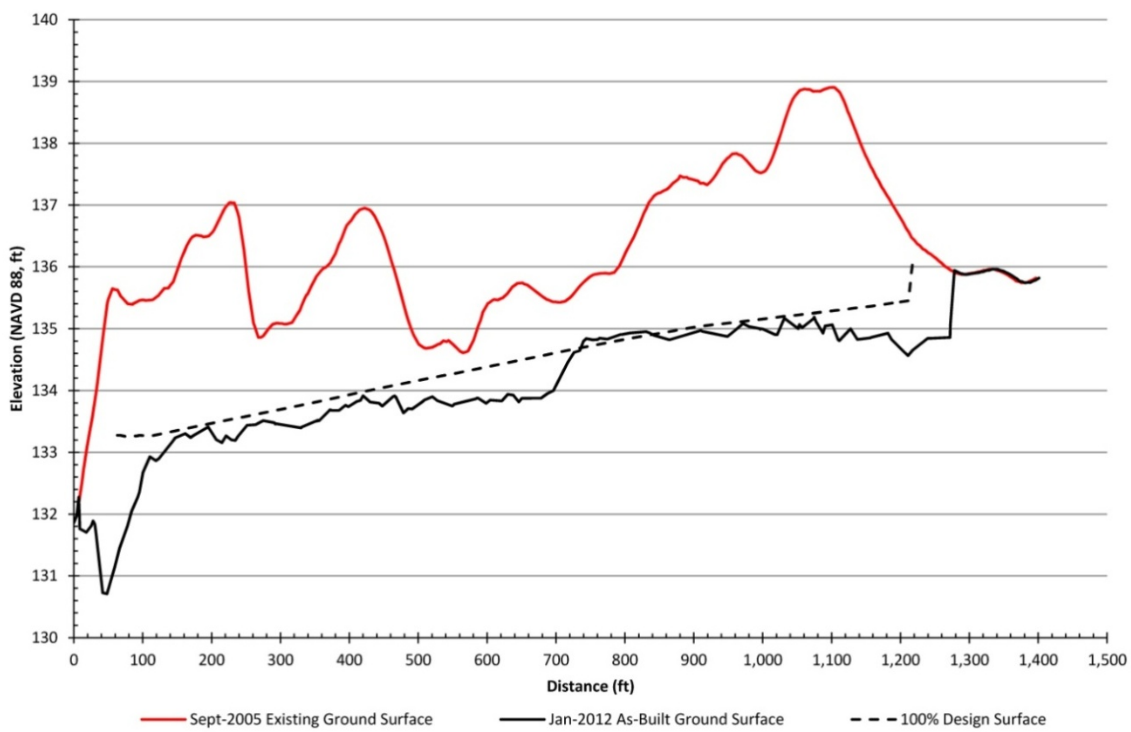

Figure 15. Longitudinal profile of Borrow Area 5 comparing existing, final design, and as-built conditions.

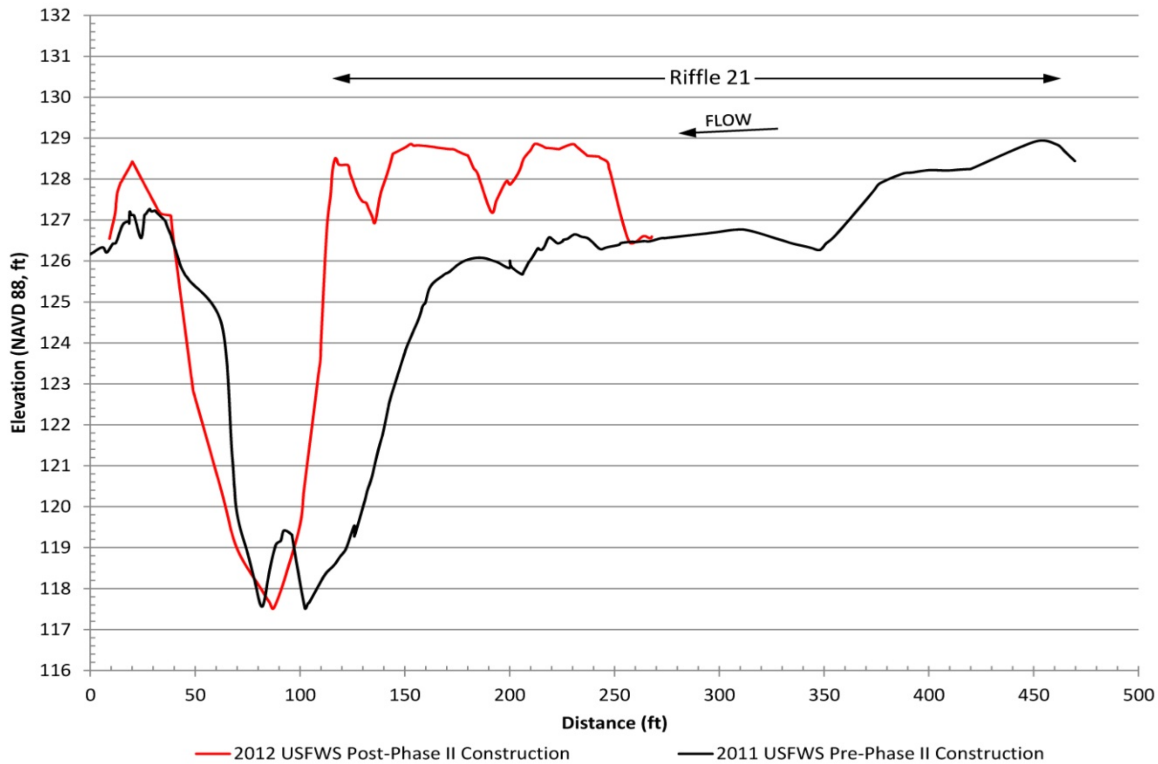

Figure 16. Longitudinal profile of Riffle 21 comparing 2011 USFWS pre-construction and 2012 USFWS post-construction topography.

3.3 Photopoints – Pre- and Post-Construction

Photopoints provide a visual way to document changes within a project area due to construction or natural events such as high flows. Currently, 13 photopoints have been established within the Bobcat Flat Phase I and Phase II project areas (Figure 2). Photopoints 1 through 5 were established within the Bobcat Flat property post-Phase I construction and the remaining 8 photopoints were established in 2011 prior to Phase II construction.

3.3.1 Methods

As-built Phase II photopoints were established in January 2012, to monitor each of the nine new coarse sediment augmentation patches, which were re-established to continue monitoring of the original Phase I coarse sediment augmentation patches. In addition, new photopoints were set to monitor constructed off-channel wetlands and floodplains (Figure 2). Phase II photopoint monuments were set and Phase I photopoints were re-set using ¼ inch rebar with yellow caps (Figure 17). Photopoint locations were established using a combination of Total Station surveys and points placed on a high resolution aerial photograph. Points were digitized or uploaded to AutoCAD Civil 3D, providing long term recoverable photopoint locations.

For pre-Phase II construction comparisons, a compilation of photographs were used: of the Phase I as-built monitoring in October 2005 and September 2006, Peaslee Creek fine sediment monitoring in May 2008, and two site visits in June 2009 and August 2011 were used. Each photographic panorama consists of several photographs stitched together using Microsoft ICE. Daily average discharge for each photo is shown as a point on Figure 10.

Phase I Photopoints 1, 4, and 5 were all established prior to Phase II construction and provide good photographic comparisons between Phase II pre- and post-construction (Figure 18 through Figure 21).

Pre-Phase II construction Photopoints 6 through 13 were not established; therefore direct pre- and post-Phase II construction photo comparisons are not ideal. Several trips between 2006 and 2011, however, provided photographs taken in the vicinity of established photopoints that allow for some visual comparisons between pre- and post-Phase II construction conditions. Photopoints set as part of the Phase II as-built monitoring effort provide a basis for future monitoring and photographic comparisons.

Figure 17. Photopoint 11, an example of photopoint monuments (re)-established as part of the as-built monitoring effort in January 2012. Each photopoint monument consisted of ¼ inch rebar topped with a yellow plastic cap; the rebar was wrapped with blue flagging to assist with photopoint recovery during subsequent monitoring. Locations of all photopoints are shown on Figure 2.

3.3.2 Results

Photopoint monitoring results are presented in Table 4 and Figure 18 through Figure 29. All but Photopoints 10 through 13 show some degree of pre-and post-Phase II construction.

Table 4. Summary of photo monitoring results.

Photopoint	Summary of results
1	Patch 2 panoramas show the Phase I as-built condition, the results of flows in excess of 6,000 cfs in 2006, and Phase II as-built conditions. Visually, as-built Phase II conditions closely match Phase I conditions (Figure 18).
2 and 3	See Section 4 of this report for details.
4, 5, and 7	These three photopoints document the conversion of a large in-channel gravel pit to a channel geometry scaled to the contemporary flow regime. Photos begin with Phase I as-built conditions and end with Phase II as-built conditions (Figure 19, Figure 20, Figure 21, and Figure 23).
6	The 2007 panorama shows the Phase I floodplain one year after cuttings were planted and again in 2011 with much improved growth. The Phase II as-built panorama shows the newly construction floodplain in the foreground without plantings (Figure 22).
8, 9, and 10	Photographs document Patches 9 through 14 and show pre-construction channel conditions to be relatively uniform, almost rectangular in shape, with no coarse sediment visible between the left and right banks of the channel. The January 2012 photos show alternating bars, pools, and riffles as a result of Phase II construction of Patches10 through 14 (Figure 24 through Figure 26).
11	Two photographs document as-built Phase II conditions of the off-channel gravel pits (now wetland ponds) enhancement areas (Figure 27).
12	Photos taken at the upstream end of the Phase I floodplain show the rapid growth of riparian cuttings planted in 2006 and minor road impact as a result of Phase II construction (Figure 28).
13	Photopoint 13 was established at the upstream end of the Phase I project area to document baseline conditions upstream of Patch I and into the upper end of Duck Slough for future Phases of construction at Bobcat Flat (Figure 29).

Phase I: Post-construction monitoring photopoint #1 10-13-05 looking from right to left bank at Patches 1 and 2.

Phase I: Post-2006 high flow monitoring photopoint #1 9-14-06 looking from right to left bank at Patches 1 and 2.

Phase II: Pre-2011 construction monitoring photopoint #1 6-29-2009 looking from right to left bank at Patches 1 and 2.

Phase II: Post-2011 construction monitoring photopoint #1 1-18-12 looking from right to left bank at Patches 1 and 2.

Figure 18. Photopoint #1, located at the middle of Patch 2. Photo monitoring shows the effectiveness of Patch 2 as a high flow coarse sediment recruitment source between 2005 and 2009. The top photo was taken in October of 2005 just after the construction of Patch 2 and the middle two photographs were taken after the 2006 high flows. The bottom photo was taken to document post-Phase II construction, note the similarities between the top and bottom photos.

Phase I: Post-construction monitoring photopoint #4 10-13-05 looking from right bank across Patch 5 to left bank.

Phase I: Post-2006 high flow monitoring photopoint #4 9-12-06 looking from right bank across Patch 5 to left bank.

