Title
Post-Project Assessment of the 2003 Cerrito Creek Restoration and Recommendations for Additional Stormwater Management

Authors
Adlong, Michelle
Cook, Michael
Kennedy, Matthew

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Michelle Adlong, Michael Cook, Matthew Kennedy

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ABSTRACT

A 700-foot-long daylighted reach of Cerrito Creek defines the southern border of the 29-acre El Cerrito Plaza shopping center and receives a majority of the Plaza's stormwater runoff. In 2003, this reach, between Talbot and Kains Avenues, underwent a restoration project that widened, re-graded and re-vegetated the channel as well as added a gravel pedestrian path parallel to the stream. The project was completed while the shopping center and parking lot underwent a major renovation. In this study, we assessed current creek conditions and compared them to the original project design as well as a 2005 post-project assessment. We found that there may have been minor channel incision since 2005, but this evidence was unreliable due to the cross section locations having not been permanently monumented. An increase in the number of gravel bars, and an increase in the diversity of sediment size indicated that the stream was transporting sediment. Native vegetation planted during the restoration appeared to be flourishing, although we documented a few invasive species that have established as well. Although the creek restoration was successful at creating wildlife habitat and a new amenity for the public, it did not address the treatment of stormwater, raising concerns about the impacts of potentially harmful urban runoff on creek water quality. We considered options to retrofit stormwater management infrastructure and concluded that flow-through biofiltration structures such as sand filters, basins, or planters would be most feasible based on the local soil conditions and available land area.

I. INTRODUCTION

The main stem of Cerrito Creek, originating in the northern extent of the East Bay hills, demarcates the southern border of El Cerrito, California where it also divides Alameda and Contra Costa Counties. The creek drains a watershed of roughly 1322 acres in Contra Costa County and discharges into San Francisco Bay just south of Point Isabel National Shoreline. Approximately 65% of Cerrito Creek's watershed is impervious (Contra Costa County 2003). Similar to many urban waterways, Cerrito Creek has numerous stormwater outfalls along its length and is used primarily to convey stormwater away from the city as fast as possible to reduce the risk of flooding. El Cerrito Plaza is a large, 29-acre retail shopping center directly north of Cerrito Creek between Kains Avenue and the Ohlone Greenway (Figure 1). Of the total area, rooftops contribute approximately 9.2 acres of impervious surface while parking lots account for the majority of the urban surfaces at 18.4 acres. Combined, building roofs and parking lots cover approximately 95% of the shopping center's total footprint. Landscaped, permeable areas make up the other 5%, approximately 1.4 acres.

This study focuses on a 700-foot reach of the creek along the shopping center's southern border between Kains and Talbot Avenues. The reach receives 60% of the stormwater runoff from Cerrito Plaza (Figure 3). The reach underwent a restoration project in 2003 concurrently with a major renovation of the shopping center and parking areas. The restoration project removed concrete and asphalt from the channel's banks, widened the creek corridor by roughly 20 feet, re-contoured the creek, and re-planted the corridor with native riparian vegetation. The restoration project goals were the creation of a natural meandering channel, reduction of flooding and bank erosion, removal of invasive species, re-vegetation of slopes with native plants, enhancement of community stewardship and environmental values, and reduction of sedimentation and maintenance problems (Berndt and Smith 2005).

The effects of urban runoff on watersheds are a growing concern in many areas of the country. The Nationwide Urban Runoff Program (NURP) monitored stormwater toxicant discharges from 28 cities and concluded that urban areas were responsible for substantial toxicant discharges (EPA, 1983a). These stormwater-related water quality concerns have implications for ecological health. For example, streams with highly impervious watersheds have poorer fish diversity than streams with undeveloped watersheds (Wang et al 2007). Additionally, storm drain outfalls typically bypass riparian zones altogether, meaning that there was little opportunity for the riparian corridor to filter and biologically uptake contaminants of concern such as nutrients, metals, and hydrocarbons (Conversation with Dr. David Sedlak, October 2011).

Of all impervious surfaces, parking lots are of particular concern. A study of stormwater from parking lots in Birmingham, Alabama, found that 41% of the samples showed medium to high toxicity (Pitt 1995), and another study demonstrated that the magnitude of toxicity from parking lot runoff was often greater than that observed in other urban stormwater samples (Greenstein 2004). Toxic polycyclic aromatic hydrocarbons (PAHs) present in parking-lot sealcoat are a source of watershed contamination. A study performed in Austin, TX showed that stormwater runoff from parking lots treated with sealcoat had mean concentrations of PAHs that were 65 times higher than unsealed asphalt and concrete parking lots and that runoff from parking lots was the primary source of PAHs to the urban creeks that were tested (Mahler 2005). Metals such as copper from vehicle brake pads are also harmful at low concentrations. Copper is a neurobehavioral toxicant in fish, and has been shown to reduce salmon alarm responses at concentrations as low as 2 μM, while typical copper concentrations in stormwater may range up to 20 μM (Sandahl et al 2007).

As of December 1, 2011, Contra Costa County required renovation projects like the parking lot renovation to submit a Stormwater Control Plan (Contra Costa Clean Water Program 2010). This regulation was implemented after the completion of the 2003 renovation and therefore this site was not required to meet the new stormwater management requirements. Fossil filters to remove hydrocarbons and sediment were installed at storm drain inlets in 2003 per minimal regulations at that time, but their effectiveness at the time of this study was undetermined. The City of El Cerrito adopted a master plan for the Ohlone Greenway that incorporates stormwater management in the form of bioswales, riparian vegetation, and pedestrian access, but the plan does not extend to this reach of Cerrito Creek (City of El Cerrito, 2010). Therefore, to our knowledge, there are no plans to change the parking lot stormwater management in the near future.

This study accomplished dual objectives. The primary objective was to evaluate the current conditions at the creek and compare them to the original restoration project goals as well as a 2005 post-project assessment performed by UC Berkeley students (Berndt and Smith 2005). The secondary objective was to evaluate the impact of the El Cerrito Plaza parking lot runoff on the creek and identify further stormwater management alterations that could improve water quality in the creek.

II. METHODS

Our methods consisted of three parts: a review of existing site-specific documents, data collection at the project site, and an impact analysis of the shopping center runoff on the creek.

Existing Document Review

We obtained site specific information such as stormwater plans by accessing the archives of the City of El Cerrito Public Works Department as well as reviewed GIS data for watersheds in Contra Costa County. We collected background information by contacting Friends of Five Creeks, the volunteer organization that currently maintains this project, as well as the civil engineering firm Aliquot Associates and Wolfe-Mason Associates which participated in the 2003 parking lot renovation and creek restoration, respectively. Most importantly, we utilized a 2005 post-project appraisal of the reach (Berndt & Smith 2005).

Field Work

We conducted field work during four site visits in October and November 2011, both before and after rain events. The first two visits consisted of qualitative observations of the creek from Ohlone Greenway to the East Shore Freeway. Photos from this visit can be found in Appendix B. This included 500 feet of the creek upstream of the project area as well as 2400 feet downstream of the project area in order to gain better understanding of the creek at a larger scale. During the third visit, we surveyed previously documented cross sections of the creek. The fourth day of field work included a sediment analysis as well as vegetation and rubbish surveys.

