Publication No. WI-2012-07

21 December 2012

The Watershed Institute

Division of Science and Environmental Policy
California State University Monterey Bay
http://watershed.csumb.edu

100 Campus Center, Seaside, CA, 93955-8001
831 582 4452 / 4431

Central Coast Watershed Studies

CCoWS

Potrero Creek Restoration Santa Lucia Preserve Monterey County (CA): Year Three Monitoring

Doug Smith PhD
Dana Riggs (WRA Consultants)
Chris Hauser (Santa Lucia Conservancy)
Andrea Goodmansen (CSU Monterey Bay)

Lead author contact details:
dosmith@csumb.edu

Acknowledgements

We are grateful for the assistance of:

- Field assistance by Alex Snyder and Elizabeth Geisler

This report may be cited as:

Smith DP, Riggs D., Hauser C., and Goodmansen A. (2012) Potrero Creek Restoration, Santa Lucia Preserve, Monterey County (CA): Year Three Monitoring: The Watershed Institute, California State Monterey Bay, Publication No. WI-2012-07, 42pp.

Submitted to:

Forrest W. Arthur, General Manager
Santa Lucia Communities Service District
One Rancho San Carlos Road
Carmel, CA, 93923

Executive Summary

A 50 m long reach of Potrero Creek was realigned in 2009 to prevent undermining of Chamisal Pass Road. In keeping with permit requirements, this report details geomorphic and ecological monitoring in 2012--the third year after realignment. The following statements summarize the conditions and recommendations.

Geomorphic Monitoring

The longitudinal profile and reference reaches above and below the pilot channel show channel evolution in keeping with a watershed that has a high rate of bedload input. Two cross sections located at the upper and lower end of the pilot channel exhibit minor adjustments that are within expected values. A cross section located in the middle of the pilot channel reach indicates that the channel is eroding its left bank (downstream view) in response to bar deposition on the right bank. Visual inspection of the reach supports that result. This condition does not meet the year 3 project target of geomorphic stability.

Continued excessive erosion of the middle part of the pilot channel will lead to project failure and renewed threat to Chamisal Pass Road. The future rate of bank erosion is difficult to predict because it will vary with the magnitude of annual rainfall and peak runoff. We recommend keeping a close watch on this site in the coming winter, with a new survey in the spring. We recommend enlisting the expertise of a civil engineer if high erosion rates continue. Bank armoring may be required if the bank continues to erode. Armoring can employ natural materials that enhance physical habitat, such as a live crib wall.

Riparian Mitigation Monitoring

Year 3 riparian zone project goals have been met. Upland vegetation has sufficient cover and is in good health, with relatively few non-native individuals present. Stream-side and instream vegetation exhibits mixed success, with a need for more bank stabilizing herbaceous species, and locally-placed woody stems. Thinning of low branches is recommended to allow sunlight to nurture low herbaceous species.

Wildlife Biological Monitoring

Overall physical habitat quality has improved in all three reaches since Year 1 and current habitat assessment scores are above baseline totals. The overall habitat assessment value from Year 3 meets the performance criteria outlined in the *Potrero Creek Restoration Monitoring and Management Plan*, as required by the Project's RWQCB, CDFG, and Corps.

In order to meet Year 5 performance criteria outlined in the *Potrero Creek Restoration Monitoring and Management Plan* and required by the Project's RWQCB, CDFG, and Corps, the pilot reach (XSEC 3) will need improvements certain habitat parameters to raise conditions to at least suboptimal in the CDFG California Stream Bioassessment Procedure. Preventing significant erosion in the pilot channel is vital in achieving Year 5 performance

criteria. Installation of willow or dogwood revetments can be used to stabilize the eroding banks and reduce sediment deposition.

Table of Contents

1 Introduction

1.1 Background

The following background paragraphs are derived from WRA (2010). In 2009, a short reach of Potrero Creek (Fig. 1) was realigned to prevent bank erosion that threatened both Chamisal Pass Road and local aquatic environmental quality. Erosion of the right bank (downstream view) was undermining a tall denuded bank that supports Chamisal Pass Road. If left unchecked, the erosion would have resulted in reactivation of a large landslide and major construction work to rebuild the road. Further, the erosion from the bank would have chronically contributed excess fine sediment to Potrero Creek (potentially occluding the channel), thereby decreasing aquatic and riparian habitat value. To repair this condition, the eroding stream reach was blocked at the upstream end, and a new pilot channel was constructed to bypass the erosion site.

The "restored" reach of Potrero Creek was designed to function as a natural stream reach with geomorphic integrity and an intact riparian corridor. This restoration project was permitted under the condition that it be monitored for geomorphic and ecological quality for a minimum of five years. The specific requirements are detailed by the U.S. Army Corps of Engineers (ACOE) Section 404 permit File Number 2008-003026, California Department of Fish and Game (CDFG) Stream Alteration Agreement No. 2008-008-R4, and Regional Water Quality Control Board (RWQCB) Water Quality Certification #32708WQ06, and as specified in the Potrero Creek Restoration Plan (WRA 2009).

Details of the project design and construction can be found in several antecedent reports (WRA 2009, 2010, 2012) on file with the Santa Lucia Conservancy, ACOE, RWQCB and CDFG.

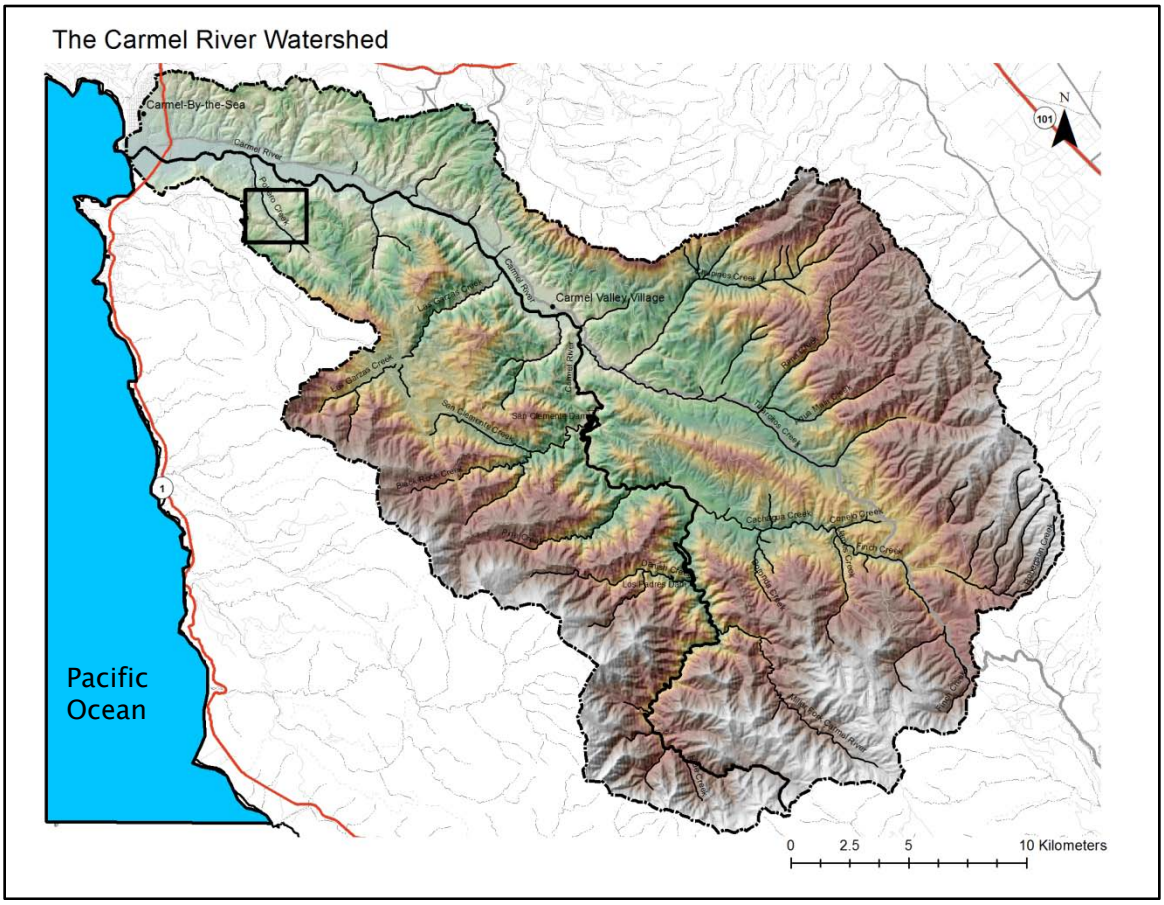

Figure 1: Box shows location of Potrero Creek restoration in the Carmel Watershed.