Phase II: Pre-2011 construction monitoring photopoint #4 8-12-2011 looking from right bank across Patch 5 to left bank.

Phase II: Post-2011 construction monitoring photopoint #4 1-18-12 looking from right bank across Patch 5 to left bank.

Figure 19. Photopoint #4 located at the backside of Patch 5, looking from the right bank across Patch 5 to the left bank.

Phase I: 10-14-05 monitoring photopoint #5 looking from right bank downstream at Patch 6, for Phase I as-built conditions.

Phase I: 9-12-16 monitoring photopoint #5 looking from right bank downstream at Patch 6 post-9,000 cfs flow event.

Phase II: Pre-2011 construction monitoring photopoint #5 6-29-2009 looking from right bank downstream at Patch 6.

Phase II: Post-2011 construction monitoring photopoint #5 1-18-12 looking from right bank downstream at Patch 6.

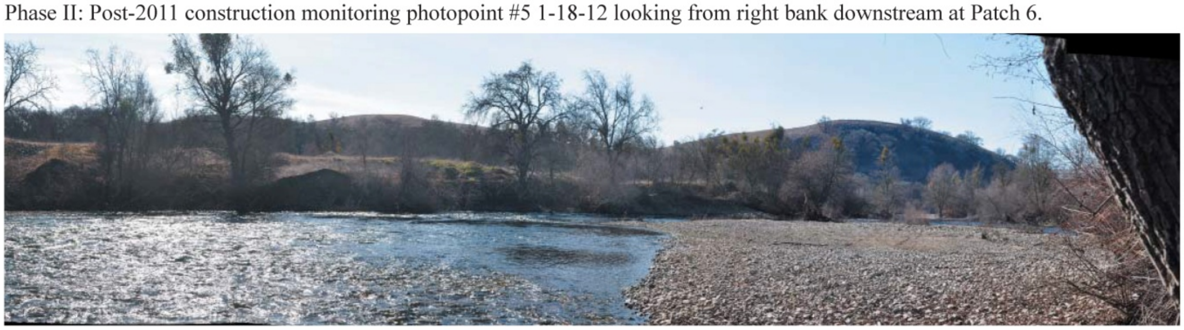

Figure 20. Photopoint #5 located at the upstream end of Patch 5. Photos indicate changes to Patch 5 as a result of high flows (2006) and fine sediment deposition (2009). The post-Phase II construction photograph also captures the 1 to 2 feet of coarse sediment placed at the upstream end of Patch 5 (shown in cross section 2395+90, Figure 13) to facilitate construction of Patches 7A and 7B.

Phase I: Post-2008 high flow monitoring photopoint #5 5-28-2008 looking from right to left bank at Patches 7A and 7B.

Phase II: Post-2011 construction monitoring photopoint #5 1-18-12 looking from right to left bank at Patches 7A and 7B.

Figure 21. Photopoint #5 located at the upstream end of Patch 5, looking from right to left bank at Patches 7A and 7B. Note the additional low flow channel confinement and increased channel velocities associated with the construction of Patch 7A.

Phase I: 2007 monitoring of photopoint #6 9-22-2007 looking at the Phase I floodplain to the left of Borrow Area 4.

Phase I: 2009 monitoring photopoint #6 6-25-2009 looking at the Phase I floodplain to the left of Borrow Area 4.

Phase II: Pre-2011 construction monitoring upstream of photpoint #6 8-12-2011 looking downstream along right bank floodplain at Borrow Area 4.

Phase II: Post-2011 construction monitoring photopoint #6 1-18-12 looking from the right bank accross Borrow Area 4 to the Phase I floodplain.

Figure 22. Photopoint #6 located along the right bank floodplain between Borrow Area 4 and the primary access road. Photo is taken looking toward the Tuolumne River.

Phase II: Pre-2011 construction monitoring photopoint #7 8-12-2011 looking from right to left bank from Patch 8 to Patches 7A and 7B.

Phase II: Post-2011 construction monitoring photopoint #7 1-18-12 looking from right to left bank from Patch 8 to Patches 7A and 7B.

Phase II: Post-2011 construction monitoring photopoint #7 1-18-12 looking at the side channel between Patch 5 and the right bank.

Figure 23. Photopoint #7 located at the downstream end of Patch 5; the top photo is looking upstream from right to left bank, the middle photo is a complete panorama looking from right to left bank with Patch 6 at the midpoint of the photo, and the bottom photo capturing the side channel between Patch 5 and the right bank.

Phase II: Pre-2011 construction monitoring approximately 300 ft downstream of photopoint #8 6-29-2009 looking from right to left bank at Patches 9-14.

Phase II: Post-2011 construction monitoring photopoint #8 1-18-12 looking from right to right bank to left bank at Patches 9-14.

Figure 24. Photopoint #8 is located on Patch 10 looking from right to left bank at Patches 9 to 14. The pre-2011 construction photo was taken from the right bank across from Patch 12.

Phase II: Pre-2011 construction monitoring opposite bank from photopoint #9 6-29-2009 looking from right to left bank at Patches 9-14.

Phase II: Post-2011 construction monitoring photopoint #9 1-18-12 looking from left to right bank at Patches 9-14.

Figure 25. Photopoint #9 is located on Patch 12 looking from left to right bank at Patches 9 to 14. The pre-2011 construction photo was taken from the right bank across from Patch 12.

Phase II: Post-2011 construction monitoring photopoint #10 1-18-12 looking from right to left bank across from Patch 14.

Figure 26. Photopoint #10 is located on Patch 14 looking from right to left bank.

Phase II: Post-2011 construction monitoring photopoint #11 1-18-12 looking into the lower constructed off-channel wetland.

Phase II: Post-2011 construction monitoring photopoint #11 1-18-12 looking into the upper constructed off-channel wetland.

Figure 27. Photopoint #11 is located between the constructed off-channel wetlands, showing integration into the surrounding constructed floodplains.

Phase I: 2007 monitoring at photopoint #12 9-22-2007 looking downstream at the Phase I floodplain.

Phase II: Pre-2011 construction monitoring 200 ft to the right of photopoint #12 8-12-2011 looking downstream at the Phase I floodplain.

Phase II: Post-2011 construction monitoring photopoint #12 1-18-12 looking downstream at the Phase I floodplain.

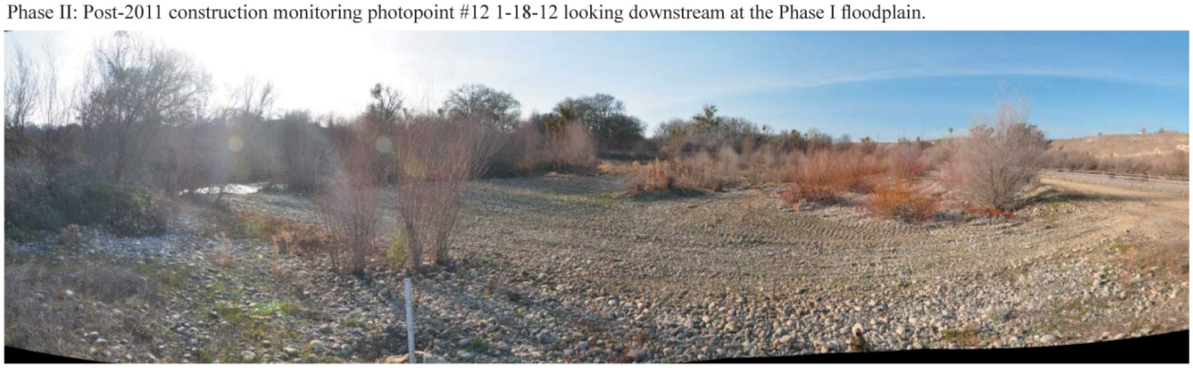

Figure 28. Photopoint #12 is located at the upstream end of the Phase I floodplain cut. Riparian cuttings were planted in the summer due to high flows late into the spring.

Phase II: Post-2011 construction monitoring photopoint #13 1-18-12 looking downstream into Duck Slough (left side of photo) and upstream into mainstem channel.

Figure 29. Photopoint #13 on the right bank pin cross section 2413+20. This photograph documents the upper end of Duck Slough and the large pool upstream of Patch 1. Both of these areas are part of the a long-term restoration plan for Bobcat Flat (M&T 2011).

3.4 Bed Texture (Pebble Counts and Bulk Samples)

Pebble counts (Leopold 1970) were used to document bed surface texture at riffles and augmentation patches within the Phase I and Phase II project boundaries. As-built pebble counts as part of the Phase II monitoring effort were done at Patches 2 and 10 (Figure 2). Phase II January 2012 as-built pebble counts at Patch 2 were compared to 2005 and 2006 pebble counts done as part of the Phase I pre-construction and as-built monitoring efforts (M&T 2006) and 2008 pebble counts done for the Peaslee Creek fine sediment impact monitoring (M&T 2008). To further document the texture of coarse sediment placed into the channel, one composite bulk sample was collected at Patch 2 (Figure 2). Additional pebble counts (Patch 3 and Riffle 20) and bulk samples (Patches 3 and 5, Figure 2) were collected to document substrate changes between 2008 and 2012 at Phase I project areas and are provided in Section 4 of this report.

3.4.1 Pebble Count Methods

Within each project area sampled, a modified Wolman-style pebble count of 100 grains was conducted to document the bed surface particle size distribution. For each of the 100 grains sampled the “b” width was measured. The “b” width represents the width of an individual grain that would not pass a specific screen size. Pebble counts were entered into a Microsoft Excel spreadsheet and sorted by rank (size). Sorted pebble counts were then plotted for each year monitored. In addition, for each pebble count, the statistical particle sizes (D_{84} and D_{50}) were computed (Leopold 1970, Bunte and Abt 2001) and are included on the charts.

3.4.2 Pebble Count Results

As-built monitoring pebble counts at Patches 2 and 10 were ranked by grain size and plotted (Figure 30 and Figure 31). A comparison of Phase I (2005) and Phase II (2012) Patch 2 as-built pebble counts indicates that above the 35 mm particle size, coarse sediment placed in 2012 was finer than that placed in 2005 (Figure 30). This change is a direct result of the use of 4 in x 4 in square screen during Phase II construction as opposed to the 5 in x 5 in screen used during Phase I construction. The Bobcat Flat RM 43 – Phase I As-Built Monitoring Final Report recommended the use of a 4 in x 4 in screen for future Bobcat Flat restoration phases (M&T 2006a).