Cross-Sectional Surveys

The post-project appraisal completed in 2005 provided useful data that could be analyzed and compared with the results of the most recent field work (Berndt & Smith 2005). The five cross sections surveyed in 2005 were re-surveyed in approximately the same locations (Figure 2). These locations did not have permanent survey monuments installed, therefore we relied on station numbers measured upstream from the Kains Avenue culvert, as well as physical descriptions of the locations such as “in the middle of the downstream reach where there appears to be a failed rock weir” (Berndt and Smith 2005). Using a civil engineering plan provided by the City of El Cerrito, we identified the rim elevation of a drain inlet at Kains Avenue. We used this elevation as our datum to determine the absolute elevations of all grade shots.

Facies Maps & Pebble Counts

We identified two representative 30-foot sub-reaches in Cerrito Creek and developed facies maps based on visual observations of areas of homogenous sediment size. The first and second sub-reach began at station 0+76 feet and 2+20 feet, respectively, upstream of the Kains Avenue culvert. Additionally, we took photographs of each mapped sub-reach; these photos supplement the facies maps and can be found in Appendix B. For the most prevalent facies on each map, we conducted a pebble count. We followed modified Wolman pebble count procedures, blindly sampling 100 random pebbles, measuring them in millimeters along the B axis, and classifying grain size based on the half-phi scale (Kondolf 1997). The smallest grain size category considered was “<8 mm” in order to maintain consistency with the 2005 post-project assessment.

Vegetation Survey

We performed a vegetation survey by walking the entire length of the reach along the El Cerrito Plaza Shopping center and identified the most prolific plants. We documented each plant, but we did not analyze limb size or plant density. Plant species were identified in the field in addition to referencing the planting plan prepared by Wolfe-Mason Associates in 2003. The list of identified plants is located in Appendix A.

Impact Analysis

Pollutant Review

Due to temporal and budgetary constraints, we were not able to directly measure contaminants from the stormwater outfalls of El Cerrito Plaza. Instead, we performed a literature review to identify relevant pollutants based on studies with similar site characteristics. These characteristics included that the majority of the runoff from the site came from the parking area, that the parking lot was recently maintained with a sealant based on visual observations, the parking lot experienced a high turn-over rate of vehicles, and that stormwater was minimally treated before entering the creek. Referencing these published studies, we drew conclusions about the likely effects of the runoff on water quality.

Stormwater Management Calculations

To perform an initial ranking of stormwater management practices, we collected basic site-specific information such as soil type and precipitation. We obtained a custom soil map from the Natural Resource Conservation Service (NRCS & USDA 2011), hourly precipitation data from the National Oceanic and Atmospheric Administration, and yearly precipitation from an isohyetal map (Contra Costa County Public Works Department 1997).

After appropriate stormwater management options were narrowed down, we utilized Contra Costa County's *Integrated Management Practices Calculator* to estimate the surface area of each treatment option (Contra Costa County Clean Water Program 2011). This calculator was a good first estimate, as it was developed specifically for Contra Costa County and was therefore appropriate for the local hydrology. Inputs to the calculator included drainage type, impervious surface area, impervious surface type, soil class, and management practice flow regime. We estimated the impervious surface area from the engineering design plans and deduced that only 40% of the parking lot drained to the 700-foot-reach of interest from the city storm drain maps. (Figure 3) We then used AutoCAD and ortho imagery to sum the relevant impervious asphalt and rooftop areas, leading to an estimate of the total area that drains directly to the north side of the reach.

III. RESULTS & DISCUSSION

Channel Morphology

The results of the cross-sectional surveys can be found in Figures 4-8, with data summarized in Table 1. Theoretically, comparing the results of the cross sections surveyed in 2005 to the surveys done this year show how the creek geometry had changed in the last six years. Unfortunately, as previously noted, the cross sections taken were not permanently monumented and therefore all of the channel movement and incision noted may be due to inaccuracies in data collection. We highly recommend that in the future, stream restoration projects install permanent cross section monuments, such as rebar stakes, to enable future assessment surveys. These monuments should be high above the water in order to avoid erosion, and should be placed on either side of the creek to ensure consistent surveys over time. Simply providing station numbers is not sufficient; the distances upstream as measured along the thalweg, as well as angles of the perpendicular cross sections, will change as the stream morphology evolves.

Our most accurate cross-section, cross section A, showed that that the creek had down-cut approximately 8 inches, further exposing the base of the masonry wall directly adjacent to the channel's flow. Additionally, the right bank had eroded slightly, possibly due to overland stormwater runoff flow or the impacts of human use. A comparison of cross-sections B,C,D, and E to those surveyed in 2005 could not be accurately made because of the error in the cross-sectional survey locations.

Sediment

Facies Map A (Figure 9) shows sediment deposition following a creek bend. A bar of primarily small pebbles and sand stretched nearly entirely across the stream bed. Surrounding the bar were deposits of different size, including sand, small gravel, and large cobbles. Pebble Count A was conducted at this bar and the results are plotted in Figure 10. The pebble count revealed a high percentage of fine sediment and a median pebble diameter of between 8-16 mm. Much of the bar was covered by watercress, which may have been present due to the small sediment size and the high levels of nutrients such as nitrogen or phosphorus (SFBRWQCB 2008). Facies Map B (Figure 11) also revealed sediment of diverse sizes distributed between two rock weirs. The weirs constricted the flow, directing it at high velocity downstream and likely influencing sediment sorting. Pebble Count B was conducted at the main gravel bar and showed a sediment of slightly larger size than in Pebble Count A, but still of median diameter between 8-16 mm.

The 2005 assessment provided neither a facies map nor the location of the pebble count, thus hindering our ability to compare the sediment size with great precision but not our ability to observe general trends. Most notably, the quantity of sediment in Cerrito Creek increased between 2005 and 2011. Less than two years after the restoration, very little sediment and few gravel bars had accreted (Berndt & Smith 2005). In contrast, our recent facies maps and pebble counts show the development of sediment deposits over the entire creek bed. Based on visual observations, the growing gravel bars have contributed to the establishment of meander bends within the wider creek corridor delineated by the rock toe.

In 2005, the sediment was uniform with a median diameter of 45 mm, and the upstream reach was muddy and lacked any sediment (Berndt & Smith 2005). Both of our pebble counts reflected a significant decrease in sediment size, although some minor facies not characterized by a pebble count appeared to have larger sediment size. We theorized that the 2005 count reflected cobble that was anthropogenically deposited during the 2003 restoration, while in the six years since the entire stream bed had become covered with sand, gravel, or cobble. Sediment deposits of the size observed may enhance fish spawning habitat in the future, though deposits characterized by our pebble counts may be slightly finer in size than might be ideal (Kondolf and Wolman 1993).

Vegetation

Two of the goals of the 2003 restoration project were to remove invasive plant species and replant the banks of the creek with native riparian vegetation. In other areas of the creek outside the bounds of the project, a volunteer organization, The Friends of Five Creeks, achieved this by tarping the banks for three years to kill off invasive species such as blackberries (Friends of Five Creeks 2011). At the site of the restoration along El Cerrito Plaza, the slopes were regraded, although it was unclear what was done to prevent the regrowth and reintroduction of invasive species. At the time of this study, there were a number of invasive plants present along the project reach such as blackberry, English ivy, and horsetail indicating that eradication methods were not entirely successful.