1.2 Study area

Potrero Creek is located in the Carmel River watershed adjacent to Chamisal Pass Road on Santa Lucia Preserve property at approximately 602410 E 4041150 N (UTM zone 10 meters) (Fig. 2). The surface geology is landslide material that is clearly visible in a roadcut above the restoration site. Below the landslide is Tertiary marine shale of the Monterey Formation (Fig. 2). The Monterey formation and derivative soils are prone to landslide hazard (Fig. 2) and erosion (Fig. 3).

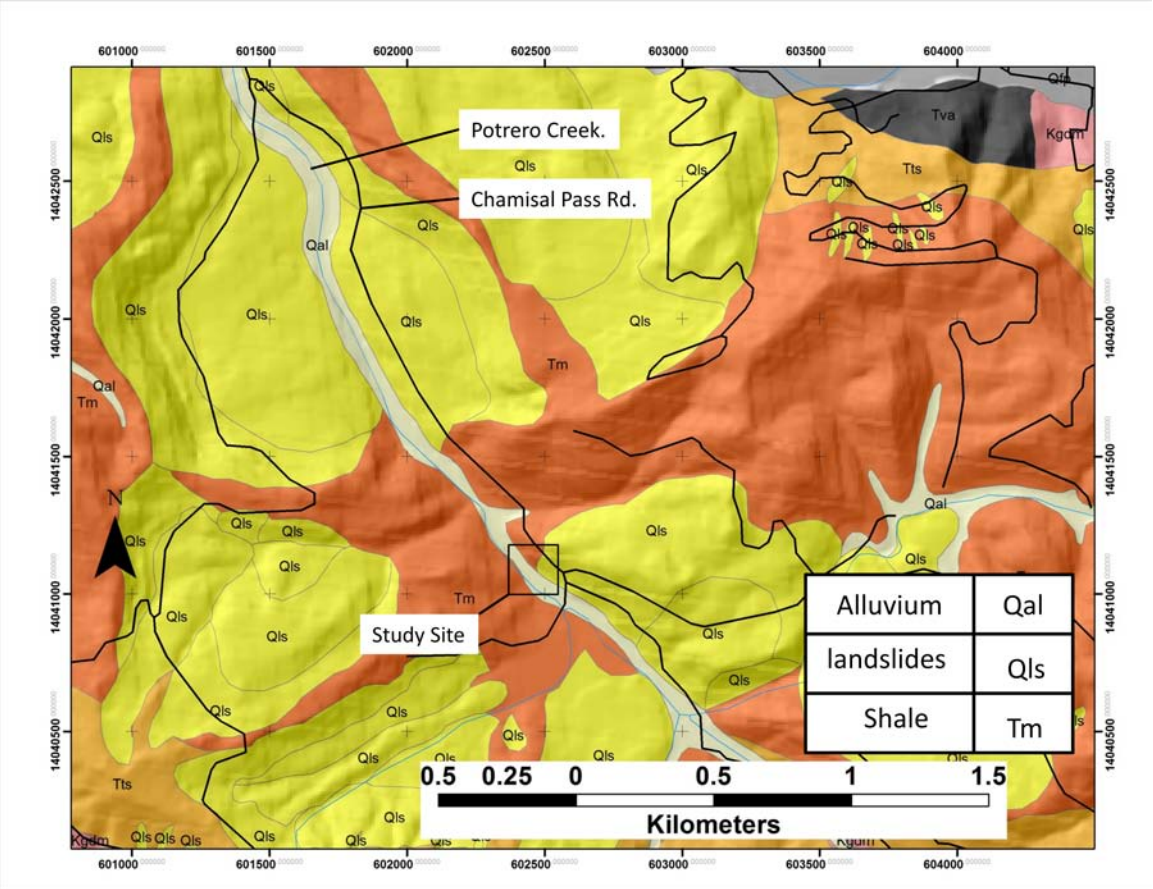

Figure 2: Location and geology of restoration site. GIS data from Rosenberg (2001)

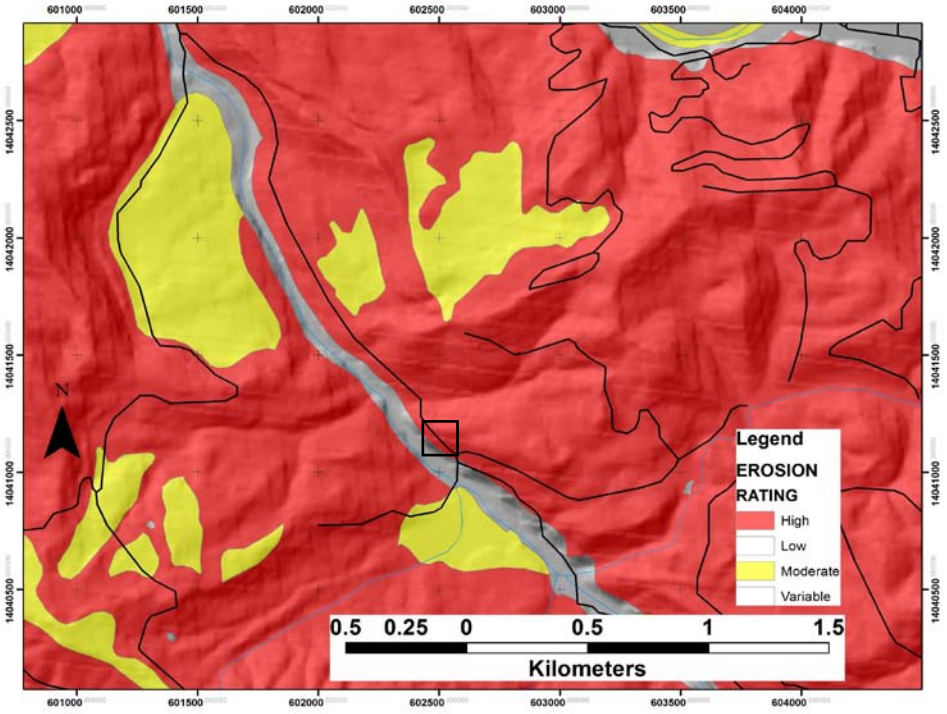

Figure3: Erosion potential of substrate of Potrero watershed. GIS data from Rosenberg (2001)

1.3 Goal

The goal of this work is to assess the physical and biological conditions of the restoration site in the third year following construction. The following criteria and standards guided the monitoring methods used this year. The criteria and standards below are copied from WRA (2010).

YEAR 1

- Water quality will resemble that of the upstream and downstream reach.
- Survival of plantings will exceed 90 percent.[1]
- Plants rated as "high" or "moderate" invasive species in the California Invasive Plant Inventory (Cal-IPC 2010) will not exceed five percent cover within the riparian area[2].
- The pilot channel banks will be stabilized by native vegetation and not show signs of significant erosion.
- The restored reach will have a habitat assessment value greater than the preexisting reach based on the CDFG California Stream Bioassessment Procedure.

[1] The *Restoration Plan* sets survival targets only for "planted riparian trees". However, the CDFG *Stream Alteration Agreement* specifies a Year 5 performance criterion of 80% survival for all plantings, so the monitoring program will assess all plantings during each monitoring effort.

[2] The *Restoration Plan* refers instead to the California Exotic Pest Plant Council (CalEPPC) "A" List or Red Alert List, an older ranking system and organization name replaced by the Cal-IPC Inventory. WRA has converted this performance criterion to "moderate" and "high" invasives, as those species would most threaten the success of the Project's revegetation efforts.

YEAR 3

- Water quality of the restored reach will be equal to or better than that of the reference reach.
- Survival of planted riparian trees will exceed 85 percent.
- Plants rated as "high" or "moderate" invasive species in the California Invasive Plant Inventory (Cal-IPC 2010) will not exceed five percent cover within the riparian area.
- The pilot channel banks will be stabilized and not show signs of significant erosion.
- The restored reach will have a habitat assessment value greater than the preexisting value for Year 1, based on the CDFG California Stream Bioassesment Procedure.