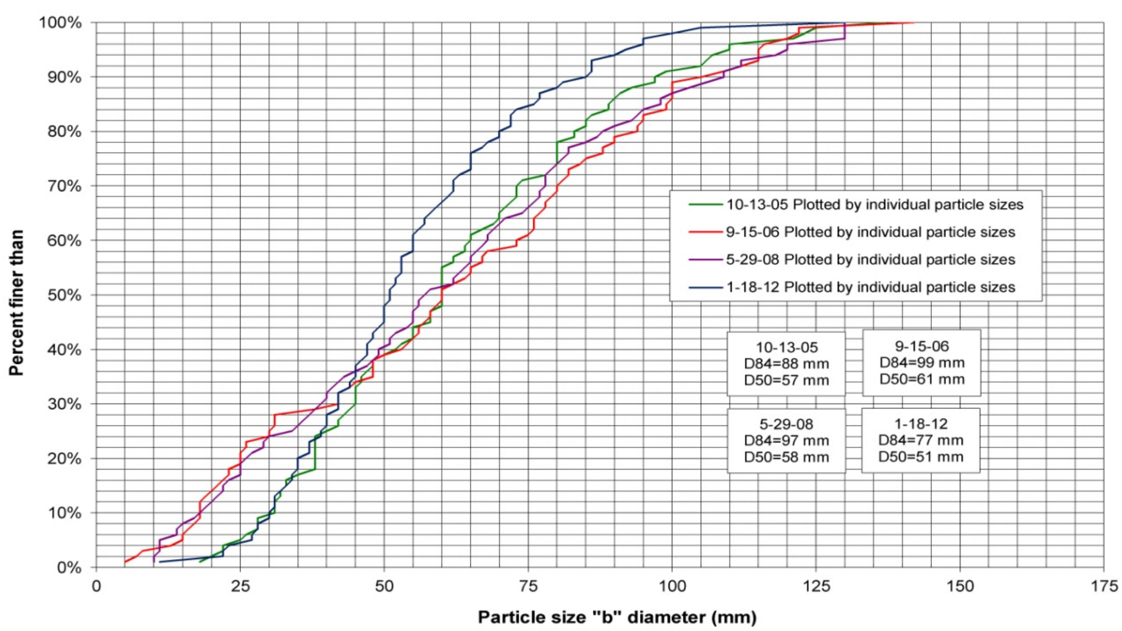

Figure 30. Summary of Patch 2 pebble count results starting with Post-Phase I construction in October, 2005 and ending with Phase II as-built in January, 2012.

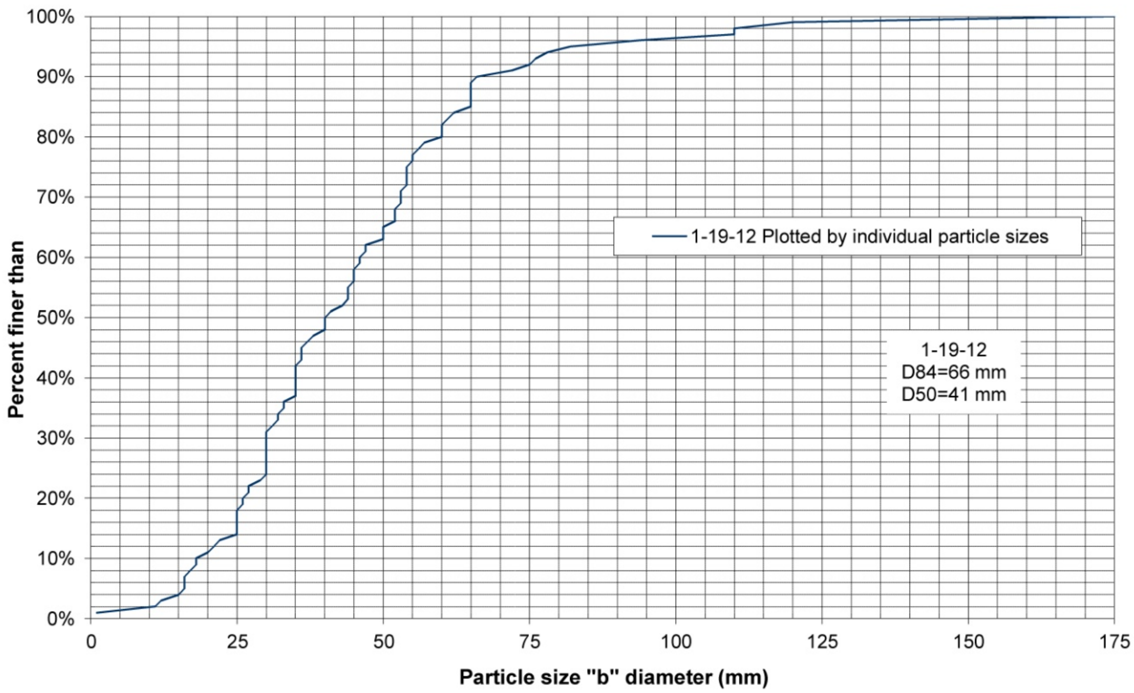

Figure 31. Pebble count results Phase II, Patch 10.

3.4.3 Bulk Sample Methods

Because the coarse sediment placed at all patches was free of fines and well mixed, one bulk sample was collected by shovel (rather than using a McNeil sampler) within Patch 2 (Figure 2). Two additional bulk samples were collected at Phase I Patches 3 and 5; these results are provided in Section 4. The composite sample weighed approximately 240 lbs and consisted of four sub-samples collected across augmentation Patch 2 (Figure 2, Figure 32). Subsample locations were selected to represent texture variability within the patch. Bulk samples were analyzed by Graham Mathews and Associates (GMA), using standard American Standards for Testing & Materials (ASTM) procedures. Sieve sizes used in the analysis are shown in Figure 33.

Figure 32. Pre- and post-shovel excavation at one of the sub-sampling locations Phase I, Patch 2.

Hydrology | Geomorphology | Stream Restoration

BULK SAMPLE: PARTICLE SIZE ANALYSIS

River:	**Tuolumne River**	**Sample #**	**Patch 3 Bag 1**
Location:	**Bobcat Flat**	**Date Collected:**	**1/19/2012**
Crew:	**MTI**	**Method of Collection:**	**Dry Shovel Excav**
Description		**Surface/Sub-surface**	
Sampler		**Bag # of #**	

Date Processed: **2/7/2012**
Processed by: **BC** **UNITS** **G**

------------------- WEIGHT ------------

Sieve	Finer than	Final Net	%	Cum%<
256		0.0	0.0%	100.0%
180	256	0.0	0.0%	100.0%
128	180	0.0	0.0%	100.0%
90	128	0.0	0.0%	100.0%
64	90	3620.0	13.6%	100.0%
45	64	2090.0	7.9%	86.4%
31.5	45	4480.0	16.8%	78.5%
22.4	31.5	3970.0	14.9%	61.7%
16	22.4	2760.0	10.4%	46.8%
11.2	16	2030.0	7.6%	36.4%
8	11.2	1670.0	6.3%	28.8%
5.6	8	888.9	3.3%	22.5%
4	5.6	634.3	2.4%	19.2%
2.8	4	464.0	1.7%	16.8%
2	2.8	345.2	1.3%	15.0%
1	2	787.6	3.0%	13.7%
0.85	1	310.8	1.2%	10.8%
0.5	0.85	1460.2	5.5%	9.6%
0.25	0.5	868.5	3.3%	4.1%
0.125	0.25	127.7	0.5%	0.8%
0.063	0.125	55.3	0.2%	0.4%
Pan	0.063	42.6	0.2%	0.2%
TOTAL:				

SIZE PARAMETERS

D5	0.5 mm
D16	3.4 mm
D25	9.1 mm
D35	15.0 mm
D50	24.2 mm
D65	34.2 mm
D75	41.9 mm
D84	57.5 mm
D90	70.1 mm
dg	15.5 mm

ADDITIONAL NOTES:

Dmax= 112.0 mm
Dmax mass= 765 g

Sample Dry Wt 26660 - Total Processed Wt 26605 = Net Loss: 54.8
% of Sample: 0.21%

Figure 33. GMA's bulk sample particle size analysis data sheet.

3.4.4 Bulk Sample Results

Bulk sample results for Patch 2 were plotted and provide a comparison between Phase I and Phase II as-built conditions (Figure 34). Flows in excess of 6,000 cfs mobilized most of the Phase I coarse sediment placed at Patch 2 to places downstream (Figure 18, M&T 2006). Therefore, only two bulk samples have been collected at Patch 2, one in 2005 and one in 2012 (Figure 2). The results show a finer coarse sediment was added during the Phase II construction, this is likely due to the use of a 4 x 4 inch upper screen size verses the 5 x 5 inch upper screen size used in the 2005 Phase I construction (Figure 34). The resulting coarse sediment added to Patch 2 during Phase II construction closely matches coarse sediment size recommendations from the Tuolumne River Coarse Sediment Management Plan (CSMP, M&T 2004) (Figure 34).

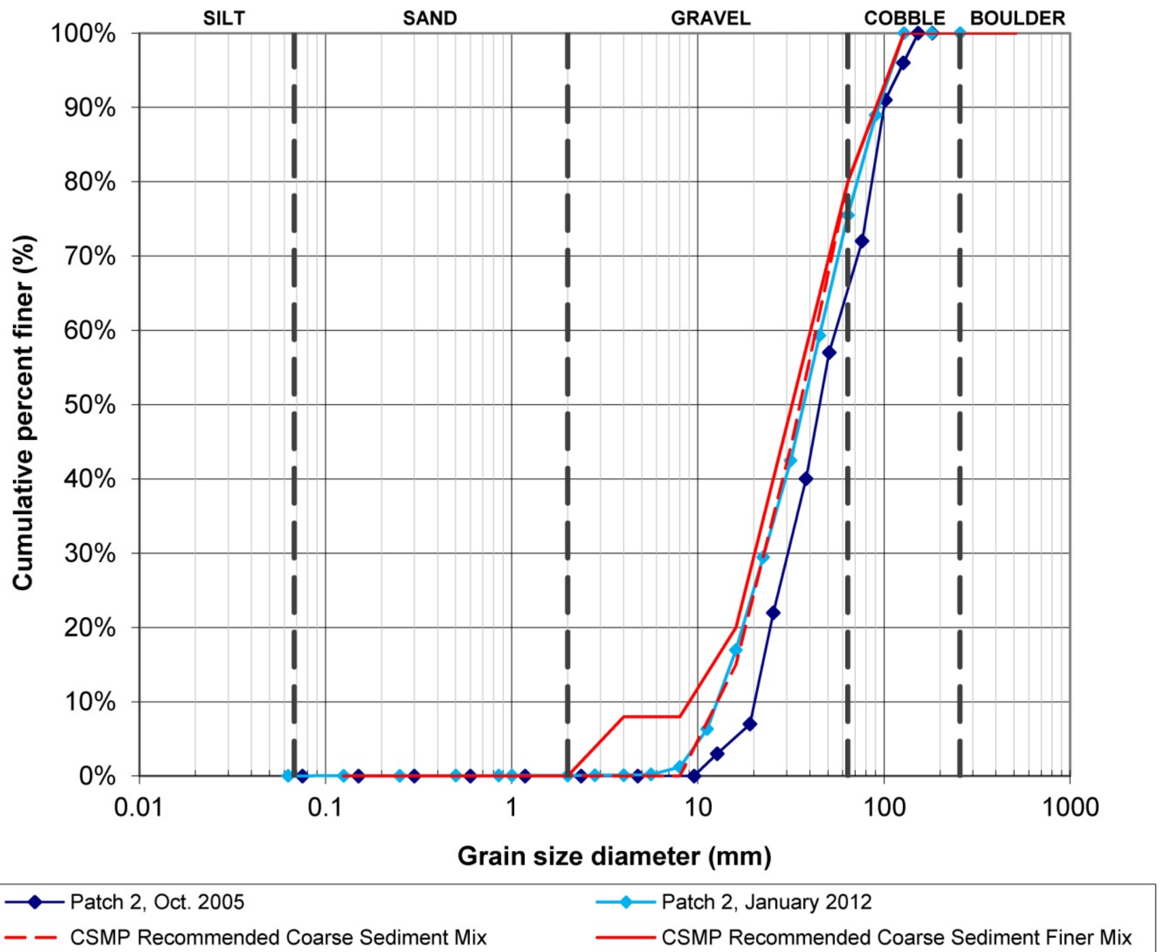

Figure 34. Patch 2 summary of bulk sample results for Phase I and Phase II as-built conditions compared to the recommended coarse sediment mix presented in the Tuolumne River Coarse Sediment Management Plan (M&T 2004).

