Pinole Creek Demonstration Project Summary Report

April 30, 2013

Prepared for the City of Pinole
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Introduction

In 2010, the City of Pinole and the Contra Costa County Flood Control and Water Conservation District (CCCFCD) constructed the Pinole Creek Demonstration Project (PCD) in Pinole, California. The PCD restored tidal marsh and riparian vegetation and reduced flood risk along approximately 1,000 feet of lower Pinole Creek. This document summarizes the history of the channel, the Pinole Creek Watershed Vision Plan, the Lower Pinole Creek Restoration Plan, and the planning, design, construction, and early monitoring results of the Pinole Creek Demonstration Project.

Watershed Overview

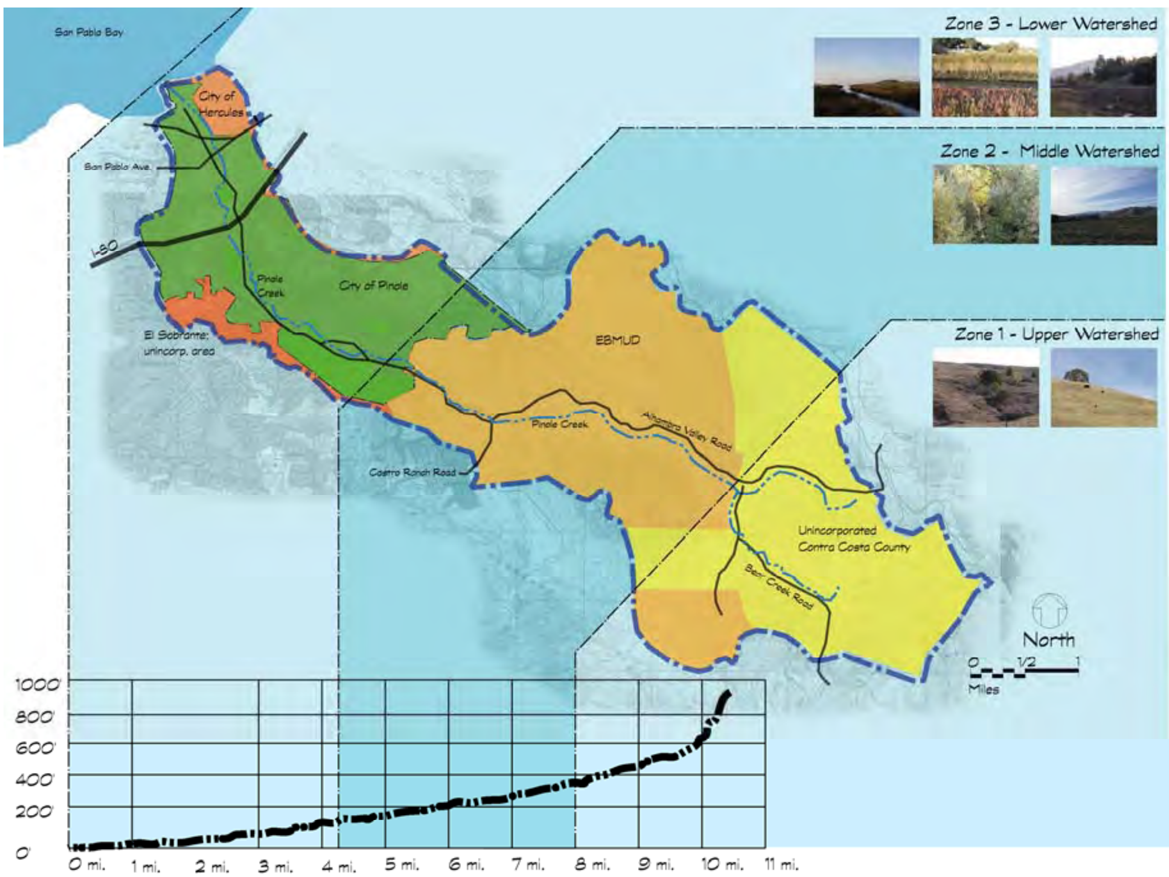

Figure 1. Pinole Creek Watershed

The Pinole Creek watershed covers approximately fifteen square miles of the west Contra Costa County. Forty-six miles of creek channels drain the Briones Hills into San Pablo Bay east of Point Pinole. The upper two-thirds of the Pinole Creek Watershed is lightly developed compared to most watersheds in the East Bay. The upper watershed is mostly privately-owned ranchettes and agricultural land. The middle watershed is primarily open space owned by the East Bay Municipal Utility District. The lower watershed is within the cities of Pinole and Hercules and is heavily urbanized.

Flood Control Channel

The existing flood control channel in lower Pinole Creek was built by the Army Corps of Engineers and the CCCFCD in 1965 following devastating storms in 1955 and 1958. The flood control channel stretches approximately 1.5 miles from I-80 to the mouth of the creek at San Pablo Bay.

Visually, the channel is typical of many flood control channels. It is trapezoidal in cross-section and mostly devoid of woody or brushy vegetation. Since the channel was constructed in 1965, Pinole Creek has not flooded the cities of Pinole and Hercules. However, the lack of habitat complexity has impaired the water quality and ecological function of the waterway.

Pinole Creek is in Flood Control Zone 9. CCCFCD's website describes the history of Zone 9 (CCCFC, 2009).