YEAR 5

- Water quality of the restored reach will be equal to or better than that of the reference reach, and better than pre-existing conditions.
- Water quality of the downstream reach will exceed pre-existing conditions.
- Survival of plantings will exceed 80 percent.
- Plants rated as "high" or "moderate" invasive species in the California Invasive Plant Inventory (Cal-IPC 2010) will not exceed five percent cover within the riparian area.
- The pilot channel banks will be stabilized and not show signs of significant erosion.
- The restored reach will have a habitat assessment value at least fifty percent greater than the pre-existing value, and all parameters should at least meet suboptimal conditions based on the CDFG California Stream Bioassessment Procedure.

---

2 Methods

The following methods were used to monitor the restoration site. We generally employed the same techniques used in previous work at this site WRA (2010) to improve inter-annual comparison.

2.1 Geomorphology

Autolevel and stadia rod surveys captured changes in cross sectional geometry and longitudinal profile of the creek. The surveys were tied to benchmark elevations established in WRA (2010, 2012), and are plotted atop previous surveys to analyze geomorphic change. These surveys are used to assess the magnitude of sediment aggradation or degradation in the channel and to assess bank stability. Cross sectional geometry and average channel gradients are also compared with previously obtained values. A spike in a large redwood tree located 70 ft upstream from the restoration site

serves as a local elevation benchmark for the cross sections and profile. In keeping with previous surveys, the spike was assigned an arbitrary elevation of 100 ft.

The longitudinal profile began at the downstream edge of a large redwood tree that has fallen across the creek, approximately 15 ft up-valley of the redwood with the benchmark spike. The profile ended 14 ft downstream from cross section 5. Five cross sections were resurveyed using the head pins as in previous years.

The following notes describe the locations of five surveyed cross sections (WRA 2010).

- XSEC 1 located upstream of the restoration area,
- XSEC 2 located at the upstream end of the pilot channel,
- XSEC 3 located approximately in the center of the pilot channel,
- XSEC 4 located at the downstream end of the pilot channel,
- XSEC 5 located downstream of the restoration area.

XSEC 1 and 5 are outside the restored reach; they serve to monitor ambient conditions for comparison with XSEC 2, XSEC 3, and XSEC 4, which cross both the abandoned and new channels within the restoration reach. Cross section surveys at XSEC 1 and 5 were conducted prior to restoration, during Year 1 monitoring, and this year (2012) for Year 3 monitoring. Surveys at XSEC 2, 3, and 4 were conducted prior to restoration, in 2009 following restoration, during Year 1 monitoring (WRA 2010), again this year (2012) for Year 3 monitoring.

Sediment and erosion monitoring was also documented with monitoring photographs taken immediately prior to restoration (August 2009), immediately following restoration, during Year 1 monitoring (August 5, 2010), and during Year 3 monitoring (September 26, 2012). Monitoring photographs were taken at the cross sections and in other key locations to document geomorphic change. Monitoring photographs are provided in Appendix A.

2.2 Riparian Vegetation Monitoring

Year 1 riparian vegetation monitoring was conducted on August 5, 2010 by WRA biologist Jennifer Mathers. Year 3 monitoring was conducted on September 26 & 27, 2012 by Santa Lucia Conservancy plant ecologist Chris Hauser. In both years, monitoring consisted of a simple count of live and dead plantings throughout the restoration area, and cover of non-native plants was assessed in all disturbed areas resulting from project construction.

2.3 Wildlife Monitoring

General wildlife surveys performed included visual surveys for amphibians and fish during monitoring surveys. Biologists began each survey at the downstream end of the long profile, and slowly moved upstream along the banks. Observations included species present, if any special status species were observed, the general location of species, and what habitat features were utilized. Wildlife visual surveys were conducted prior to the geomorphic surveys to maximize the potential of detecting special status species, and were conducted throughout the length of the long profile. Stream habitat assessments were also performed on each stream reach utilizing the CDFG California Stream Bioassessment Procedure field data sheets for high and low gradient streams (Appendix B). The CDFG procedure uses a qualitative assessment of habitat parameters such as epifaunal substrate and available cover, embeddedness, velocity and depth regime, sediment deposition, channel flow status, channel alteration, frequency of riffles or bends, bank stability, vegetative protection, and riparian vegetative zone width. Additionally, water clarity, temperature, pH, and conductivity were measured. The maximum score for each reach is 200, with high scores indicating optimal habitat and low scores indicating poor habitat quality for species. Each reach was assessed and a total score was assigned and compared.

3 Results

3.1 Geomorphology

Year 3 longitudinal profile and cross section surveys were conducted on September 26, 2012. All headpins and temporary benchmarks were located, reflagged and reoccupied during the survey, except for the left headpin of cross section 4. The left headpin is visible for cross section tape alignment, but a fallen tree trunk has covered the pin and 2 nearby survey shots on that transect. Inter-annual survey precision is acceptably high, given the good agreement between left and right head pin elevations in the cross sections plots.

A total of 278 feet of Potrero Creek thalweg was surveyed for the longitudinal profile; which was consistent with previous surveys. Figure 4 shows the longitudinal profile results for Year 3 monitoring overlaid with the pre-restoration, 2009 post-restoration, and 2010 Year 1 monitoring surveys. Table 1 shows the overall gradient for each of the long profile surveys. The following changes are apparent in the profile.

- Overall gradient decrease is driven by net erosion at upstream end and net deposition at the downstream end of the survey reach. The gradient within the restoration reach has remained relatively stable at about 2.2%.

- An upward deflection in the profile located at 150 ft in 2009 and 110 ft in 2010 is less apparent in 2012.
- Overall variation in the profile cannot be differentiated from steady-state equilibrium.
- A qualitative review of the site in August 2011 noted that a log had made a short step and pool sequence near the exit of the restoration reach (WRA 2012). That log and step-pool geometry are still present in September 2012. The feature is located at approximately 223 ft in the profile (Fig. 4).

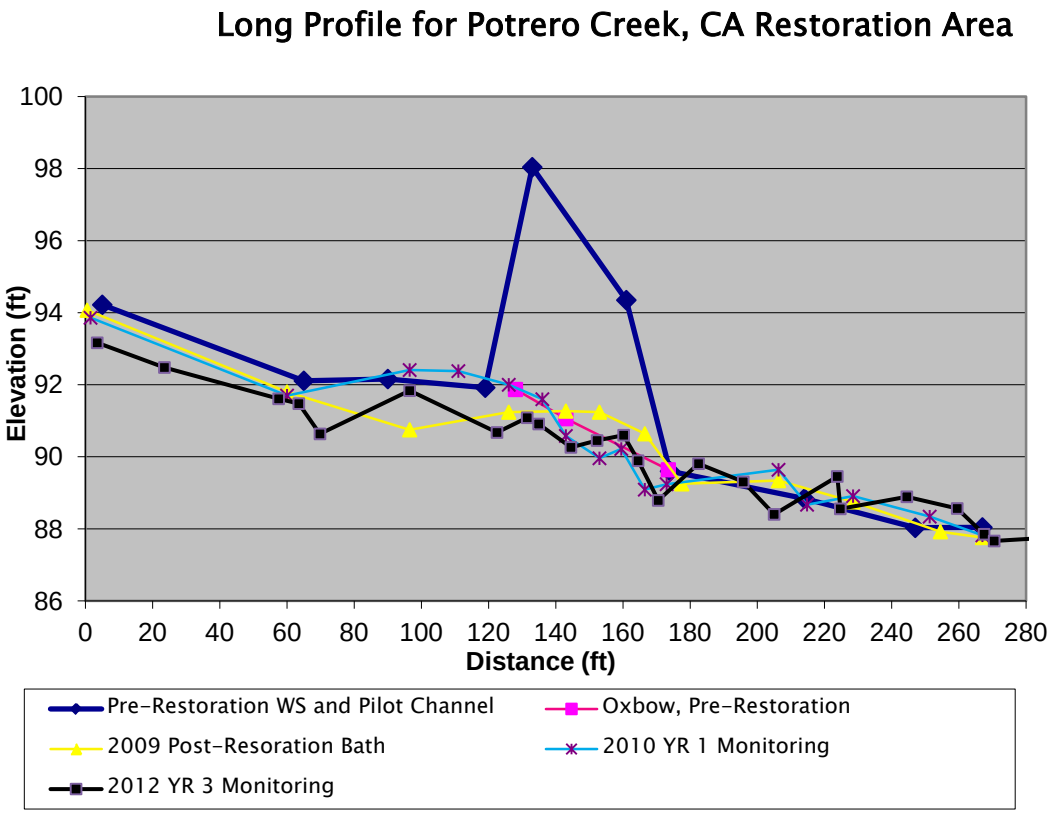

Figure 4: Longitudinal profile of Potrero creek restoration site.