3.5 Phase II Discussion

Restoration strategies outlined in the Phase II Bobcat Flat Gravel Augmentation Project (M&T 2006b) and implemented as part of the Phase II project included:

- Restoration Strategy A. Channel rehabilitation by addition of large volumes of coarse sediment at the downstream end of steep riffles, thereby better distributing the slope and increasing spawning and rearing habitat (Figure 35).
- Restoration Strategy B. Channel reconstruction by means of placing gravel into the channel and contouring a more natural pool-riffle sequence to distribute the slope (Figure 36).
- Implementation of Restoration Strategies A and B will introduce clean gravel obtained and processed on-site. A portable screen will be used to remove sand sized fractions, as well as larger cobbles, with remaining materials in the spawning gravel/cobble size classes added to the river.

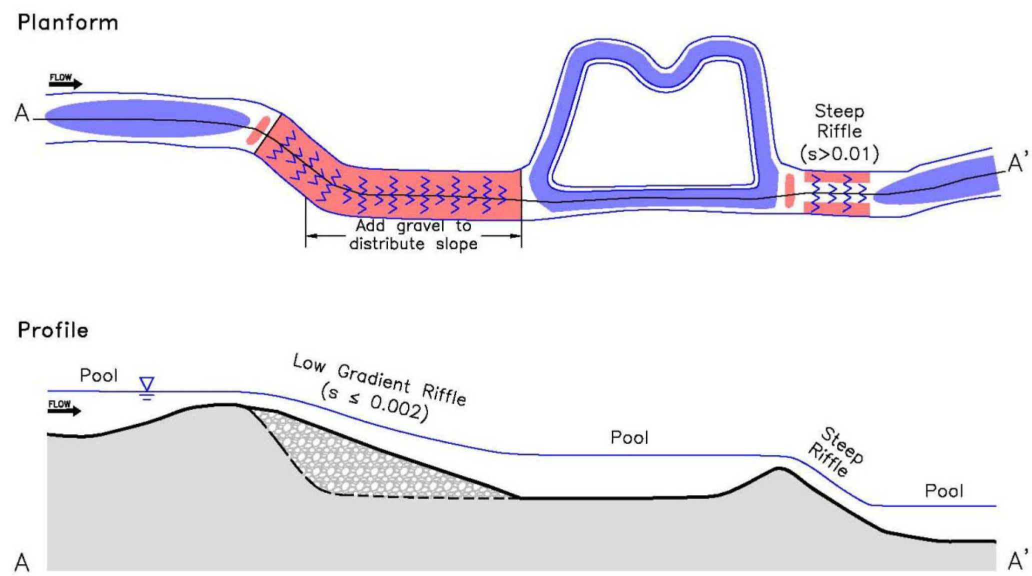

Figure 35. Restoration Strategy A – Addition of coarse sediment at the downstream end of a steep riffle to lengthen and redistribute slope.

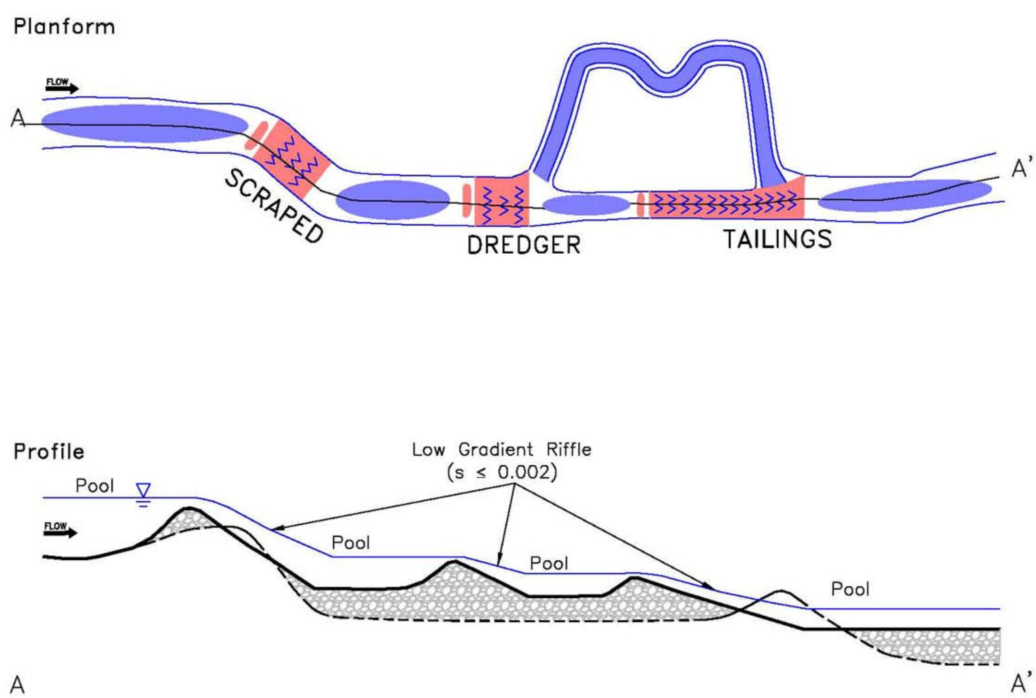

Figure 36. Restoration Strategy B – Redistribute channel slope by addition of coarse sediment in a series of pools and riffles to redistribute existing slope.

Phase II as-built monitoring results provide comparisons to determine if Restoration Strategies A and B were met and to provide guidance for future projects within the Bobcat Flat property and other projects within the Tuolumne River corridor below La Grange Dam.

As-built monitoring results meeting Restoration Strategies A and B include:

- Coarse sediment placed at the downstream end of Riffle 21 (Figure 2, Figure 16) reduced channel slope from 1% to 0.1% and increased the overall riffle length by 70 ft.

- Approximately 11,000 yd^3 of coarse sediment were successfully added to Patches 10 – 14 (Table 2), converting one long pool into a series of three alternating riffle-pool sequences beginning at Patch 9 (Figure 14 and Figure 24 through Figure 26). Total riffle length increased from 50 ft to 300 ft, increasing available salmonid spawning and rearing habitat, reducing predatory fish habitat, and increasing BMI habitat.
- Topographic and photo monitoring showing coarse sediment can be excavated in large quantities from hydraulically disconnected surfaces adjacent to the Tuolumne River, be sorted, and successfully placed into the channel, with the result of improving mainstem channel geometry and floodplain hydraulic connectivity to the contemporary flow regime (Figure 9, Figure 22, and Figure 23).

Future projects within the Bobcat Flat property boundary and/or downstream of the La Grange Dam should consider the following:

- Use of a 4x4 inch upper screen size, as recommended in M&T 2006a, resulted in a coarse sediment size that met the CSMP coarse sediment recommendations (Figure 34).
- Proper placement of an upstream coarse sediment source can result in successful recruitment by high flows. Patch 2 provides the perfect location for a short-term high flow coarse sediment recruitment pile. Cross section 2412+10 clearly shows that coarse sediment added to Patch 2, as part of the Phase I project, was mobilized by high flows in 2006 and again in 2011 (Figure 11) and is assumed to be providing coarse sediment supply to downstream reaches. At minimum, coarse sediment should continue to be added to Patch 2 after flows in excess of 6,000 cfs have been met or exceeded, or coarse sediment storage volumes upstream of Patch 1 are in balance, such that coarse sediment into Patch 1 equals coarse sediment out of Patch 1. Post-2006 high flow monitoring of Patch 1 (Figure 2) showed little to no topographic change (M&T 2006), indicating that contemporary flows are likely not transporting coarse sediment through this reach of the Tuolumne River. Photopoint 13 shows a long slow pool upstream of Patch 1 that is and most likely will be trapping coarse sediment into the future (Figure 29).
- Use of a 25% contingency when estimating coarse sediment augmentation volumes should continue. For the total Phase II project, coarse sediment volumes estimated with a 25% contingency nearly met the actual coarse sediment placed within all Phase II patches (Table 2).

4 ADDITIONAL MONITORING

4.1 Background and Rationale for Additional Monitoring

During the 2007 AFRP proposal process, several comments and questions were raised concerning the benefits associated with coarse sediment augmentation in regulated rivers. One AFRP reviewer stated:

> The use of coarse sediment to break up long pools and create more spawning habitat is questionable. There is evidence that gravel augmentation in a regulated river is often unsuccessful and may even be detrimental. "…there is some concern that gravel augmentation efforts may cause detrimental changes to channel morphology under a regulated flow regime, such as reductions in channel width, pool filling, and channel migration, due to inadequate transport and routing of these added coarse sediments." (CALFED 2005). While pool filling and channel migration are probably desirable in this case, past efforts at gravel augmentation in regulated rivers have experienced initial success followed by declining benefits as fine sediment has filled interstitial voids, in the absence of flushing flows that periodically mobilize gravel and wash out fines. A secondary problem is the gradual dispersion of habitat elements as downstream sediment transport exceeds the rate

> of sediment replenishment from upstream. A key to whether this design will be successful is the relationship between the critical shear stress (entrainment threshold) of the gravel relative to the boundary shear stress of flows. Creation of riffles can also have the effect of drowning out existing riffles upstream, so that there is little net change in spawning habitat. This component of the restoration plan (Point Bar/Pool Tail/Riffle Series) is less well justified than the other project elements, and if cuts in scope are required this would be the obvious area. Given the interest in gravel augmentation in regulated rivers I would recommend inclusion of this element as a research project, but in this case it needs to be better supported by the Project Performance Evaluation Plan, recommended examples:
>
> Creation of the Point Bar/Pool Tail/Riffle features at the downstream end of the project will trigger channel migration and increased sinuosity that will sustain transport of bedload, creating and maintaining sustainable spawning habitat in the long term. Monitoring would measure bank migration rates compared to historic rates from aerial photos, and measure particle size or bed permeability for evidence of interstitial filling by fines.
>
> Another aspect to test would be the long term morphology of the introduced riffles, to test the laboratory research of Lisle et al. (1997) that shows that such features tend to diffuse over time. It would also be helpful to assess the long term viability of spawning habitat in the side channels to examine if they degrade over time.

The questions raised by AFRP are at the core of the restoration strategy being used to rebuild the river ecosystem within Bobcat Flat. There are similarities to other restoration programs in California, such as the Trinity River Restoration Program. The Trinity River Restoration Program's foundational documents propose to restore a functional ecosystem by combining regulated flows with long-term gravel augmentation, and one-time mechanical restoration, that re-scales the channel geometry and floodplain topography to a contemporary flow regime (USFWS & HVT 1999).