Despite the presence of invasive species, many of the native plants established during the restoration were thriving. These include dogwood trees, alder trees, and willows (Wolfe Mason 2003). In the upper reach from Cornell to Talbot Avenue, the corridor had steeper banks and the vegetation was much denser. The blackberry and English ivy species dominate in some sections along this reach. With the competition between the invasive versus native species at the site, maintenance such as pulling of invasive English Ivy during moist soil conditions was needed in order to prevent invasive species from crowding-out the native plant life that was planted during the 2003 restoration project.

Possible Pollutants in El Cerrito Plaza Runoff

All of the stormwater runoff from the impervious surfaces of El Cerrito Plaza is discharged directly to Cerrito Creek in four locations. According to engineering design plans, roughly 40% of the runoff from the Plaza enters the reach from two culverts along city streets and one outfall along the edge of the parking lot. The other 60% of the runoff enters the city storm system and discharges into the creek at an outfall 700 feet downstream of Kains Avenue, west of San Pablo Avenue. The plaza parking lot appeared to have been recently resurfaced during our visits in October of 2011. Therefore, high levels of polycyclic aromatic hydrocarbons (PAHs) from parking lot seal coat may be entering the creek (Mahler 2005). However, without verifying the products used specifically on this parking lot, it was impossible to estimate the PAH contribution.

The large impervious surface area of parking lots acts as a collection area to funnel toxic metals into urban streams. These surfaces receive metals such as copper from brake pad emissions and zinc from tire wear via direct contact as well as atmospheric deposition (Davis 2001). We assumed that parking lots that have high vehicle turnover rates, such as this shopping plaza, were more likely to have higher concentrations of metals deposited on their surfaces. Therefore it was possible that the Plaza parking lot was contributing higher levels of zinc and copper than other area parking lots.

Fossil filters within the stormwater catch basins were installed in 2003 to filter all the water from the roof and parking lot drainage systems (Aliquot, 2011). When maintained properly and regularly, fossil filters can remove hydrocarbons, metals and particulate matter. At the shopping plaza, the extent and frequency of maintenance was unclear and compliance monitoring seemed to be self-regulated. Upon inspection of two of the catch basins, the fabric of the fossil filters appeared torn and there was an accumulation of trash inside the basin, indicating that the fossil filters may not be functioning as intended. A photo of the fossil filters can be found in Appendix B, photo B6.

Pollutants entering the creek are a concern with regard to their effect on the success of the restoration project. A long term study of the water quality of the creek along this reach would need to be conducted to make any definitive site-specific conclusions regarding the exact effect of the parking lot runoff.

Stormwater Management Improvement Options

Insufficient stormwater management at El Cerrito Plaza may be detrimental to water quality in Cerrito Creek. While this is not related to the original project goals, it is relevant to the ecology of Cerrito Creek. Two methods exist to improve the quality of stormwater: direct impervious area reduction, and installation of stormwater management facilities. Within the latter are subcategories of surface infiltration, subsurface infiltration, and hybrids of both (Portland BES 2008). Further, the flow scheme of many surface infiltration facilities can be altered to achieve varying levels of infiltration based on site constraints. Commonly used techniques within these categories are listed and evaluated in Table 3.

The primary constraints for the Cerrito Plaza parking lot sub-basin were soil type and the available space. The native soil formation was Tierra Loam C; this soil is well-drained but had a poor permeability that may be 0.06 in/hr or lower (NRCS 2011). Therefore, the native soil was not well-suited for subsurface infiltration-based stormwater management facilities. This left the option of surface infiltration facilities, which can be designed to accommodate the low-permeability soil, as well as impervious surface area reduction techniques.

Available parking area is very important to the businesses at the Plaza and high costs could make a stormwater project prohibitive to the developer. Since improvements to this stormwater system were not a requirement by the local government, we sought to propose stormwater management techniques that had a small surface area footprint and were therefore compatible with the existing parking lot layout without requiring substantial renovation.

Our goal of stormwater management was to improve water quality by reducing the contaminants--specifically metals and PAHs--delivered to Cerrito Creek. Although some impervious area reduction techniques described in Table 3 were ideal for reducing peak runoff, they would not reduce the contaminant loads to the creek. Also, excluding subsurface infiltration facilities due to soil type, the ideal stormwater management facilities thus fell under the surface infiltration category. Bioretention facilities, specifically the planter, filter strip, and basin, were options that fit the above-described constraints. For example, the raised vegetated islands at the site could be changed to depressions with carefully selected plant species.

The design of either filter strips or basins can be altered to accommodate the poor soil permeability. First, they can be designed with the flow-through scheme that allows for some pollutant filtration and reduction of runoff rates, but does not require infiltration into the native soil (Portland BES 2008). These facilities can be lined with gravel and sand, perhaps with the addition of an underdrain. We recommend that the soil be amended with a high-organic fraction soil such as compost, which increases sorption of common pollutants (U.C. Davis Extension 2011). Indeed, swales with compost-amended soil have been shown to remove over 300% more copper and zinc than swales with non-amended soil (Lenth 2011).

We conducted preliminary design calculations to size a flow-through planter for the south side of El Cerrito Plaza that drains to the daylighted reach. Based on a mean annual rainfall of 22.5 inches and an impervious area of approximately 17.5 acres, the planter would need to be at least 30,000 square feet or 0.7 acres in area (Contra Costa Clean Water Program 2010). This represents only about 4% of the total impervious area, but is still a significantly large--perhaps prohibitively large--area. In contrast, if the runoff from the roofs were to be collected separately and the planter were to serve only the parking lot, the planter area would need to be at least 18,000 square feet or 0.4 acres. Stormwater management is integral to the water quality of urban streams, and we recommend that future stream restoration projects consider stormwater management during the planning process.

IV. CONCLUSIONS

The 2003 restoration of Cerrito Creek along El Cerrito Plaza identified six restoration goals. The restoration project partially achieved its first two goals of creating a “natural meandering channel” and reducing erosion. The stream channel had successfully maintained the appearance of a meandering channel due to strategically placed riprap armoring the banks, however there was little evidence that the channel was meandering “naturally.” The cross sections of the channel appeared to show that the creek morphology is stable due to the rock toe and incision control weirs. More importantly, cross section locations were not monumented, therefore any findings based on the cross sections could have been in error. We recommend that future restoration projects install permanent monuments so the locations can be consistent in assessments over time.

The third and fourth goals were to eliminate invasive species and to replant the banks with native vegetation. Since the replanting, many invasive species had re-entered the region and populated the banks. The undesirable species seemed to be more plentiful along the upper sub-reach of the restoration project and therefore we recommended increased maintenance between Cornell Avenue and Talbot Avenue. Despite the re-population of some invasive species, many native plants had flourished along the reach creating a rich and diverse ecosystem.

The fourth goal--enhancement of community stewardship and environmental values--was not evaluated in this assessment. The fifth goal sought to decrease sedimentation and maintenance problems that were likely due to deposition in the formerly channelized creek. Our observations and facies maps showed an increasing number of gravel bars and greater diversity in sediment size compared to the 2005 study; and our pebble counts indicated smaller sediment in general. However, sediment deposition was no longer considered a maintenance problem.