Table 1: Longitudinal Profile Gradient and Changes in Slope

Survey	Gradient (% slope)	Incremental Change in Gradient (% slope)
Pre-restoration	2.31	N/A
2009 Post-restoration	2.36	+0.05
2010 Year 1 Monitoring	2.26	-0.10
2012 Year 3 Monitoring	1.96	-0.4
Overall post-restoration change (2012-2009)		-0.5

The five cross sectional profiles are presented in Figures 5 through 9. The resulting changes in cross sectional area are reported in Table 2.

The upstream reference profile (Fig. 5) and the upstream end of the restored reach (Fig. 6) show that the stream has been alternately aggrading and degrading, in keeping with previous interpretations (WRA 2010, 2012). Alternating periods of aggradation and degradation show that the stream reach is passing an episodically-high upstream sediment load on a multiannual time frame without net change. While this behavior is in keeping with steady-state equilibrium, the time under evaluation is too short to make that evaluation. Of note is that the amount of vertical change (2 ft to 3 ft) is very high for a small creek, indicating that there is likely stream-bank instability or other chronic sediment sources located higher in the watershed. Figure 2 indicates that this watershed is underlain by highly erodible substrate that will generate excess sediment when disturbed.

Cross section 3 (Fig. 7) is located in the middle of the pilot channel reach. Both visual inspection and the cross sectional survey indicate rapid erosion at this site. WRA (2012) reported excess erosion here in the August 2011 visual inspection as well. Bank sloughing and sediment recruitment have constructed a side-attached bar that has grown from left to right across the original pilot channel thalweg (Fig. 7, Fig 10, Appendix A p. 32). The bar has forced scouring flows against the right bank. The right bank is undercut from 1 to 3 feet, and has retreated approximately 5 feet since the 2010 survey. At this cross section, the channel has generally enlarged in size since inception (Fig. 7; Table 2, Appendix A, p. 32)

Cross section 4, at the downstream end of the pilot channel, shows bank stability and net aggradation (Fig. 8). The downstream reference cross section (Fig. 9) has gradually built a side-attached bar on the right bank. In response, the thalweg has moved from right to left. Both Cross sections 4 and 5 have experienced net aggradation through time (Table 2).

The surveys of cross sections 3, and 4 show that the original channel (Oxbow) is aggrading (Figs. 7 & 8), especially where it is influenced by backwater from the creek at the downstream end (Fig. 8). Figure 10 shows the cross section locations and the general location of pilot channel bank erosion in the vicinity of cross section 3.

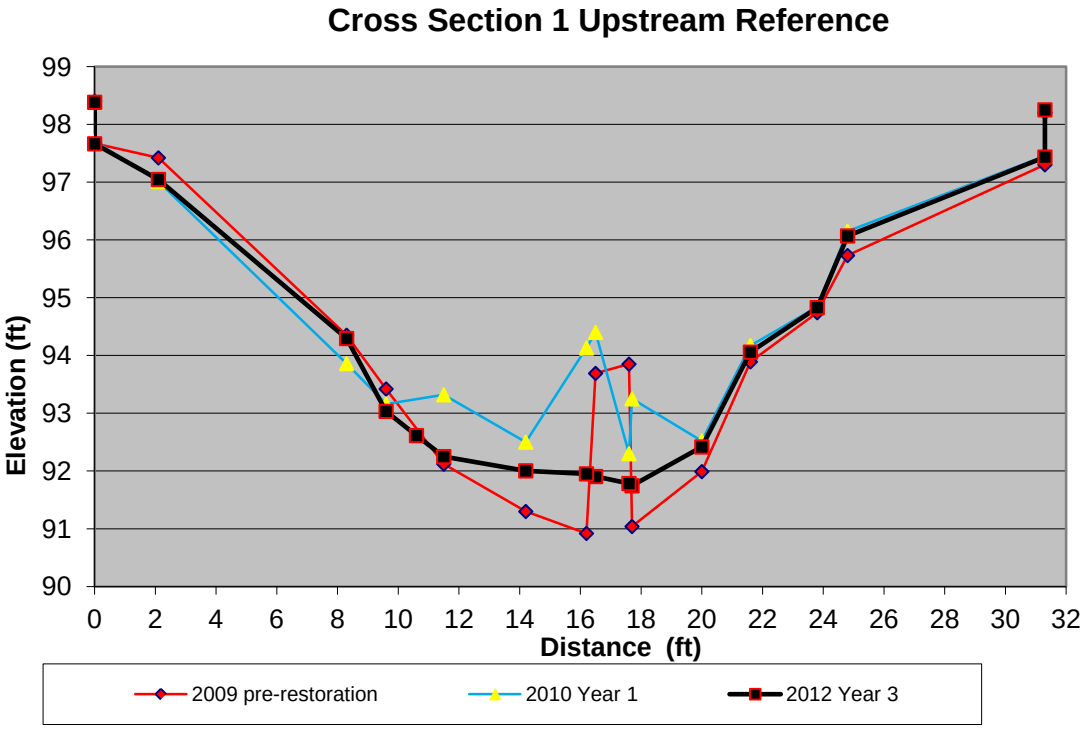

Figure 5: Cross section 1, located upstream from restored reach. Downstream view.

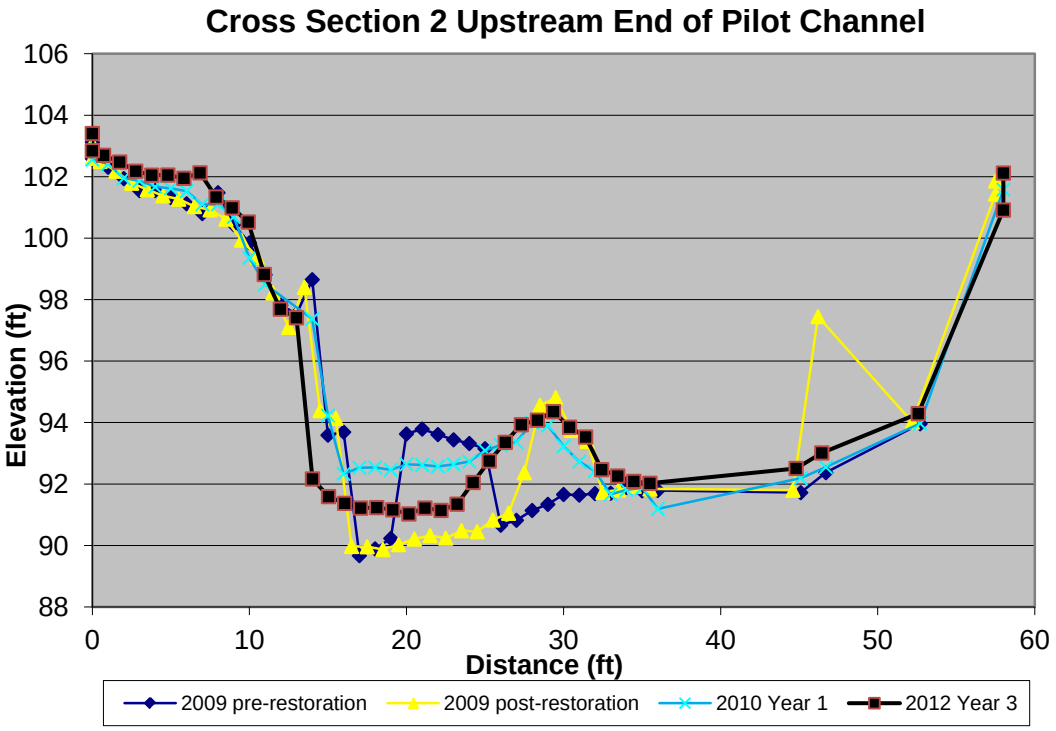

Figure 6: Cross section 2, located at the upper end of the pilot reach. Downstream view.