Although additional project monitoring of Phase I elements was not funded as part of the Phase II as-built monitoring contract, FOT was able to fund limited additional monitoring effort. The intention of the additional monitoring effort was to respond to questions being raised as to the effectiveness of coarse sediment augmentation on the Tuolumne River. The Phase I project added approximately 11,000 yd^3 of coarse sediment to six patches during the summer of 2005 (M&T 2006a). Additional monitoring efforts included topographic and cross section surveys and sediment sampling at Phase I project areas, that attempt to answer the following questions:

1. Can the addition of appropriately scaled coarse sediment break up long pools and steep drops to result in a pool-riffle channel geometry scaled to contemporary flow regimes?
2. Over time, will addition of coarse sediment reduce the existing channel complexity by filling in pools, scouring bars, and/or eliminating side channels and alcoves?
3. Can high flow coarse sediment recruitment piles prevent degradation of downstream constructed coarse sediment features, such as riffles and bars?
4. Will mainstem channel geometry and floodplain surfaces scaled to a contemporary flow regime maintain coarse sediment suitable for spawning and rearing salmonids within the active channel?

Although additional monitoring was limited, some opportunity to assess topographic, sediment composition, channel complexity, and vegetation changes between October 2005 and January 2012 can be evaluated from the additional monitoring data collected.

4.2 Topography

4.2.1 Methods

Two monitoring surveys were used to evaluate topographic changes between September 2006 and May 2011. The first topographic monitoring was completed in September 2006 by M&T to document changes as a result of flows in 2006 that exceeded 6,000 cfs (Figure 10). The second was completed in May of 2011 by USFWS to provide baseline topography to evaluate pre-construction salmonid habitat using a 2-D hydrodynamic model. AutoCAD Civil 3D was used to compare September 2006 and May 2011 topography by subtracting the 2011 from the 2006 topography. The result is a topographic map showing feet of difference between the two surfaces. A positive number indicates fill (deposition) and a negative number indicates cut (scour) between 2006 and 2011. A "no change" in topography was set to include cut of up to − 0.25 ft and fill of up to + 0.25 ft. This +/- 0.25 ft range accounts for measurement errors associated with grain size and equipment limitations.

A second surface comparison was done to evaluate pool depths and determine if a uniform channel bed is occurring as a result of the Phase I coarse sediment addition. The May 2011 topography was subtracted from a September 2005 water surface elevation survey (Q = 250 cfs at La Grange). The results are shown as feet above (+) or below (-) the 250 cfs water surface elevation.

4.2.2 Results

Topographic differencing between 2006 and 2011 (Figure 37) showed areas of scour (< -0.25 ft), deposition (> +0.25 ft), and/or no net change (< +0.25 ft and > -0.25 ft) as a result of flows in excess of 6,000 cfs (Figure 10), including:

- Cut/fill volumes within the 2006 topographic mapping boundary totaled 900 yd^3 of cut and 1,200 yd^3 of fill;
- Little to no topographic change at Patch 1;
- Upwards of 6 ft of scour at Patch 2 and 5 ft of deposition between Patches 2 and 3;
- Alternating bank scour and mainstem deposition between Patches 3 and 4; and
- 1 to 2 ft of deposition within the middle portion and up to of 4 ft of scour along the downstream right bank of Patch 4 (Figure 37).

Subtracting the May 2011 topography from the September 2005 water surface elevation provided depths above, at, or below the 250 cfs water surface elevation (Figure 38). Figure 38 shows the maintenance of pools, runs, riffles, and bars between Patches 1 and 6, including:

- Riffles at or near Patches 2, 3, 4, and 6 that are 1 to 4 feet deep;
- Pools in excess of 6 ft deep between Patches 3 and 4 and adjacent to Patch 5;
- Medial bar forming at Patch 3 and right bank bars downstream of Patch 2 and at Patch 5; and
- Long runs (3 to 6 ft deep) along the left bank of Patch 3 and right bank downstream of Patch 4.

4.3 Cross Sections

Cross sections 2403+95 and 2408+10 (Figure 2) were surveyed to document changes between pre-Phase I construction in May 2003 and current conditions in January 2012 at Patches 3 and 4. Cross sections at Patches 2 and 5 are summarized in Section 3.2.

4.3.1 Methods

Cross section survey methods are consistent with those reported in Section 3.2.1.

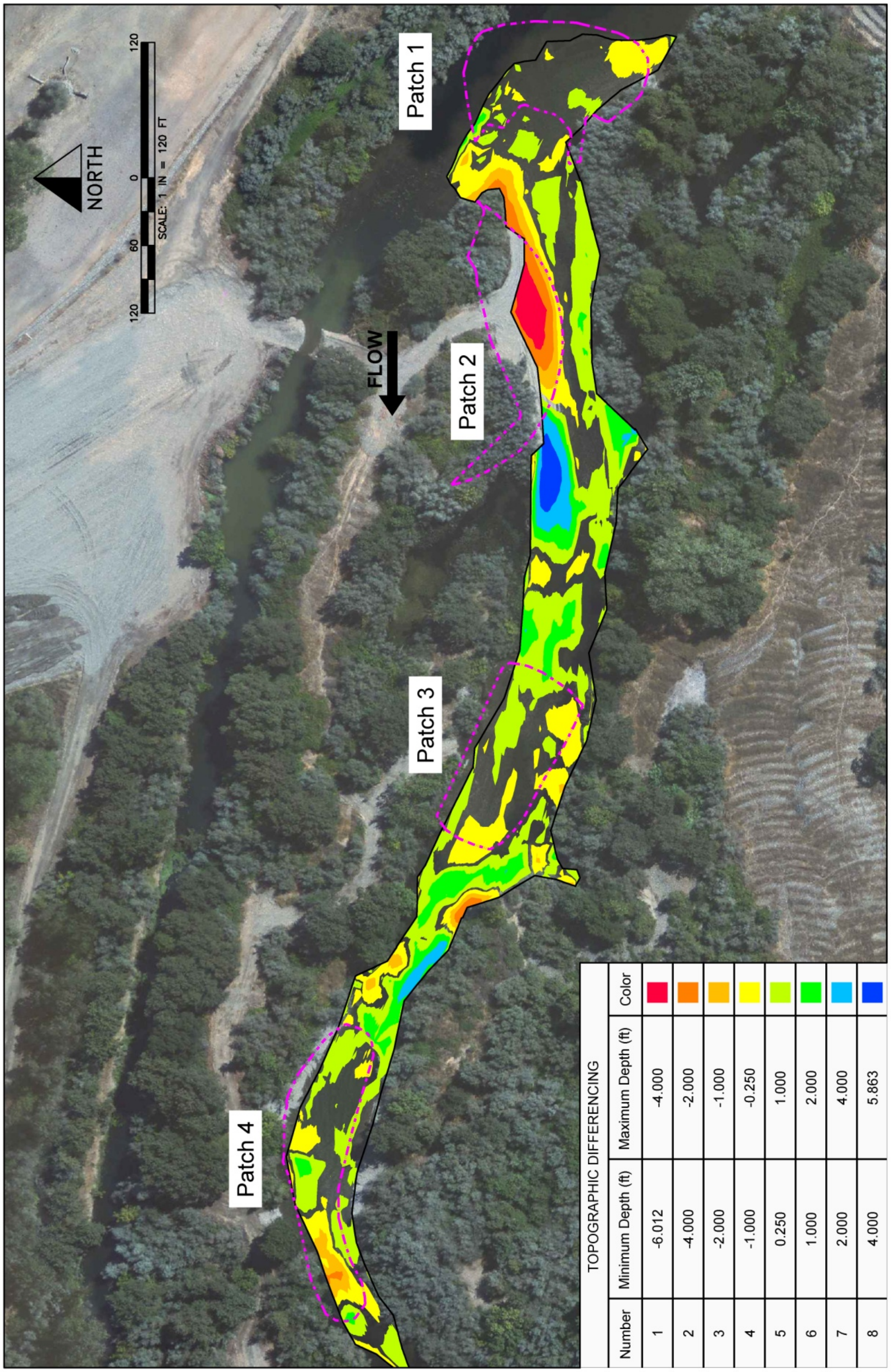

Figure 37. Topographic differences at Phase I Patches 1 through 4 showing feet of deposition and scour between 2006 and 2011 as a result of flows in excess of 6,000 cfs (Figure 10).

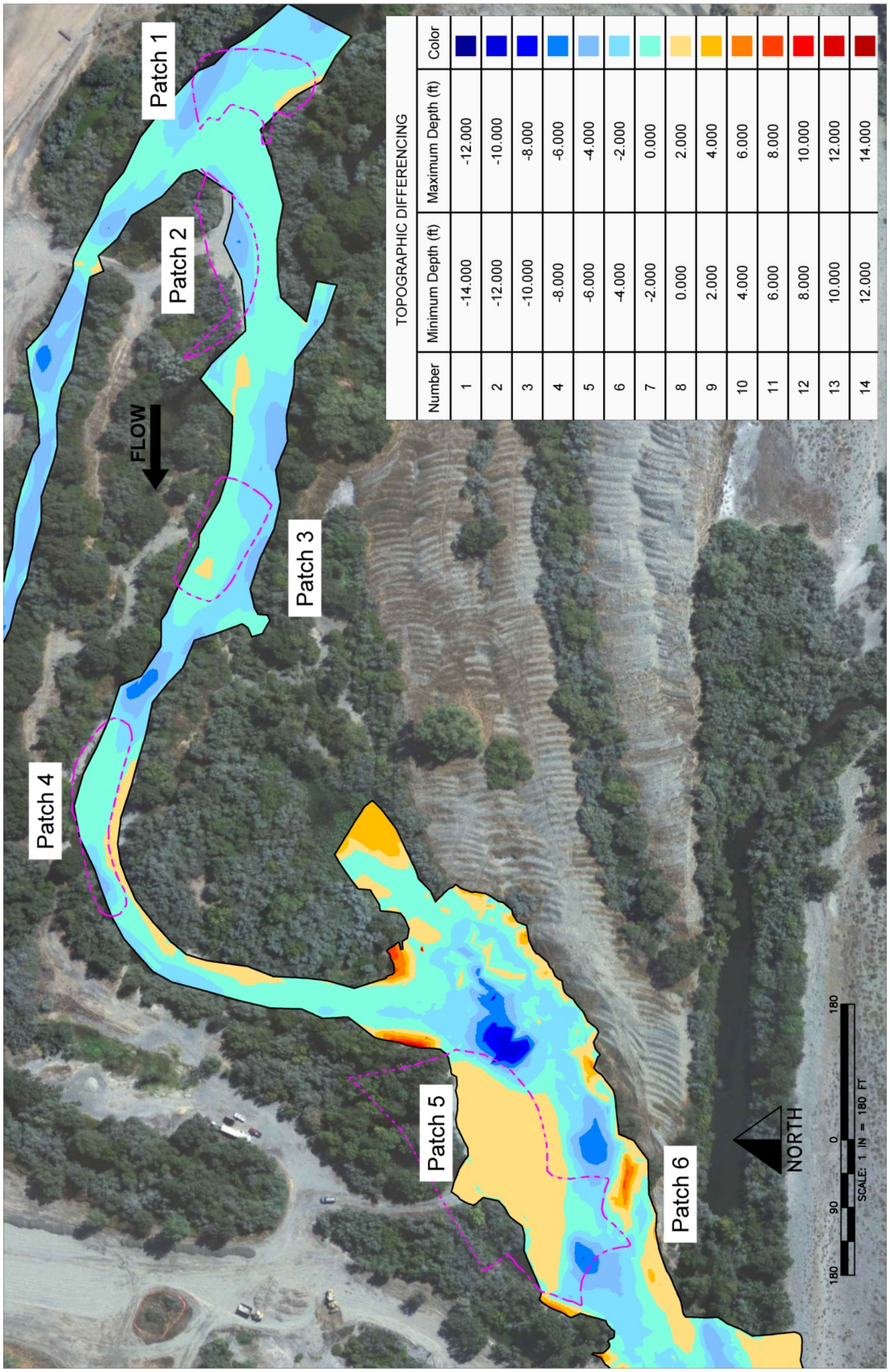

Figure 38. Depth of the May 2011 ground surface above and below the September 2005, approximately 250 cfs, water surface elevation.