Though El Cerrito Plaza was a potentially large contributor to toxic pollutants in the creek, this issue was not addressed in the 2003 restoration project. Through site analysis and literature review, we inferred that the plaza parking lot had a potentially large, negative impact on the creek ecosystem and could have a detrimental impact on the success of the 2003 project. This problem could be addressed through the use of flow-through bioretention structures such as filter strips, basins, or planters as these would be most feasible based on the local soil conditions and available land area. After preliminary calculations, we found that a basin, for example, would need to be at least approximately 18,000 square feet in area in order to treat the runoff that flows directly to the reach of Cerrito Creek adjacent to the plaza. Amending the soil in the basin with high-organic fraction compost would enhance the removal of pollutants of concern, particularly metals, and thereby improve creek water quality. Although not part of the restoration goals, stormwater management improvements in the parking lot could greatly enhance the water quality in Cerrito Creek.

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VI. FIGURES & TABLES

Figure 1: Context map showing El Cerrito Plaza in the Cerrito Creek watershed.

Figure 2: Cross-section locations along restoration project reach.

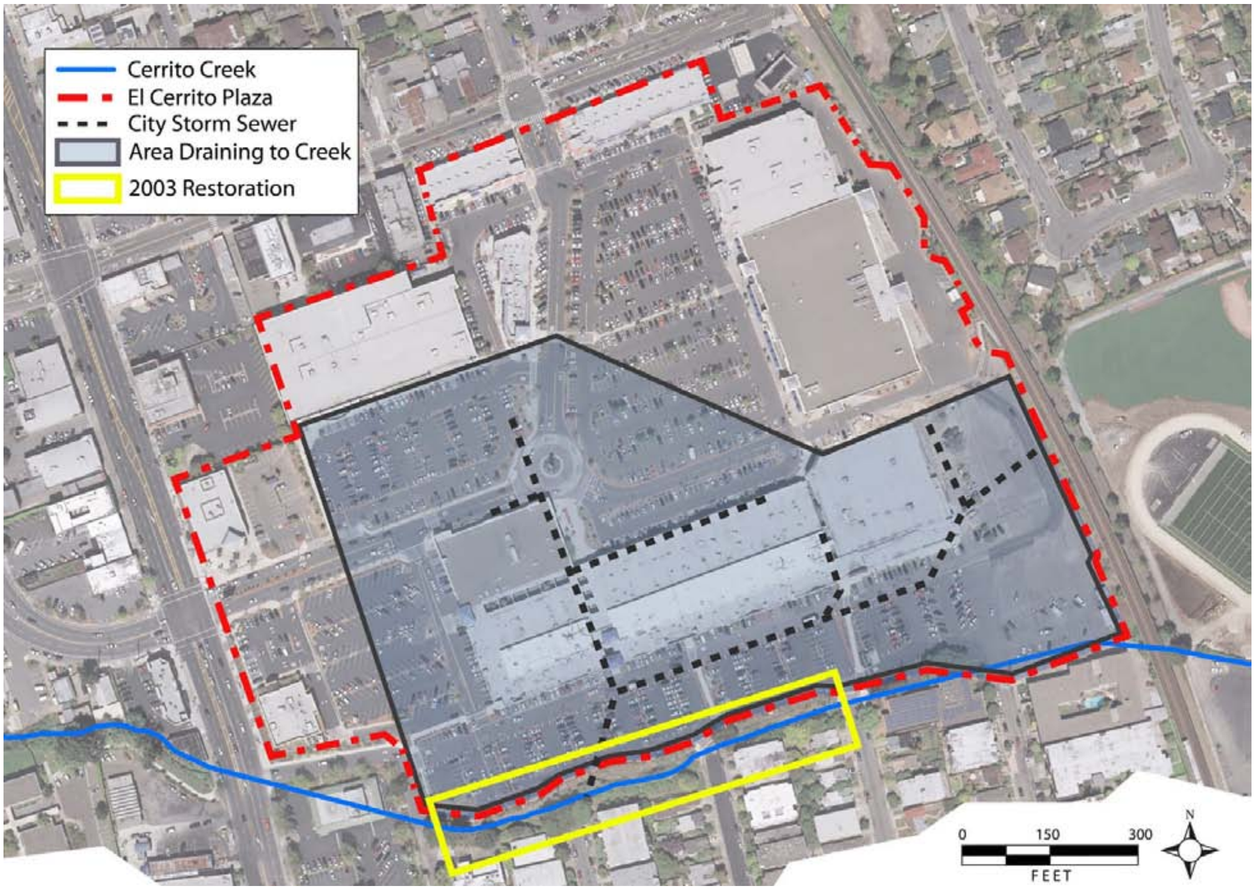

Figure 3: Map of Cerrito Plaza and Cerrito Creek showing area of impervious surface discharging directly to reach of restoration project.

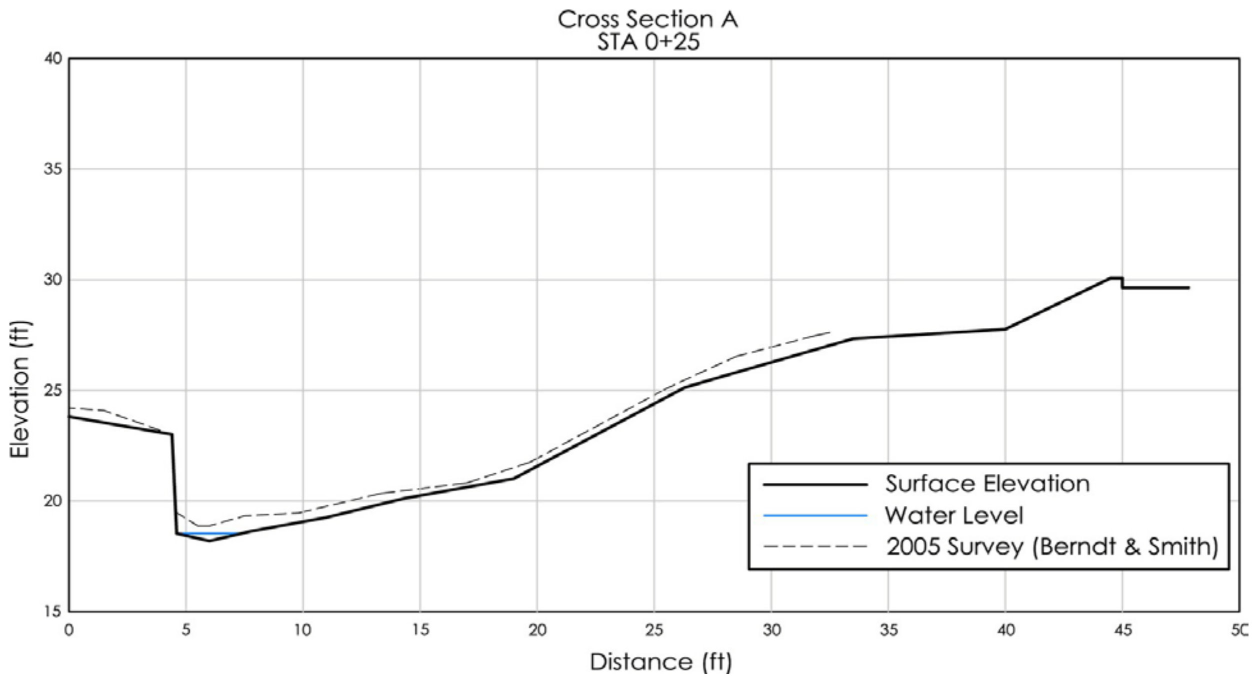

Figure 4: Cross Section A at STA 0+25, showing recent (2011) and past (2005) surface elevations.