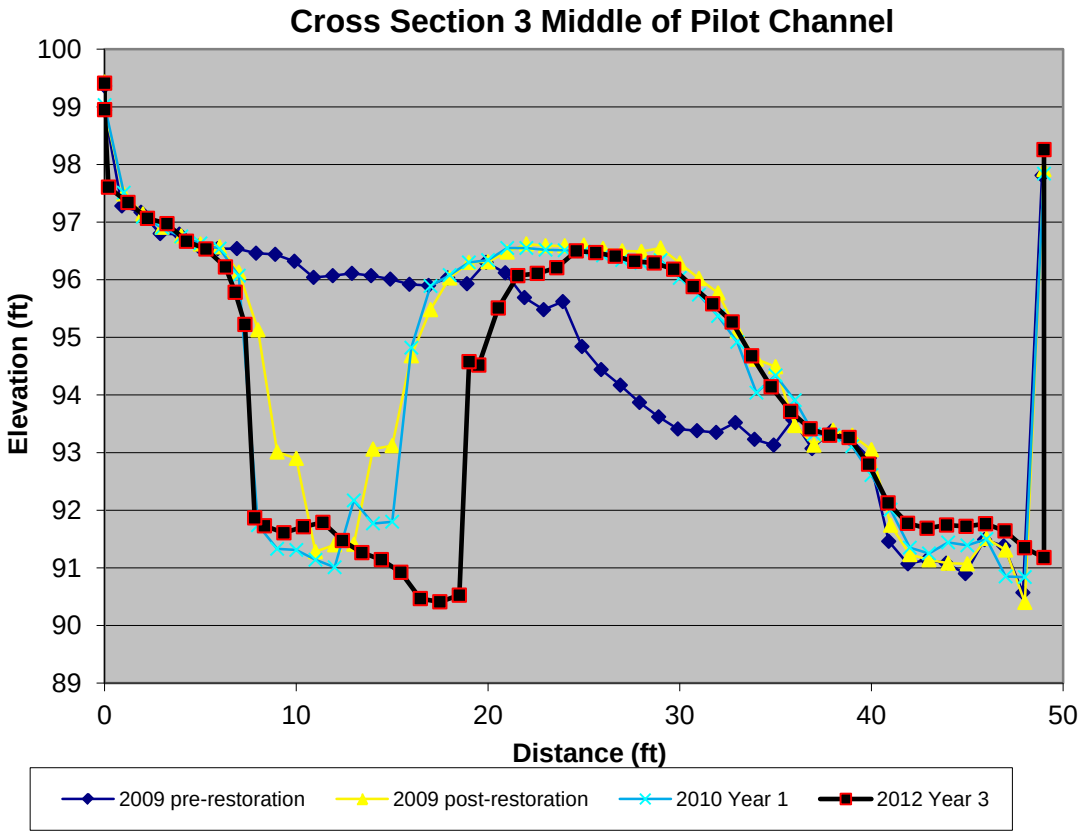

Figure 7: Cross section 3, located in the middle of the pilot channel. Downstream view.

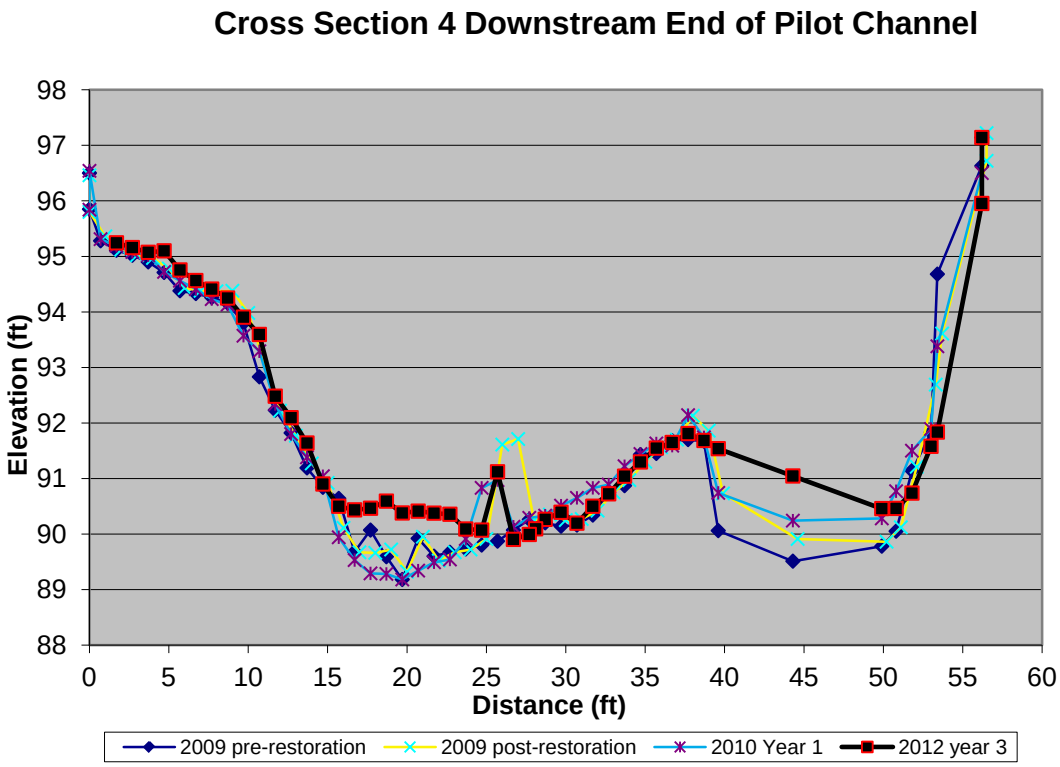

Figure 8: Cross section 4, located at the downstream end of the pilot channel. Downstream view.

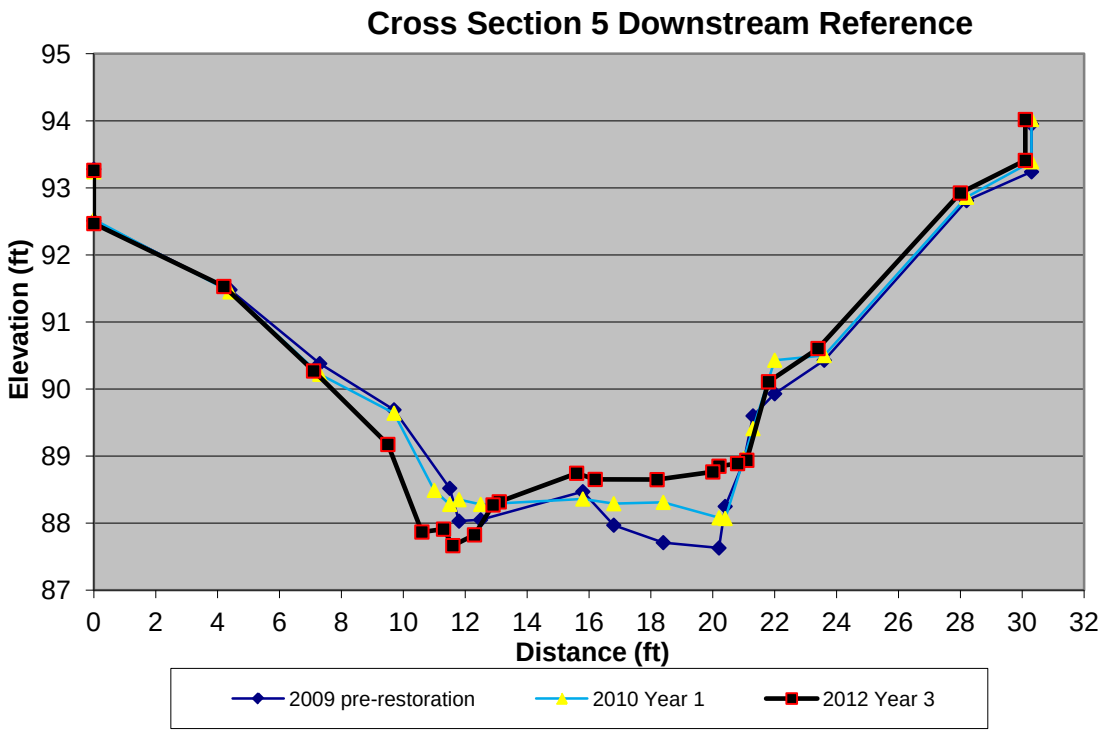

Figure 9: Cross section 5, located downstream of restored reach. Downstream view.