4.3.1 Results

Cross section 2403+95 at Patch 4 (Figure 2), showed little change to the bed topography with up to 1 ft of deposition along the right bank constructed point bar (Figure 39). Cross section 2408+10 at Patch 3 (Figure 2), showed approximately 1 ft of deposition through the cross section below the surveyed water surface elevations (Figure 40). This cross section surveys may indicate that sediment supply is in balance through Patch 4 and that the channel geometry at Patch 3 has reached equilibrium, with deposition occurring uniformly across the active channel. However, deposition at Patch 3 may also indicate that the mainstem channel is continuing to adjust vertically, using coarse sediment supplied by Phase I construction and bank scour (Figure 37) to redistribute in-channel slope between Riffles 20 and 21.

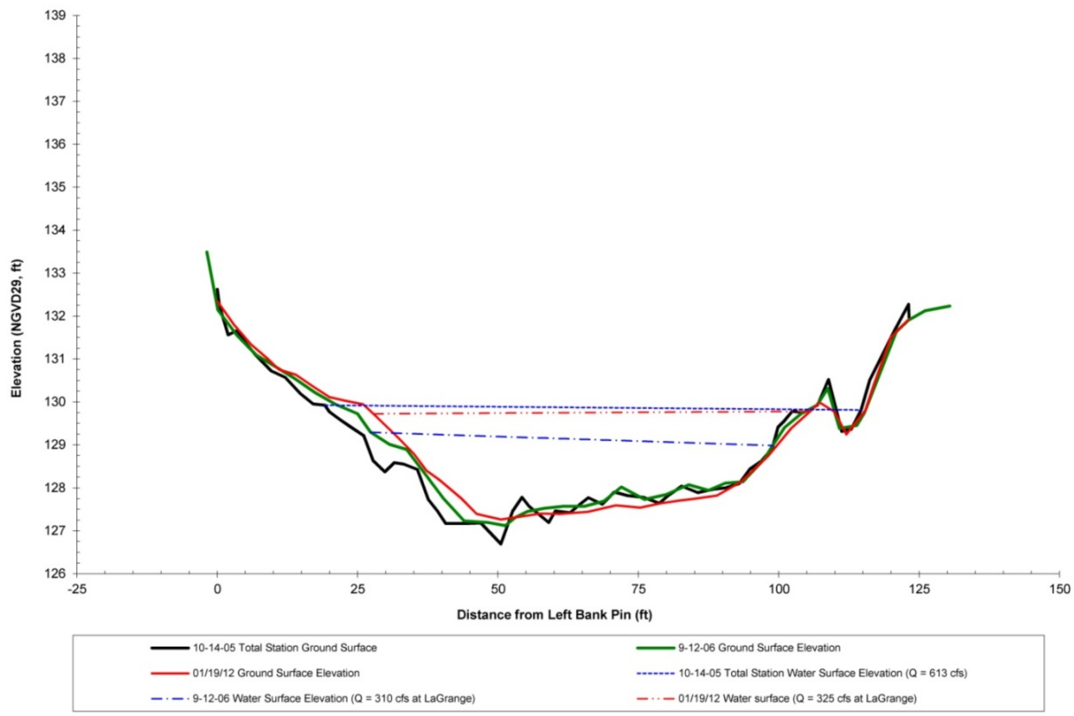

Figure 39. Cross section 2403+95, Patch 4, monitoring results from October 2005 (post-Phase I construction) and January 2012.

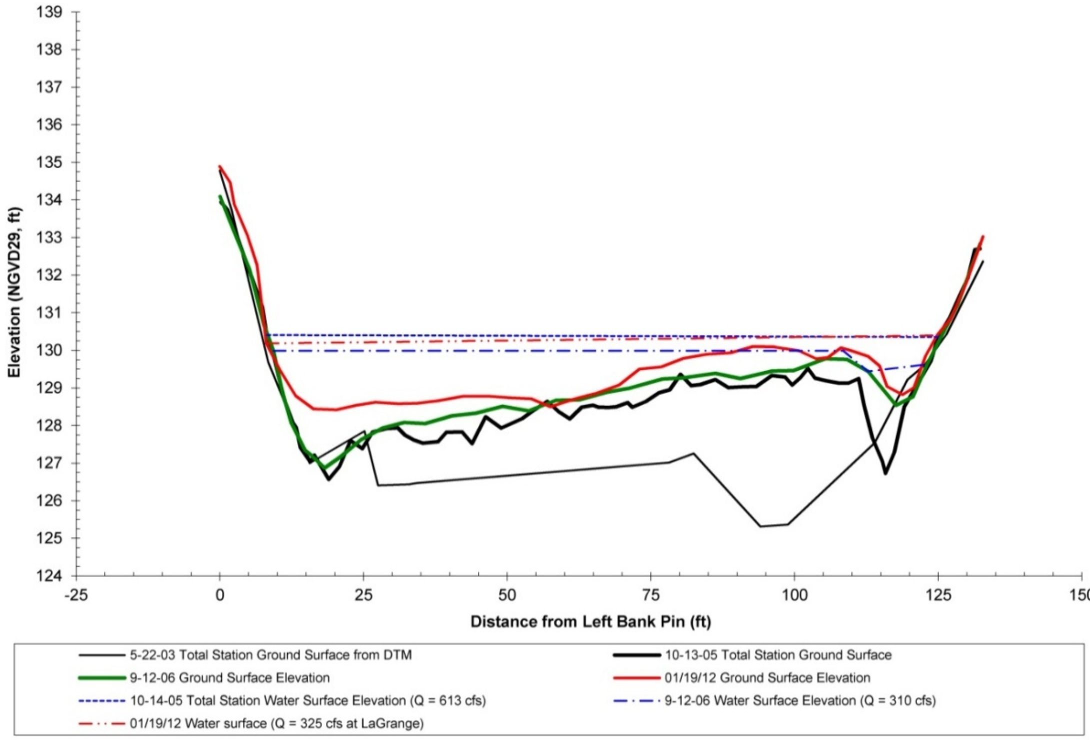

Figure 40. Cross section 2408+10, Patch 3, monitoring results from May 2003 (pre-Phase I construction), September 2006 post-Phase I construction, and January 2012.

4.4 Pebble Counts and Bulk Samples

Pebble counts were conducted at Patch 3 and Riffle 20 and bulk samples collected at Patches 3 and 5, (Figure 2). Pebble counts and bulk samples were collected at Phase I project areas to document substrate changes between 2003 and 2012 in an effort to evaluate lasting geomorphic impacts and quality of the Phase I gravel augmentation.

4.4.1 Pebble Count Methods

Pebble count methods are consistent with those described in Section 3.4.1.

4.4.2 Pebble Count Results

As-built monitoring pebble counts at cross section 2412+90 in Riffle 20 (Figure 41), and Patch 3 (Figure 42) were ranked by grain size and plotted. A comparison of pebble counts at Riffle 20 showed a fining of the surface grain size with the D_{84} and D_{50} particle sizes decreasing from 95 mm (3.75 in) to 60 mm (2.4 in) and 51 mm (2 in) to 34 mm (1.33 in) respectively (Figure 41). Results are similar at Patch 3 with the D_{84} and D_{50} surface particle sizes decreasing from 83 mm (3.25 in) to 57 mm (2.25 in) and 56 mm (2.2 in) to 35 mm (1.4 in) respectively (Figure 42). Results also showed that only 5% of the surface grain size is less than 10 mm (0.4 in) (Figure 41 and Figure 42).

4.4.3 Bulk Sampling Methods

Bulk sampling methods are consistent with those described in Section 3.4.3.

4.4.4 Bulk Sampling Results

The bulk samples taken at Patch 3 showed an overall fining of material with a grain size distribution in October 2005 (Phase I as-built) of 0% sand (0.07 mm to 2 mm), 55% gravel (2 mm to 64 mm) and 45% cobble (64 mm to 300 mm), and in January 2012 of 12% sand, 82% gravel and 6% cobble

(Figure 43). Bulk sample results at Patch 5 showed a much more substantial fining of grain size distribution between October 2005 (Phase I as-built) and January 2012. Coarse sediment distribution in October 2005 consisted of 0% sand, 55% gravel, and 45% cobble, and in January 2012 of 35% sand, 60% gravel and 5% cobble (Figure 44).

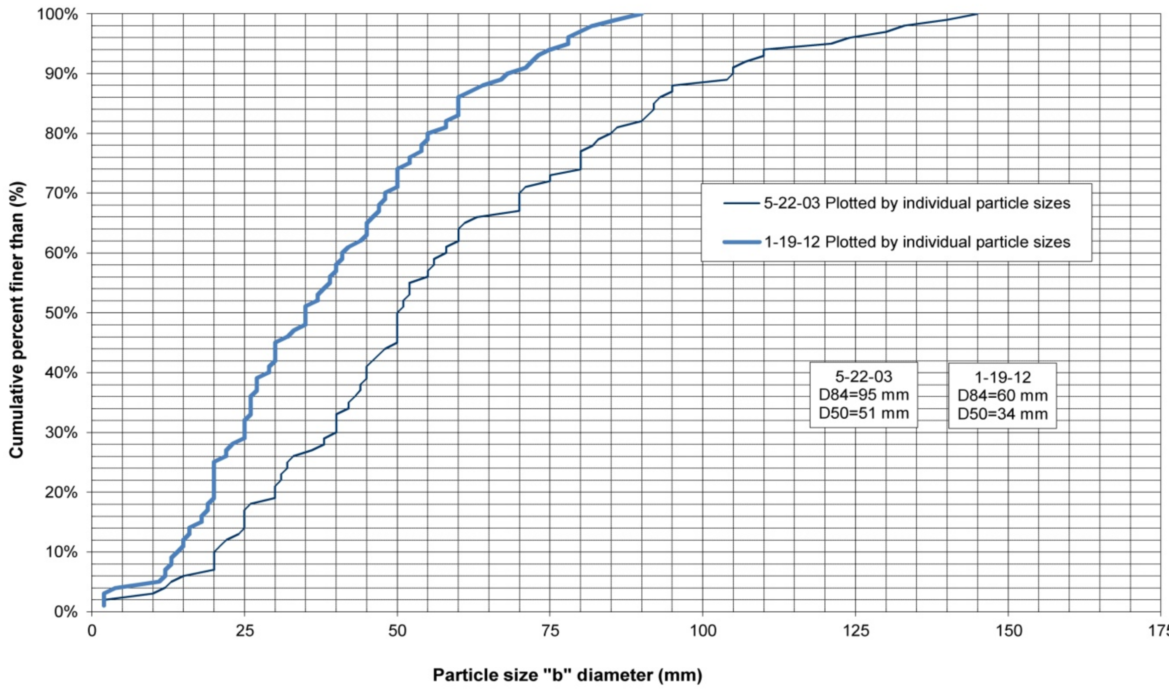

Figure 41. Summary of Riffle 20, cross section 2412+90 pebble count results starting with pre-Phase I construction in May 2003 and ending with post-Phase II construction in January 2012.