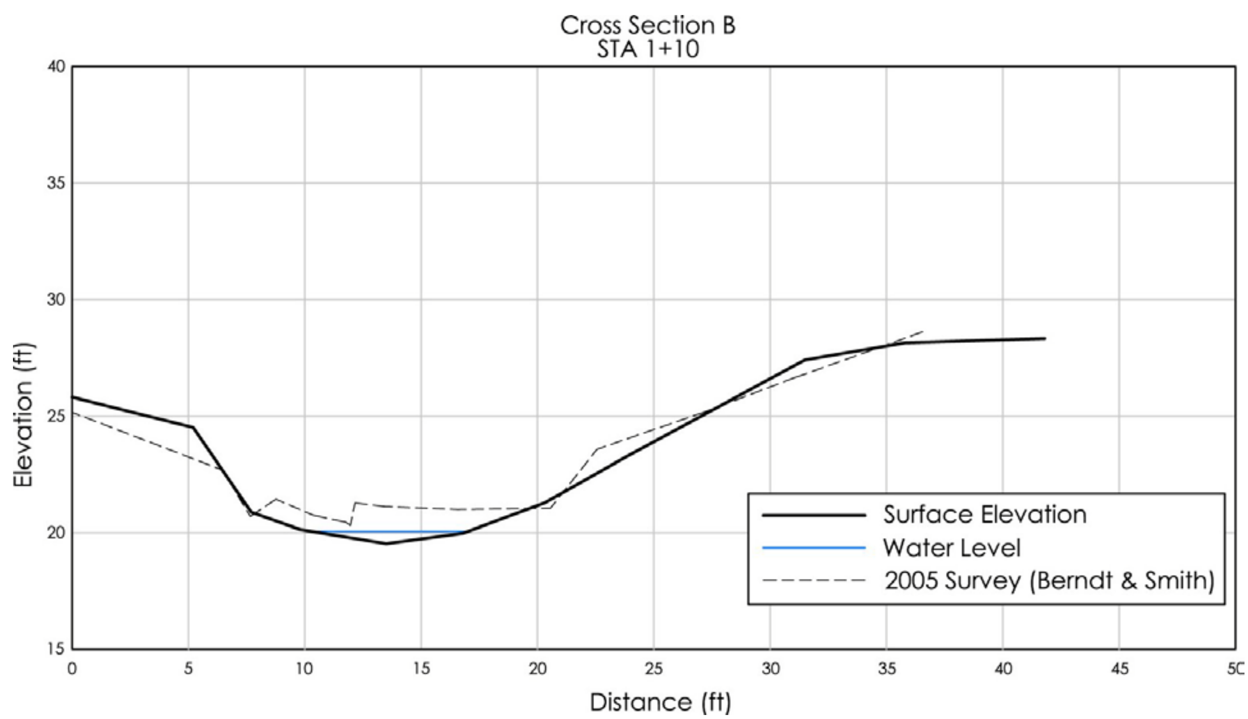

Figure 5: Cross Section B at STA 1+10, showing recent (2011) and past (2005) surface elevations.

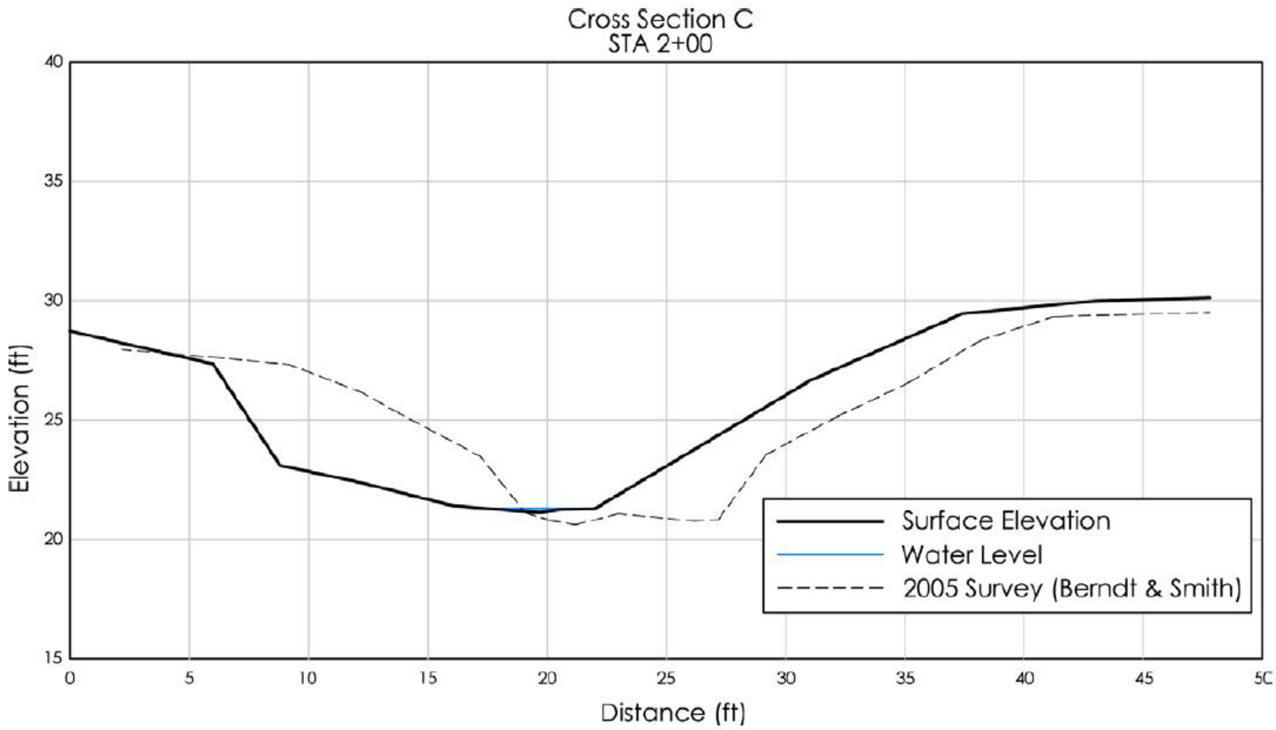

Figure 6: Cross Section C at STA 2+00, showing recent (2011) and past (2005) surface elevations.