Table 2. Cross Section Area (square feet) and Changes from Each Survey

Cross Section Area (ft^2)					
Survey	**XSEC 1**	**XSEC 2**	**XSEC 3**	**XSEC 4**	**XSEC 5**
Pre-restoration	88.66	386.01[1]	158.43[1]	290.22[2]	92.84
2009 Post-restoration	--	377.23[1]	164.85[1]	284.45[2]	--
2010 Year 1	82.26[1]	383.29[1]	171.78[1]	273.52[2]	94.99
2012 Year 3	91.43	355.76	210.19	262.31	77.90
Change in Area (ft^2 and %)					
2009 Post -2009 pre	No change	-8.79	6.44	-6.11	No change
2010- 2009 Pre	-6.79[1]	-1.97	13.32	-17.12	2.15
2010- 2009 Post	Same as above	6.82	6.88	-11.01	Same as above
2012-2010	9.17 (11%)	-23.53 (7%)	38.40 (22%)	-11.21 (4%)	-17.10 (18%)
Cum. change (prerestoration to 2012)	2.38 (3%)	-30.26 (8%)	51.75 (33%)	-27.91 (10%)	-14.94 (16%)
Cum. change (postrestoration to 2012)	Same as above	-21.47 (6%)	45.34 (28%)	-22.14 (8%)	Same as above

Notes: *Numbers in red denote sediment aggradation and a loss in cross section area between surveys (an increase in sediment at the transect). Numbers in green denote sediment degradation and an increase in cross section area between surveys (a decrease in sediment at the transect).*

[1]Values adjusted slightly from previous reports for technical reasons.

[2]A treefall precluded 2 survey shots near the left benchmark in 2010. Prior cross sectional areas were adjusted by removing those shots for better inter-annual comparison of channel shape.

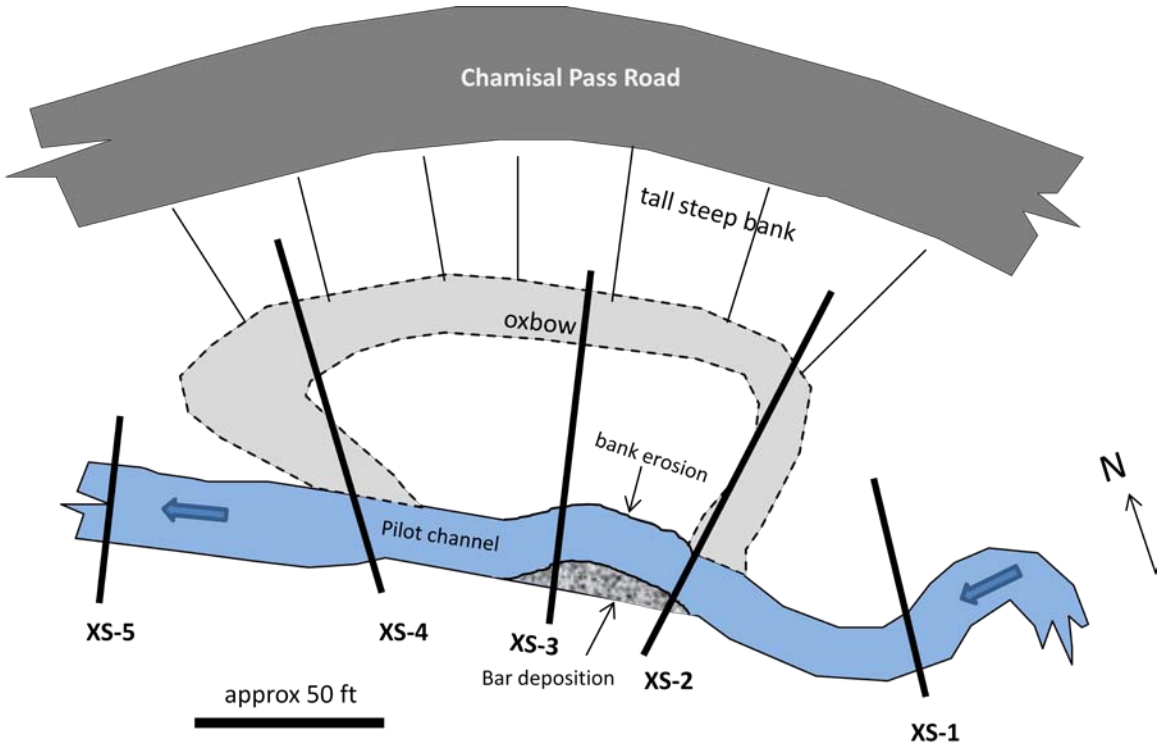

Figure 10: Site sketch map showing cross section locations and general area of bank erosion. Map redrawn from WRA (2010). Pilot channel alignment was originally straight between cross sections 2 and 3.

3.2 Riparian Vegetation

As surveyed on September 26 and 27, 2012, both upland and riparian native vegetation appeared to be recovering well, with a very high cover of native plants, a high survival rate of planted trees and shrubs, and very low cover of non-native invasive plants. Both vegetation goals stated for year 3 have been achieved: (1) survival of planted riparian trees currently exceed 85 percent, and (2) cover of plants rated as "high" or "moderate" invasive species in the California Invasive Plant Inventory do not exceed 5 percent.

Upland impacted areas were almost completely covered with spreading vines of California blackberry (*Rubus ursinus*) and common snowberry (*Symphoricarpos albus*), totaling at least 95% cover. Upland invasive weeds consisted of 2 French broom (*Genista monspessulana*) which had likely spread from off site, and one bull thistle (*Cirsium vulgare*) growing in bare soil on a gravel bank near the stream, all of which were hand pulled. In contrast to the Year 1 report, black mustard (*Brassica nigra*) and poison hemlock (Conium maculatum) were absent from the upland area.

In-stream vegetation was dominated by rooted cuttings of western dogwood (*Cornus sericea* ssp. *occidentalis*) which had been planted earlier in the year. These cuttings were quite extensive along the natural channel and the pilot channel, but were absent from the oxbow (Figure 10). As noted in the Year 1 monitoring report, in-stream and stream bank herbaceous vegetation was not recovering as well as the upland vegetation, as many of the planted species were likely washed away during the first year. While the in-stream vegetation was free of any serious noxious weeds, one potential concern was the extensive spread of the non-native water cress (*Nasturtium officinale*) which covered the entire streambed of the pilot channel, but is generally absent from other stream reaches within this watershed.

3.3 Wildlife

No special status species were observed during the December 2nd visit. Water clarity was poor due to recent heavy rainfall. Conditions at the time of the visit were also not conducive to observing avian species. Habitat features such as backwater refugia, instream woody debris and cover, and slow moving, deep pools were present and similar to year 2 observations of these features.

The results of the CDFG California Stream Bioassessment Procedure for Year 3 are provided in Table 3. Individual habitat parameters that contribute to the stream habitat assessment scores are presented in Table 4. Results of water quality parameters for Year 3 are provided in Table 5. Transect locations correspond with geomorphic cross-section transects; for clearer analysis only three transects (upstream, mid-pilot channel, and downstream) were utilized for comparison. Datasheets for all ten habitat parameters for Year 3 monitoring are provided in Appendix B.