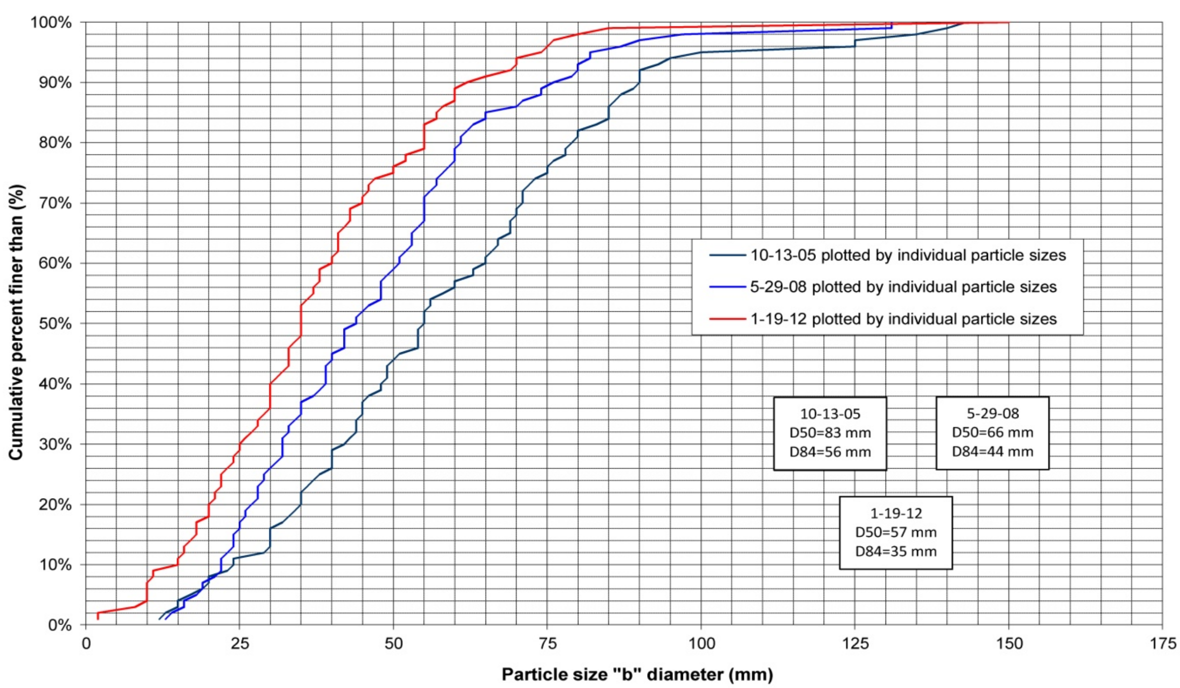

Figure 42. Summary of Patch 3 pebble count results starting with post-Phase I construction in October, 2005 and ending with post-Phase II construction in January 2012.

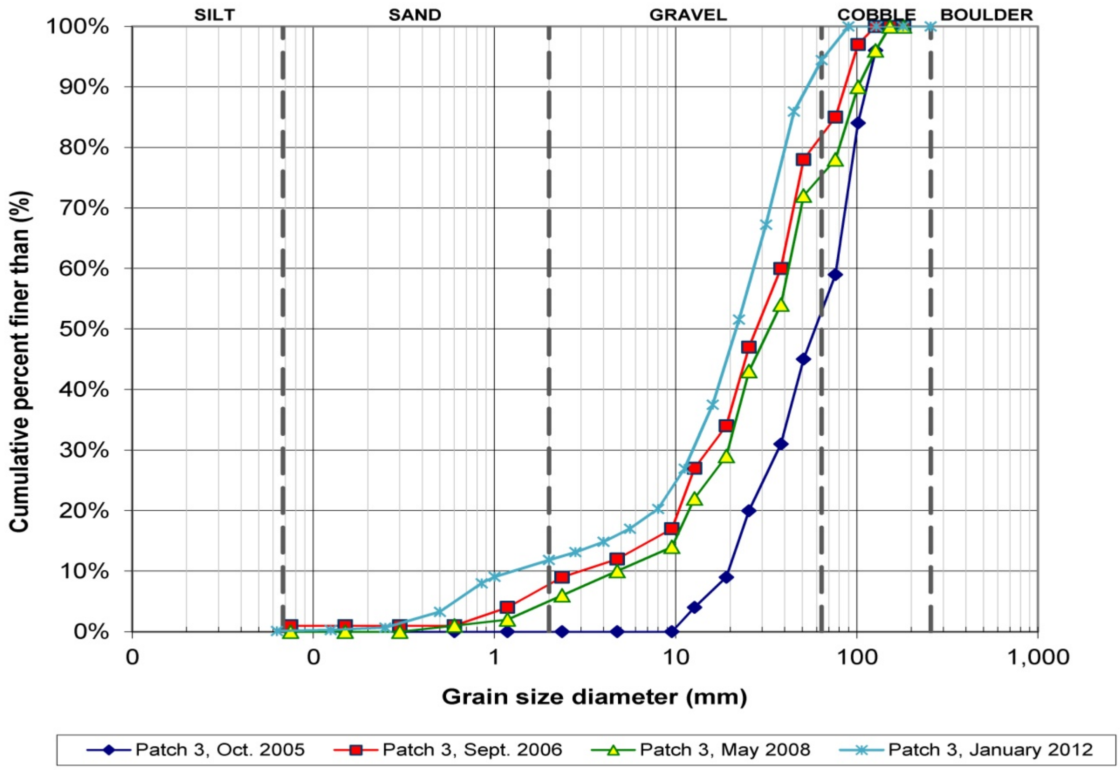

Figure 43. Summary of Patch 3 bulk sampling results starting with post-Phase I construction in October, 2005 and ending with post-Phase II construction in January 2012.

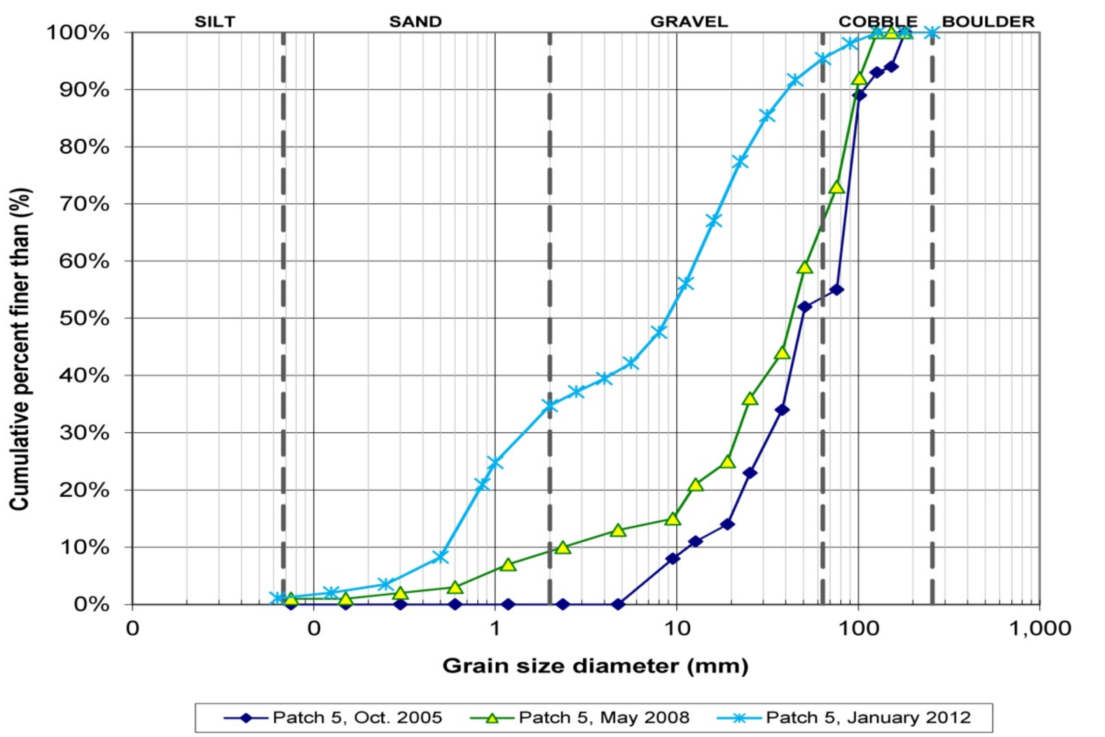

Figure 44. Summary of Patch 5 bulk sampling results starting with post-Phase I construction in October, 2005 and ending with post-Phase II construction in January 2012.

4.5 Phase I Photopoints – 2005 Pre-Phase I Construction to January 2012

Photopoints provide a visual way to document changes within a project area due to construction or natural events such as high flows. Five photopoints were established within the Bobcat Flat property post-Phase I construction. Three of the Phase I photopoints (1, 4, & 5) were monitored as part of the Phase II as-built monitoring and are reported in Section 3.3. The remaining two Phase I photopoints (2 & 3) are reported below.

4.5.1 Methods

Pre-Phase I construction photographs were compiled from Phase I planning and data collection trips to Bobcat Flat; therefore, pre-Phase I construction photos are approximate. Photopoints 2 and 3 were established in October 2005 post-Phase I construction and reoccupied in September 2006, May 2008, and January 2012. Each photographic panorama consists of several photographs stitched together using Microsoft ICE.

4.5.2 Results

Photopoint monitoring results for Photopoints 2 and 3 are presented in Figure 45 and Figure 46. Photopoint #2 showed the deposition of coarse sediment in the form of a medial bar between October 2005 and September 2006. In addition, a large tree along the left bank was recruited into the river between September 2006 and May 2008 indicating lateral scour along the left bank toe. Photopoint #3 showed reworking of the coarse sediment between October 2005 and January 2012 with no obvious change in coarse sediment storage or channel geometry. A large alder along the right bank (top left of each photograph from October 2005 to May 2008) was recruited into the river between May of 2008 and January 2012. This indicates lateral scour along the toe of the right bank and likely channel migration into the right bank.

Pre-construction looking downstream from Patch 2 into Patch 3.

Pre-construction looking from right to left bank at Patch 3.