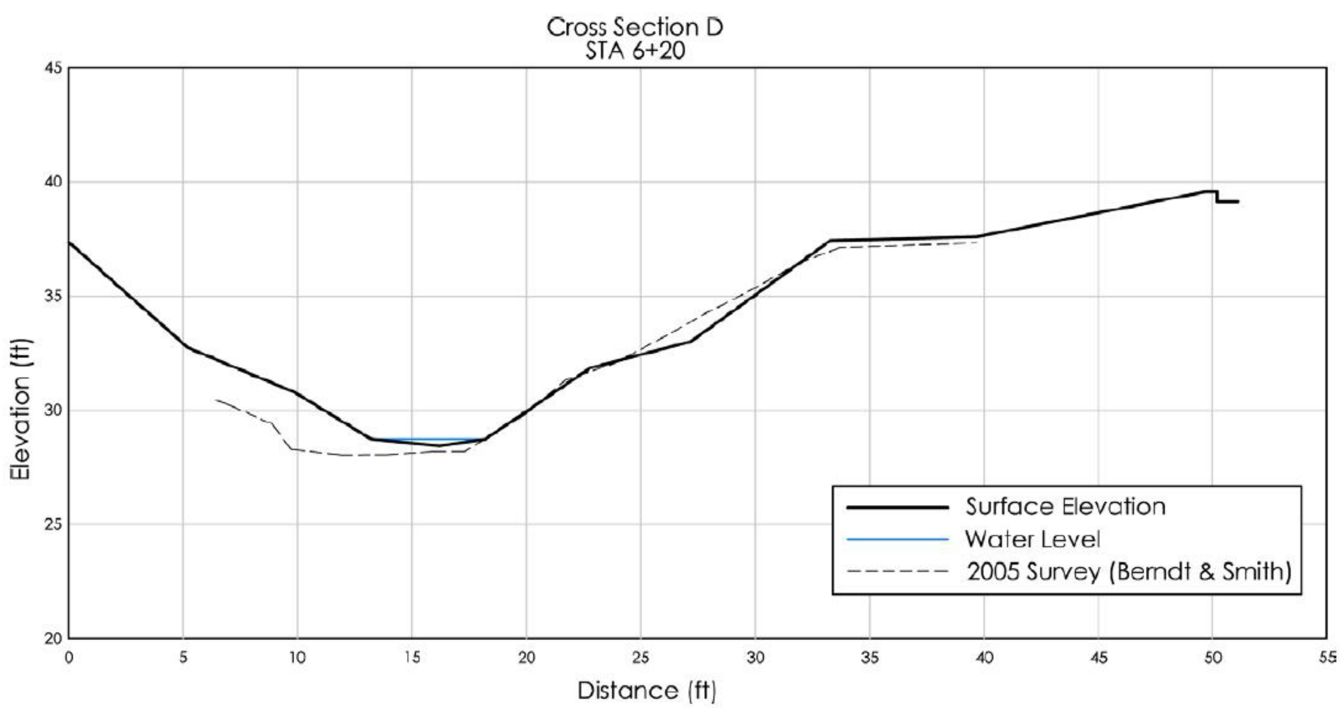

Figure 7: Cross Section D at STA 6+20, showing recent (2011) and past (2005) surface elevations.

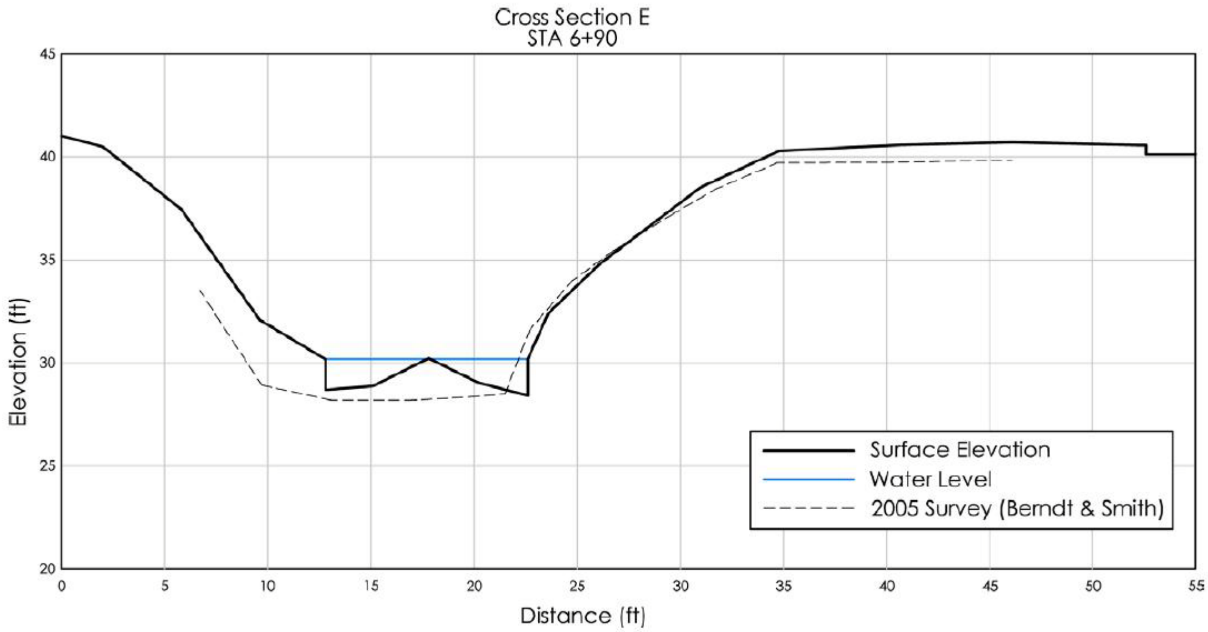

Figure 8: Cross Section E at STA 6+90, showing recent (2011) and past (2005) surface elevations.

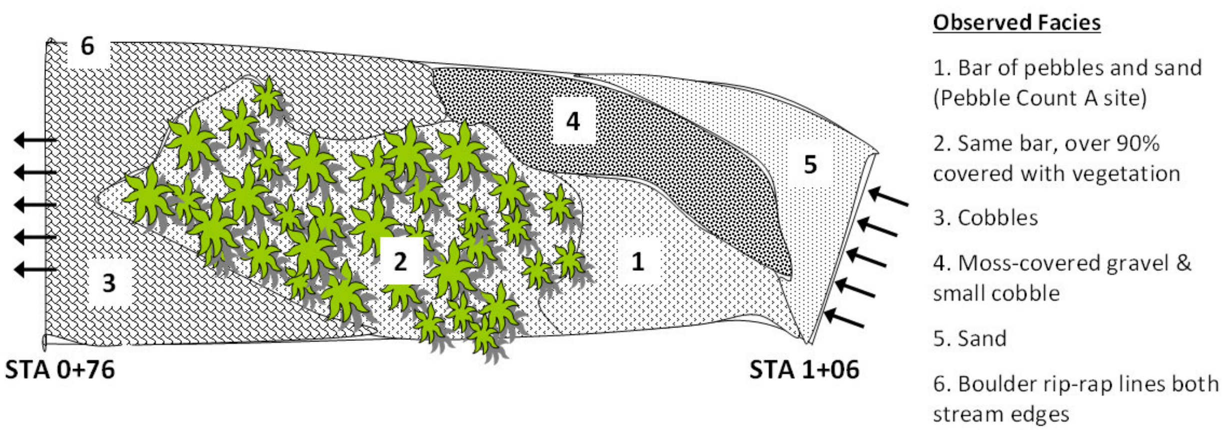

Figure 9: Facies Map A, from 76-106 feet upstream of Kains Avenue. Pebble count A (see Figure 12) was performed at location 1 in this map . Note: Not to scale.