Table 3. CDFG Stream Bioassessment Physical Scores for Monitoring Years

Monitoring Year	XSEC 1 Stream Habitat Score	XSEC 3 Stream Habitat Score	XSEC 5 Stream Habitat Score
Baseline	169	133	164
Year 1	162	129	156
Year 2	162	120	152
Year 3	174	137	168

Table 4. Habitat Parameters of the CDFG Stream Bioassessment Scores for Monitoring Years

Habitat Parameter	XSEC 1				XSEC 3				XSEC 5			
	Baseline	Year 1	Year 2	Year 3	Baseline	Year 1	Year 2	Year 3	Baseline	Year 1	Year 2	Year 3
Epifaunal Substrate/Cover	18	18	18	18	10	13	14	18	16	16	16	16
Embeddedness	15	16	12	16	13	10	9	16	18	16	13	16
Velocity/Depth Regimes	16	15	15	18	13	15	15	16	15	15	12	17
Sediment Deposition	10	5	12	15	10	6	8	10	15	8	12	13
Channel Flow Status	16	13	14	13	16	11	12	12	15	13	12	16
Channel Alteration	20	20	18	18	18	18	16	10	19	19	18	16
Frequency of Riffles	18	18	18	18	17	19	16	19	18	18	17	18
Left Bank Stability	10	10	9	9	8	5	3	3	10	9	9	10
Right Bank Stability	9	9	9	9	2	3	2	5	7	8	9	9
Vegetative Protection, Left Bank	10	10	10	10	9	5	3	6	7	7	9	10
Vegetative Protection, Right Bank	8	9	9	10	4	5	4	8	5	8	8	8
Riparian Vegetative Zone Width, Left Bank	10	10	10	10	10	10	10	8	10	10	10	10
Riparian Vegetative Zone Width, Right Bank	9	9	8	10	3	9	8	6	9	9	7	9
Total	*169*	*162*	*162*	*174*	*133*	*129*	*120*	*137*	*164*	*156*	*152*	*168*

Table 5. Water Quality Results for Monitoring Years[1]

Parameter Sampled	XSEC 1				XSEC 3				XSEC 5			
	Baseline	Year 1	Year 2	Year 3	Baseline	Year 1	Year 2	Year 3	Baseline	Year 1	Year 2	Year 3
Water Temperature (Celsius)	14.5	13.4	13.6	6.5	-	13.5	13.6	6.3	14.0	13.8	13.8	5.9
pH	7.5	6.6	7.2	6.5	-	6.6	7.1	6.3	7.6	6.7	7.3	5.9
Conductivity (υs)	-	746	837	887	-	747	836	895	-	761	776	906

Notes: [1]Year three parameters were measured during baseflow conditions on Dec. 12, 2012.

Results from the stream habitat assessment conducted in Year 3 indicate the overall physical habitat quality within the pilot channel (XSEC 3) has improved significantly since Year 1. Substantial improvements were noted in Epifaunal Substrate and Available Cover with an increase in parameter conditions from marginal to optimal. Embeddedness and Velocity/Depth Regimes also increased to within the optimal condition category. Additional improved habitat parameters resulting from project activities include Frequency of Riffles (or bends) and Riparian Vegetative Zone Width. Increases in scores for Right Bank Stability and Right Bank Vegetative Protection were also noted despite continued erosional issues. This is likely due to improved stability and vegetation growth along the rest of the reach.

As shown in Table 4, several habitat parameter conditions have decreased within the pilot channel (XSEC 3) since Year 1. Channel flow has decreased since Year 1 to suboptimal conditions. The greatest decrease occurred from Year 2 to Year 3 but this recorded decrease is likely due to the seasonal timing of the survey and significantly lower annual rainfall in year 3. The Channel Alteration habitat parameter has decreased significantly since Year 1 from 18 points to 10 points and is now categorized as marginal; however, this parameter is expected to be low since creating an embankment was necessary to redirect stream flow in Year 1. This parameter is expected to improve over the next few years as stream habitat matures.

Overall physical habitat quality has improved in all three reaches since Year 1 and current habitat assessment scores are above baseline totals. The overall habitat assessment value from Year 3 meets the performance criteria outlined in the *Potrero Creek Restoration Monitoring and Management Plan*, as required by the Project's RWQCB, CDFG, and Corps.

4 Recommendations

Criteria and standards for this project are stated in the "Goals" section of this report. Below we compare the Year 3 monitoring observations to specific Year 3 project goals. We make management recommendations to move the project toward success, in cases where observations show that Year 3 goals are not being met,

4.1 Geomorphology

The Year 3 goal for geomorphology is specific: *"The pilot channel banks will be stabilized and not show signs of significant erosion."* This condition is being met at cross section 4 and, to a lesser degree, at cross section 2. Although the cross section 2 survey does not indicate lateral erosion (Fig. 6), visual inspection in August 2011 and September 2012 indicate that the right bank of cross section 2 is slowly eroding. This bank is the plug that directs flow away from the old channel into the pilot channel. Bank integrity is critical to project success.

The right bank erosion problem noted near cross section 2 accelerates downstream from cross section 2 to cross section 3 (Fig. 7), where the problem has become severe. The erosion at cross section 3 is representative of many feet of stream upstream and downstream from the cross section. The erosion is the direct result of lateral channel migration, forced by the growth of a side-attached bar on the left side. An indirect cause is the lack of an adequate floodplain width in this river reach.

The bank has retreated about 5 feet to the right between the 2010 and 2012 surveys. If that average rate is maintained, the pilot channel will avulse to the original channel in about six years. Actual bank retreat rate will vary with the magnitude of winter runoff.

Project success hinges upon controlling the excess bank erosion in the middle of the pilot channel. Riparian plantings alone will be insufficient action. The two geomorphic variables to consider are:

- reducing the shear stress on the right bank,
- increasing the shear strength of the right bank.

Shear stress (τ) can be modeled as $\tau = \gamma RS$, where

Ɣ is the specific weight of water,
R is the hydraulic radius (approximately the average depth), and
S is the surface slope of the flowing water.

Of those variables, only R and S can be altered. Providing lateral flood accommodation space would reduce R, but that option is not practical in this site. Enlarging the channel (removing the side attached bar) could reduce R, but it is likely that the bar would re-grow in the same place in subsequent winters. Installing a grade control structure downstream of the reach would create backwater to reduce S, but, given the already low overall gradient of the thalweg, a backwater structure would tend to accelerate lateral migration, rather than reduce it.

Given the above analysis, it will be better to focus on increasing the shear strength of the eroding bank. Many alternatives exist for this kind of work, including planted revetments. While much of natural bank strength comes from plant roots, the site is very shady, so hard physical structures that are well keyed into the bed and bank are to be favored.

4.2 Riparian Vegetation

Upland vegetation is recovering well, as demonstrated by a high absolute cover of native species, and little bare ground, very few invasive plants. No additional upland planting is recommended at this time.

In-stream and streamside vegetation, however, is demonstrating mixed success. While nearly all the western dogwood stakes were alive and well rooted (and met the minimum goal), very few herbaceous rhizomatous streamside species were present, and the absence of herbaceous streamside species may have been partly responsible for the severe bank erosion occurring on cross section 3. In addition to the lack of herbaceous vegetation, the thickly planted western dogwood stakes will, over time, begin to fill the channel with branches, slowing the water and catching debris during high flows, thus increasing the risk of the stream moving back into the oxbow channel, which is not well vegetated, even with dogwoods.

Suggested treatments and approximate timeline for improving the vegetation include implementing the following:

1. Fall 2012, thin the lower tree canopy, especially the thicket of young white alder (Alnus rhombifolia) about 50%, to allow more sunlight to reach the ground, in order to increase the success rate of the herbaceous streamside species.

2. Fall 2012, plant herbaceous rhizomatous streamside species within and above the pilot channel, as part of the bank stabilization process for cross section 3. Appropriate herbaceous species include valley sedge (*Carex barbarae*) and panicled bulrush (*Scirpus microcarpus*), both already present on site.
3. Fall 2012, plant live stakes of western dogwood in the upper and middle portions of the oxbow, to catch debris and slow water flow during high water events, preventing the stream from moving back into the old channel.
4. Summer 2013, as the herbaceous plants become dominant along the stream banks, incrementally remove the planted dogwood stakes from within and above the pilot channel. This will benefit the herbaceous species, whose fine root systems are better suited to protecting the stream banks, while simultaneously keeping the channel more open for high water flows.