Post-construction photopoint #2 10-13-05 looking from left to right bank at Patch 3.

Post-2006 high flows photopoint #2 9-13-06 looking from left to right bank at Patch 3.

Photopoint #2 5-28-08 looking from left to right bank at Patch 3.

Post-2011 high flows photopoint #2 1-18-12 looking from left to right bank at Patch 3.

Figure 45. Photopoint #2, located on the left bank across from Patch 3. Note the development of a medial bar and large wood recruitment as a result of high flows and coarse sediment additions.

Pre-construction panorama looking from right to left bank at Patch 4.

Post-construction photopoint #3 10-13-05 looking from left to right bank at Patch 4.

Post-2006 high flows photopoint #3 9-13-06 looking from left to right bank at Patch 4.

Photopoint #3 5-28-08 looking from left to right bank at Patch 4.

Post-2011 high flows photopoint #3 1-18-12 looking from left to right bank at Patch 4.

Figure 46. Photopoint #3, located at the middle of Patch 4 along the left bank. Photo monitoring shows the effectiveness of coarse sediment along with high flows at reworking bank and recruitment of large wood.

4.1 Phase I Discussion

Bobcat Flat Phase I construction was completed September 21, 2005 (M&T 2006a). Phase I coarse sediment additions totaled approximately 11,000 yd^3, building six distinct alluvial bars and riffles within the mainstem Tuolumne River and constructing approximately 10.5 acres of floodplain (Figure 2). Since construction, two dam releases exceeding 6,000 cfs have occurred, the first in 2006 and the second in 2011 (Figure 10). As part of the Phase II as-built monitoring, limited additional monitoring was conducted, including: bulk samples, pebble counts, photopoints, topography, and cross sections.

The additional monitoring was done in an effort to address a series of questions raised by AFRP reviewers during the Phase II proposal process. The questions and relevant monitoring results are presented below:

Question 1: Can the addition of coarse sediment, appropriately scaled, break-up long pools and steep drops that result in a pool-riffle channel geometry scaled to contemporary flow regimes?

Response: Coarse sediment can be successfully added to a mainstem channel, breaking-up long deep pools and steep riffles and be maintained by contemporary flow regimes. Coarse sediment was added at Patches 3 and 4 (Figure 2) to break up an 800 ft long run with an average depth of 5 ft (M&T 2004b). Now, six years after Phase I was constructed, during which two high flow events in excess of 6,000 cfs reworked the Phase I gravel augmentation patches, the long-run has evolved into a series of bars, riffles, runs, and pools. Topographic (Figure 38) and photo (Figure 45 and Figure 46) monitoring between 2005 and 2011 showed the continued evolution and maintenance of bars, riffles, pools, and runs between Phase I Patches 3 and 4.

Question 2: Over time, will addition of coarse sediment reduce the existing channel complexity by filling in pools, scouring bars, and/or eliminating side channels and alcoves?

Response: Monitoring of Phase I coarse sediment additions (Patches 1 through 6) indicated that pools and runs and overall channel complexity persists in 2011 (Figure 38). Figure 38 shows pools in excess of 10 ft deep and runs 6 ft to 8 ft deep. Further, the addition of coarse sediment, in combination with high flows, has begun to erode channel banks, and recruit trees and coarse sediment into the mainstem channel (Figure 47). The large alder recruited by high flows in 2011 (Figure 47) has induced sediment deposition upstream and scour adjacent to and downstream of the fallen tree (Figure 37).

Figure 47. Large alder along the right bank opposite Patch 4 left bank bar, recruited by 2011 high flows, showed deposition upstream and scour adjacent to and downstream of the fallen tree (Figure 37).

Question 3: Can high flow coarse sediment recruitment piles prevent degradation of constructed coarse sediment features, such as riffles and bars, downstream?

Response: Although additional monitoring would allow for a more definitive answer, the monitoring results indicate that high flow coarse sediment recruitment sources prevent channel degradation. Topographic monitoring from September 2006 to May 2011, of the Phase I project area between Patches 1 and 4, indicated that without the coarse sediment supply from Patch 2 this reach of river would have had a net scour of coarse sediment (Figure 37). High flows between WY 2005 and WY 2011 successfully recruited coarse sediment placed at Patch 2 during Phase I construction (Figure 11 and Figure 37). Topographic differencing between 2005 as-built topography and May 2011 showed approximately 1,000 yd^3 of coarse sediment was mobilized from Patch 2 with most settling out between the downstream boundary of Patch 2 as a right bank bar and within Patch 3 as a medial bar (Figure 37 and Figure 45). Monitoring results at Patch 2 indicate, under current channel conditions, that Patch 2 is a suitable location for a high flow coarse sediment recruitment pile, providing a readily available sediment supply for the Phase I and Phase II projects.

Question 4: Will mainstem channel geometry and floodplain surfaces scaled to a contemporary flow regime maintain coarse sediment suitable for spawning and rearing salmonids within the active channel?

Response: Monitoring results between October 2005 and January 2012 indicate the answer is yes. Bulk samples were collected at Patches 3 and 5 between October 2005 and January 2012 (Table 5). Phase I Patches 3 and 5 increased coarse sediment supply and storage within the Tuolumne River mainstem channel; however, each patch had distinctly different objectives. Patch 3 primary objectives were to provide immediate and long-term coarse sediment suitable for Chinook salmon spawning and juvenile rearing habitat and increase invertebrate production while Patch 5 was intended to restore an overly wide mainstem channel geometry to one that functions effectively with the contemporary flow regime (M&T 2004b).

Patch 5 photographic monitoring (Figure 19), and sediment sampling (Figure 44) showed fine sediment deposition with riparian vegetation establishing on the bar surface. These results confirm that Patch 5 is depositional, and is thus beginning to establish more contemporary channel geometry.

Photo monitoring of Patch 3 (Figure 45) showed coarse sediment deposition as a medial bar between 2005 and 2006, likely a result of 2006 high flow recruitment and deposition of coarse sediment from Patch 2 and Patch 3. Patch 3 was sampled four times between October 2005 and January 2012 (Table 5) and showed a 14% increase in coarse sediment less than 10 mm between 2005 and 2006 (Figure 43). The Patch 3 bulk sample sieve results were used to calculate Chinook salmon and steelhead trout egg survival using equation(s) developed by Tappel and Bjornn (1983). The resulting analysis showed little to no change (+/- 2%) in the percent egg survival for Chinook salmon between 2005 and 2012 as a result of high flows and fine sediment deposition within Patch 3 (Figure 48). Egg survival results for steelhead trout are the same between 2005 and 2008; however, egg survival did decrease by 17.3% between 2008 and 2012 (Figure 48), likely due to the increase in fine sediment (Figure 43).

Monitoring of the Phase I project over the past seven years indicates that fine sediment is depositing into coarse sediment augmentation patches within the mainstem channel; however, egg survival remains high. Over the same period, the rescaling of a large in-channel gravel pit (Patch 5) has resulted in approximately 2 feet of deposition, comprised mostly of fines (Figure 44), outside the low flow channel.

Table 5. Patches 3 and 5 bulk sampling dates.

Patch Number	Sampling Dates			
	October 2005	**September 2006**	**May 2008**	**January 2012**
3	●	●	●	●
5	●		●	●

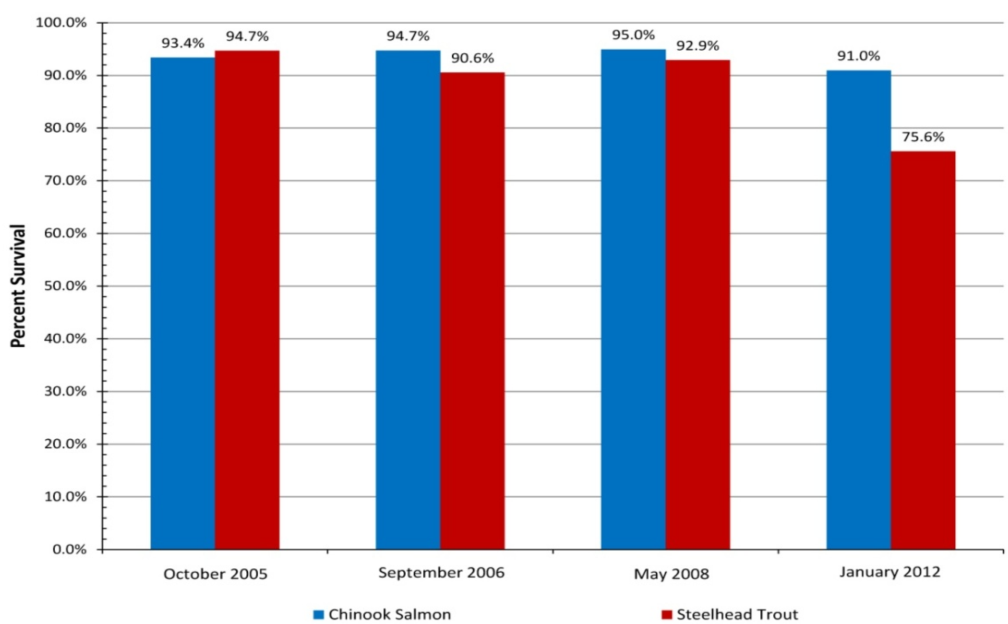

Figure 48. Chinook salmon and steelhead trout percent egg survival estimates at Phase I Patch 3, between October 2005 and January 2012 from Tappel and Bjornn (1983).

5 RECOMMENDATIONS

Recommendations from Bobcat Flat Phase I and Phase II monitoring include:

1. Continue adding coarse sediment to Patch 2: Patch 2 is working as a coarse sediment recruitment source for Phase I and Phase II projects and should be replenished when opportunities arise. Coarse sediment additions should be added to Patch 2 as part of any future Bobcat Flat restoration project until upstream storage deficits have been filled. A ready source of material for future Patch 2 coarse sediment augmentation is within the Phase I stockpile area (Figure 2). Approximately 6,000 yd^3 is available to be sorted and cleaned and should produce approximately 5,200 yd^3 of coarse sediment between ¼ in and 5 in. Based on a 5-year recurrence of flows at La Grange of 7,570 cfs (M&T 2000), approximately 500 yd^3 to 1,000 yd^3 could be added to Patch 2 every 5 years.
2. Use a "dry screen method" to clean coarse sediment: Comparing a "dry screen method" and a "wet screen method" to sort and clean coarse sediment prior to placing in the river channel, resulted in the "dry screen method" producing a cleaner finished product.
3. Construct channel and floodplain geometry scaled to contemporary flows: Rescaling of the channel geometry through the addition of coarse sediment and lowering of floodplain surface to contemporary flow regimes will continue to remove fine sediment (less than 2 mm) from the channel, restore floodplain function and maintain high egg survival percentages.
4. Construct microtopography as part of any in-channel gravel augmentation project: Topography variability in riffles (dunes) provides immediate salmonid habitat benefits and increased BMI productivity (CMC 2001, CMC 2002, and DWR 2006).
5. Complete the remaining Phase II project areas: With designs and permits in place, funding is all that is needed to complete the remaining Phase II project areas (Figure 2).

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APPENDIX A
BOBCAT FLAT PHASE II, 100% DESIGN SHEETS