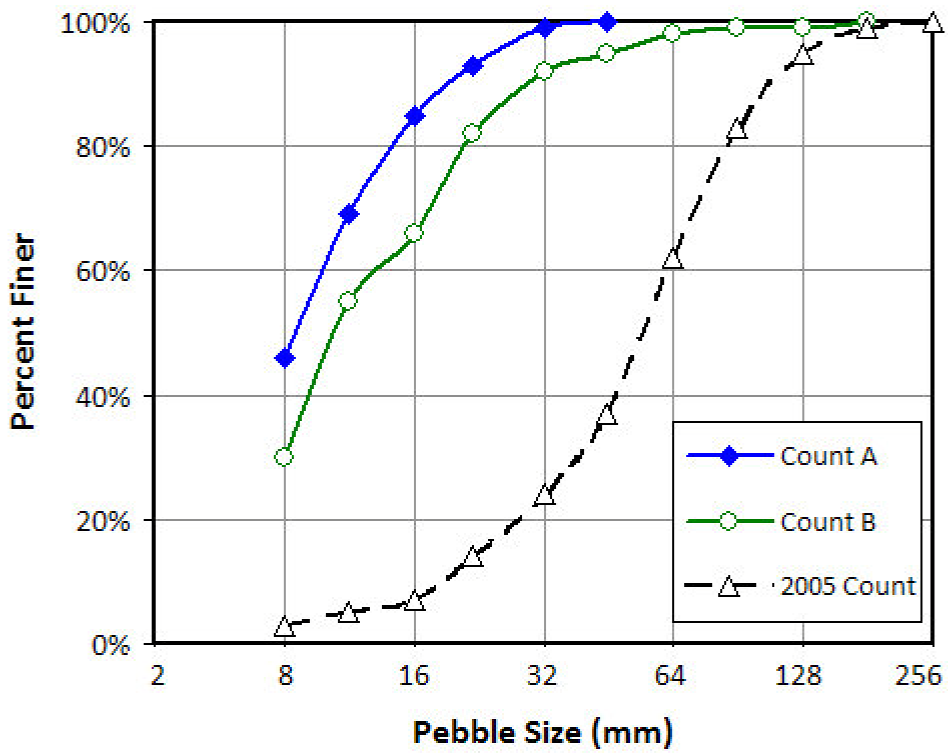

Figure 10: Pebble count results for gravel bars at (a) 91 feet upstream of Kains Avenue culvert, and (b) 220 feet upstream of Kains Avenue culvert. Pebble count data is shown in Table 2.

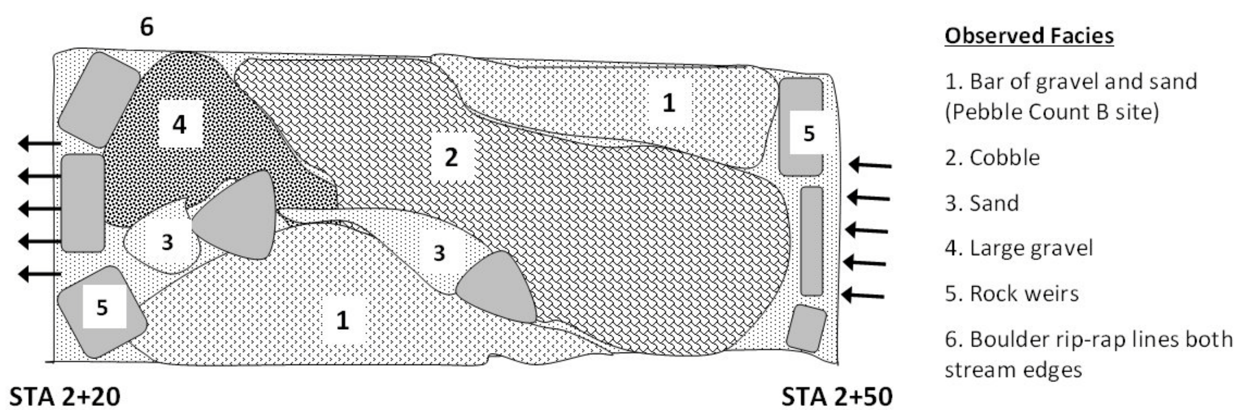

Figure 11: Facies Map B, from 220-250 feet upstream of Kains Avenue. Pebble Count B (see Figure 12) was performed at location 1 on this map.. Note: Not to scale.

Table 1: Data from cross-sectional surveys.

Horizontal Distance (ft)	Surface Elev. (ft above MSL)	Notes
Cross Section A, STA 0+25		
0.0	23.82	Top of berm at south bank
4.4	23.01	Top of wall
4.6	18.53	Bottom of wall/water edge
6.0	18.19	Thalweg
7.9	18.64	Water edge
11.0	19.26	Top of bank
14.3	20.11	Top of floodplain
19.0	21.01	Base of Redwood tree
26.3	25.13	
33.5	27.33	
40.0	27.60	Top of slope/edge of path
44.5	30.07	Top of curb
45.0	29.64	Parking lot gutter
Cross Section B, STA 1+10		
0.0	25.82	Top of south bank
5.2	24.52	Top of sack crete wall
7.7	20.88	Top of rock toe
9.8	20.14	Edge of water
13.5	19.53	Thalweg (pool at rock weir)
16.8	19.98	Edge of water
20.3	21.28	Flood plain
23.8	23.25	Top of rock toe
31.5	27.42	Top bank (floodplain)
35.8	28.15	Edge of path
41.8	28.34	Edge of path (North bank)
Cross Section C, STA 2+00		
0.0	28.72	Top of south bank
6.0	27.33	Top of wall
8.8	23.10	Bottom of sackcrete wall
12.2	22.37	High water mark
16.0	21.42	Bottom of slope
17.4	21.29	Edge of water
19.7	21.11	Thalweg, 0.1 ft below surface
20.5	21.24	Edge of water
22.0	21.28	Bottom of slope
22.4	21.85	High water mark (north side)
31.0	26.63	Mid-slope
37.4	29.44	top of slope
43.0	29.98	2nd edge of path
47.8	30.11	Edge of walking path

Horizontal Distance (ft)	Surface Elev. (ft above MSL)	Notes
Cross Section D, STA 6+20		
0.00	37.35	Top of south bank
5.20	32.74	
9.90	30.77	Top rock toe
13.20	28.74	Edge of water
16.20	28.44	Thalweg
18.20	28.73	Edge of water
20.40	29.89	High water mark
22.80	31.86	Bottom of slope
27.20	33.01	
33.30	37.43	Edge of path
39.70	37.60	Edge of path
50.20	39.58	Top of curb
50.30	39.13	Parking lot edge, north bank
Cross Section E, STA 6+90		
0.0	41.02	
2.0	40.49	Edge of slope on south bank
5.8	37.45	Top of rock toe
9.6	32.09	Bottom of rock
12.8	30.17	Edge of water (surface)
12.8	28.69	Edge of water (bed)
15.1	28.88	Underwater (thalweg?)
17.8	30.23	Underwater
20.2	29.04	Underwater
22.6	29.42	Edge of water (bed)
22.6	30.19	Edge of water (surface)
23.8	32.41	On rock toe
26.1	34.81	Middle of slope
31.0	38.53	Middle of slope
34.8	40.29	Top of slope
40.6	40.58	Edge of path
46.1	40.71	Edge of path
52.2	40.57	Top of curb
52.6	40.12	Top of parking lot pavement
Storm Drain On North Bank between Kains & Talbot		
N/A	25.19	Storm drain outlet, invert elev.