4.3 Wildlife

In order to meet Year 5 performance criteria outlined in the *Potrero Creek Restoration Monitoring and Management Plan* and required by the Project's RWQCB, CDFG, and Corps, the pilot reach (XSEC 3) will need improvements in the following habitat parameters to raise conditions to at least suboptimal in the CDFG California Stream Bioassessment Procedure-- Sediment Deposition, Channel Alteration, and Bank Stability. Aspects of these parameters are expected to improve over time as the stream habitat matures; however, additional work is recommended to meet the Project's RWQCB, CDFG, and Corps requirements for Year 5. Preventing significant erosion in the pilot channel is vital in achieving Year 5 performance criteria. Installation of willow or dogwood revetments can be used to stabilize the eroding banks and reduce sediment deposition. Additional measures may be required to stabilize the banks of the pilot channel, and recommendations by a geomorphologist or hydrologist should be sought if Year 5 performance criteria are not met. Additional instream plantings will be important not only for increasing bank stability, but also for meeting Year 5 planting performance criteria.

5 References

Rosenberg, L. 2001. Geologic resources and constraints Monterey county California. County of Monterey Environmental Resource Policy Department.

WRA (2009). Restoration and Monitoring Management Plan, Potrero Creek, Santa Lucia Preserve, Monterey County, California: Report prepared by WRA Consultants for Santa Lucia Community Services District, 23pp + appendices. (This report was presented in 2007, then revised in 2009)

WRA (2010). Potrero Creek restoration project, Santa Lucia Preserve, Monterey County, California: Report prepared by WRA Consultants for Santa Lucia Community Services District, 19pp + appendices.

WRA (2012). Year Two Monitoring Report, Potrero Creek restoration project, Santa Lucia Preserve, Monterey County, California: Prepared by WRA Consultants for Santa Lucia Community Services District, 16pp + appendices.

6 Appendix A: Photomonitoring

Photo point P1: Right bank of XSEC 1, downstream view. Arrow points to rootwad. Top left is 2009 post-construction. Top right is 2011 year2 monitoring. Bottom is 2012 Year 3 monitoring.

Photo point P2: Left bank of XSEC 2, downstream view. Arrow points to bent tree. Top left is 2009 post-construction. Top right is 2011 year2 monitoring. Bottom is 2012 Year 3 monitoring.

Photo point P3: Left bank of XSEC 3, upstream view. Arrow points to mouth of pilot channel. Top left is 2009 post-construction. Top right is 2011 year2 monitoring. Bottom is 2012 Year 3 monitoring.

Photo point P4: Left bank of XSEC 4, upstream view. Arrow points to temporary benchmark. Top left is 2009 post-construction. Top right is 2011 year2 monitoring. Bottom is 2012 Year 3 monitoring.

Photo point P4: Left bank of XSEC 4, downstream view. Arrow points to oxbow confluence. Top left is 2009 post-construction. Top right is 2011 year2 monitoring. Bottom is 2012 Year 3 monitoring.

Photo point P5: Right bank of XSEC 5, upstream view. Arrow points to overhanging tree. Top left is 2009 post-construction. Top right is 2011 year2 monitoring. Bottom is 2012 Year 3 monitoring.

Mouth of pilot channel: downstream view. Arrow points to rock and rootwad. Top left is 2009 post-construction. Top right is 2011 year2 monitoring. Bottom is 2012 Year 3 monitoring

7 Appendix B: Physical Habitat Quality Assessment Field Notes

CALIFORNIA DEPARTMENT OF FISH AND GAME
AQUATIC BIOASSESSMENT LABORATORY

WATER POLLUTION CONTROL LABORATORY
REVISION DATE-- MAY 1999

PHYSICAL HABITAT QUALITY
(California Stream Bioassessment Procedure)

WATERSHED/ STREAM: Potrero Creek
COMPANY/ AGENCY: WRA
SITE DESCRIPTION: XSEC 1 (upstream)

DATE/ TIME: 12/2/12
SAMPLE ID NUMBER:

Circle the appropriate score for all 20 habitat parameters. Record the total score on the front page of the CBW.

Parameters to be evaluated within the sampling reach

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	**SUBOPTIMAL**	**MARGINAL**	**POOR**
1. Epifaunal Substrate/ Available Cover	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; most favorable is a mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% (30-50% for low gradient streams) mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% (10-30% for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	20 19 **(18)** 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
	20 19 18 17 **(16)**	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/ Depth Regimes *(deep<0.5 m, slow<0.3 m/s)*	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow).	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
	20 19 **(18)** 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	20 19 18 17 16	**(15)** 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
	20 19 18 17 16	15 14 **(13)** 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameters to be evaluated in an area longer than the sampling reach

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	**SUBOPTIMAL**	**MARGINAL**	**POOR**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
	20 19 (18) 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
	20 19 (18) 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left of right side by facing downstream	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
	Left Bank 10 (9)	8 7 6	5 4 3	2 1 0
	Right Bank 10 (9)	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zones covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
	Right Bank (10) 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities haveimpacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
	Right Bank (10) 9	8 7 6	5 4 3	2 1 0

total = 174

CALIFORNIA DEPARTMENT OF FISH AND GAME
AQUATIC BIOASSESSMENT LABORATORY

WATER POLLUTION CONTROL LABORATORY
REVISION DATE-- MAY 1999

PHYSICAL HABITAT QUALITY
(California Stream Bioassessment Procedure)

WATERSHED/ STREAM: Potrero Creek
DATE/ TIME: 12/2/12
COMPANY/ AGENCY: WRA
SAMPLE ID NUMBER: ——
SITE DESCRIPTION: XSEC 3 (Project Area)

Circle the appropriate score for all 20 habitat parameters. Record the total score on the front page of the CBW.

Parameters to be evaluated within the sampling reach

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	**SUBOPTIMAL**	**MARGINAL**	**POOR**
1. Epifaunal Substrate/ Available Cover	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; most favorable is a mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% (30-50% for low gradient streams) mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% (10-30% for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	20 19 **(18)** 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
	20 19 18 17 **(16)**	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/ Depth Regimes *(deep<0.5 m, slow<0.3 m/s)*	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow).	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
	20 19 18 17 **(16)**	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	20 19 18 17 16	15 14 13 12 11	**(10)** 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
	20 19 18 17 16	15 14 13 **(12)** 11	10 9 8 7 6	5 4 3 2 1 0

Parameters to be evaluated in an area longer than the sampling reach

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	**SUBOPTIMAL**	**MARGINAL**	**POOR**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
	20 19 18 17 16	15 14 13 12 11	(10) 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
	20 (19) 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left of right side by facing downstream	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
	Left Bank 10 9	8 7 6	5 4 (3)	2 1 0
	Right Bank 10 9	8 7 6	(5) 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zones covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	Left Bank 10 9	8 7 (6)	5 4 3	2 1 0
	Right Bank 10 9	(8) 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities haveimpacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
	Left Bank 10 9	(8) 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 (6)	5 4 3	2 1 0

total = 137

CALIFORNIA DEPARTMENT OF FISH AND GAME
AQUATIC BIOASSESSMENT LABORATORY

WATER POLLUTION CONTROL LABORATORY
REVISION DATE-- MAY 1999

PHYSICAL HABITAT QUALITY
(California Stream Bioassessment Procedure)

WATERSHED/ STREAM: Potrero Creek
DATE/ TIME: 12/2/12
COMPANY/ AGENCY: WRA
SAMPLE ID NUMBER:
SITE DESCRIPTION: XSEC 5 (downstream)

Circle the appropriate score for all 20 habitat parameters. Record the total score on the front page of the CBW.

Parameters to be evaluated within the sampling reach

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	**SUBOPTIMAL**	**MARGINAL**	**POOR**
1. Epifaunal Substrate/ Available Cover	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; most favorable is a mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% (30-50% for low gradient streams) mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% (10-30% for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	20 19 18 17 (16)	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
	20 19 18 17 (16)	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/ Depth Regimes *(deep<0.5 m, slow<0.3 m/s)*	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow).	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
	20 19 18 (17) 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	20 19 18 17 16	15 14 (13) 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
	20 19 18 17 (16)	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameters to be evaluated in an area longer than the sampling reach

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	**SUBOPTIMAL**	**MARGINAL**	**POOR**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
	20 19 18 17 (16)	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
	20 19 (18) 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left of right side by facing downstream	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 (9)	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zones covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	(8) 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities haveimpacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 (9)	8 7 6	5 4 3	2 1 0

total = 168