Table 2: Pebble count data for gravel bars at 91 feet upstream of the Kains Avenue culvert (Pebble Count A), and 220 feet upstream of the Kains Avenue culvert (Pebble Count B).

B-axis Length (mm)	Pebble Count A		Pebble Count B	
	Count	Percent Finer	Count	Percent Finer
<8	46	0	30	0
8	23	46%	25	30%
11.3	16	69%	11	55%
16	8	85%	16	66%
22	6	93%	10	82%
32	1	99%	3	92%
45	0	100%	3	95%
64	0	100%	1	98%
90	0	100%	0	99%
128	0	100%	1	99%
180	0	100%	0	100%
256	0	100%	0	100%
Vegetation	5	-	0	-
Garbage	0	-	3	-

Table 3: Summary of stormwater best management practices and evaluation of applicability to El Cerrito Plaza site. The ratings are -, 0, and + for negative, neutral, and positive influence, respectively.

Method	Evaluation Criteria			Description
	Contaminant Removal	Surface Area	Soil Compatibility	
Impervious Surface /Direct Volume Reduction				
Ecoroof	0	+	+	A roof that has been planted with a layer of soil and drought-tolerant vegetation to directly reduce impervious surface area.
Rainwater Harvesting	0	+	+	A system whereby roof runoff is captured for non-consumptive reuse after the installation of cisterns and appropriate plumbing infrastructure.
Pervious Pavement	+	+	-	A parking lot or street that has been finished with pervious asphalt, pervious concrete, or permeable pavers.
Surface Infiltration				
Filter Strip	+	+	+	A sloped, vegetated, narrow strip that run parallel to adjacent impervious surfaces and can filter, reduce flow velocities, and infiltrate runoff.
Planter	+	+	+	A landscaped "reservoir" of varying shapes and sizes that can be designed for either infiltration or flow-through flow schemes.
Sand Filter	+	+	+	A landscaped area similar to the planter, but with a layer of sand at the bottom.
Swale	+	+	0	A long, narrow vegetated depression that allows water to infiltrate into the ground.
Basin	+	0	0	A flat-bottomed, landscaped depressions that retain stormwater until it infiltrates. Can also be designed for flow-through.
Curb Extension	0	+	0	A retrofit to existing strees by extension of the curb into the parking zone and planting the additional curb area like a swale.
Tree Box Filter	-	+	+	A method to use evergreen trees to intercept precipitation and shade impervious area; also reduces heat gain in stormwater
Rain Garden	+	-	+	Vegetated area that is similar in function to a swale, but with a larger area and less slope. Often fed by runoff from disconnected downspouts.
Vegetated Wetlands	+	-	0	An natural vegetated area that provides both retention and contaminant removal.
Pond	-	-	0	A body of water that can be designed either as a "wet ponds" or a "dry pond" that reduces peak runoff rates and suspended solids.
Subsurface Infiltration				
Drywell or Sump	0	+	-	A vertical, perforated concrete cylinder that allows infiltration into the subsurface on private property (drywell) or public property (sump).
Soakage Trench	+	0	-	A shallow trench that is backfilled with rock. Stormwater enters through a buried, perforated pipe and infiltrates below ground.
Other Techniques				
Inlet Protec-tion Device	-	+	+	A flow-through facility (such as a fossil filter) that removes sediment, grease, and trash, typically by mechanical separation or settling.

Sources: City of Portland B.E.S. 2008, Contra Costa Clean Water Program 2010, Hinman 2011, U.C. Davis Extension 2011, Pennsylvania DEP 2006, U.S. E.P.A. 2011.

APPENDIX A: Plant List

Note: This list of plants was produced to roughly characterize the vegetation at the restoration site. The species below were not identified by a qualified botanist and therefore this list is subject to inaccuracies.

Upper Reach: Talbot Ave to Cornell Ave

Steep banks, no flood plane/bench, dense growth makes public access to creek difficult. In many areas, water cannot be seen through foliage.

- Western Redbud - *Cercis occidentalis*
- Dogwood - *Cornus nuttallii*
- Manzanita - *Arctostaphylos sp.*
- California Sagebrush - *Artemisia californica*
- Lamb's Ear - *Stachys byzantina*
- English Ivy - *Hedera helix* (North facing bank primarily)
- Willows - *Salix sp.* (various)
- Poison Oak - *Toxicodendron diversilobum* (skin test used, plant not visually identified)
- Privit- *Forestiera sp.*

Lower Reach: Cornell Ave to Kains Ave

Thinner undergrowth and a higher canopy than in the upper reach makes creek more accessible to the public. Roughly 5 nodes of flood benches were located along the reach. More sunlight reaches the floor of the corridor.

- English Ivy - *Hedera helix* (limited, close to Cornell Ave)
- Blackberry - *Rubus fruticosus* (limited, close to Cornell Ave)
- Redwood -*Sequoia sempervirens* (34", 36" DBH near Kains Ave)
- Willow - *Salix sp.* (prolific along entire reach)
- Papyrus - *Cyperus papyrus*
- Various Long grasses
- Holly - *Ilex sp.*
- Pine - *Pinus sp.*
- Alder - *Alnus sp.* (DBH 5.5" prolific, some larger 8")
- Cattails - *Typha sp.* (usually found in groups, eg. near stormwater outfall)
- Privit - *Forestiera sp.*
- Palm plant - *Arecaceae sp.* (only 1 along reach)
- Horse Tail *Equisetum sp.*

APPENDIX B: Site Photos

Figure B1: Edge of Cerrito Plaza parking lot and Cerrito Creek riparian zone, looking west (downstream) from Talbot Avenue.

Figure B2: Stormwater outfall from El Cerrito Plaza parking lot to Cerrito Creek.

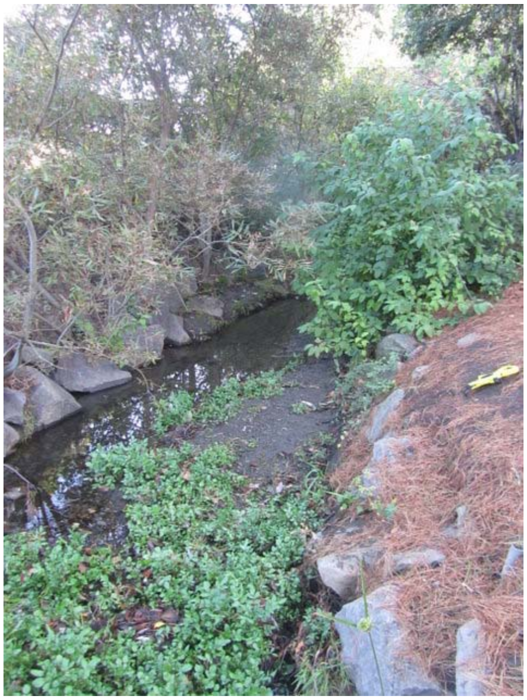

Figure B3: Photo of the site of Facies Map A.

Figure B4: Photo of the site of Facies Map B

Figure B5: Deep pool just downstream of Talbot Avenue culvert. Invasive species as well as native plants are visible.

Figure B6: View into a parking lot drainage basin showing collection of debris and rubbish. Scheduled maintenance for these structures was undetermined.