> *Flood Control Zone 9 was formed in the early 1950s to provide funding for construction and maintenance of regional drainage infrastructure in the Pinole Creek watershed. It initially provided, from a portion of the ad valorem property tax, local matching funding for a joint District / Army Corps of Engineers project extending from the mouth of the creek up to Highway 80.*
>
> *Prior to the passage of Proposition 13 in 1978, Zone Boards, which consisted of representatives from the watersheds, adjusted the tax rates of each Flood Control Zone annually. When Proposition 13 came around, several of the zone facilities were constructed, maintenance was up to date and there was enough money in the funds to set the tax rate very low or at zero. Upon passage, Proposition 13 froze those tax rates, in effect shutting off the tax revenue needed to adequately fund the maintenance of the Zones' flood control facilities.*
>
> *The State responded by setting up the Special District Augmentation Fund. This fund provided assistance for many years until the Fund was removed from the State budget during a State budget crisis. Today the several Zones remain severely underfunded. The District is actively seeking ways to compensate for lack of funding for maintenance.*

Without a reliable or consistent source of funding, the CCCFCD has limited its maintenance activities in lower Pinole Creek. The upper reaches of the federal project have only adjusted slightly. The lower reaches have changed significantly. The original design invert of the channel has filled in with as much as four feet of sediment which has diminished the channel capacity. Much of this deposition likely occurred soon after the last channel dredging and the channel profile has now approached a state of equilibrium.

Modeling results indicated that pre-Pinole Creek Demonstration Project channel capacity in Lower Pinole Creek ranged from 1 in 13-year to 1 in 35-year (RI) levels of protection, down from the 1 in 50-year (RI) protection of the channel as designed by the Army Corps. In addition to a reduction in the channel capacity resulting from sediment deposition, upstream alterations to the watershed have increased the original design discharge from 2,100 cubic feet per second (CFS) to 3,700 CFS for the 1 in 50-year (RI). The 1 in 100-year (RI) is estimated at 4,100 CFS.

Photo 1. Kite aerial of the mouth of Pinole Creek pre-restoration

At the mouth of the creek are four bridges which (to varying degrees) constrict the channel and reduce flood conveyance. Furthest downstream is the Bayfront Bridge, a bike and pedestrian bridge that is part of the Bayfront Park Loop Trail. The bridge provides pedestrian access to Bayfront Marsh. The next upstream bridge is the Union Pacific Railroad (UPRR) Bridge. Immediately upstream of the UPRR Bridge is Railroad Avenue Bridge, a vehicular bridge. The Railroad Avenue Bridge has the greatest impact on flood conveyance. The fourth bridge is the Bay Trail Bridge that provides pedestrian and bike access across the creek for users of the Bay Trail. All four bridges are pictured in the photo above (Photo 1).

Approximately 3,000 feet upstream is the Burlington Northern Santa Fe (BNSF) Bridge. This bridge is just beyond the tidal influence of San Pablo Bay. Between the BNSF Bridge and I-80 are several more creek crossings including a pedestrian bridge at Fernandez Park and road crossings at San Pablo Avenue, Tennant Avenue, Pinole Valley Road, and Henry Road.

Watershed Vision and Planning

Photos 2 and 3. Pinole Creek community workshops

The Pinole Creek Demonstration Project represents the culmination of many years of local community efforts to restore some ecological integrity to this single objective flood control channel built in 1965. What follows is a brief history of recent watershed planning.

Initial Efforts

In 2001, in anticipation of grants and other restoration opportunities, Ann Riley (then of the Waterways Restoration Institute) convened a workshop consisting of the CCCFCD, the City of Pinole, Pinole Redevelopment Agency, local community members, and other interested parties to discuss restoration of Pinole Creek. This workshop generated considerable momentum for watershed planning and restoration including the formation of the Friends of Pinole Creek.

In 2002, the Urban Creeks Council of California (UCC) received grants from the State Coastal Conservancy, Pinole Redevelopment Agency, and CCCFCD that funded the creation of the watershed-wide, community-based vision plan and an initial restoration plan for the flood control project reach.

Vision Plan

The Pinole Creek Watershed Vision Plan, led by the Restoration Design Group (RDG), employed a collaborative process that engaged UCC, Friends of Pinole Creek Watershed, the City of Pinole Redevelopment Agency, and the CCCFCD, and local community members. The vision plan was developed through an open, democratic process and reflected a wide range of communal interests.

The resulting Community Vision Statement for Pinole Creek Watershed imagined the future state of the watershed:

The Pinole Creek Watershed unifies a diverse community that is actively involved in its stewardship. Pinole Creek is a central feature of the landscape, and hosts a healthy riparian habitat, including a native steelhead trout population. Its clean waters are safe for children to play in, a creek-side trail links parks, schools, and neighborhoods and local shopping centers and cafes overlook the creek. The upper watershed is rural in character, with rangeland, equestrian, agricultural, and open space uses that are managed for long-term health of natural resources. Property owners, residents, schools, and agencies work cooperatively to protect and enhance the watershed for future generations.

Through the development of the Vision Plan, a watershed council was established and included representatives from the following organizations: East Bay Municipal Utility District, CCCFCD, City of Pinole, Friends of Pinole Creek, San Francisco Estuary Institute, Restoration Design Group, Urban Creeks Council of California, Contra Costa Resource Conservation District, City of Hercules, Watershed Project, and local residents.

Lower Pinole Creek Restoration Plan
The Urban Creeks Council and Restoration Design Group developed a design alternative for the flood control channel with funding from the State Coastal Conservancy. The proposed design was developed concurrently with and informed by the vision planning process. Major design features included the creation of a meandering low-flow channel, re-vegetation of the riparian corridor and a regional creek side trail.

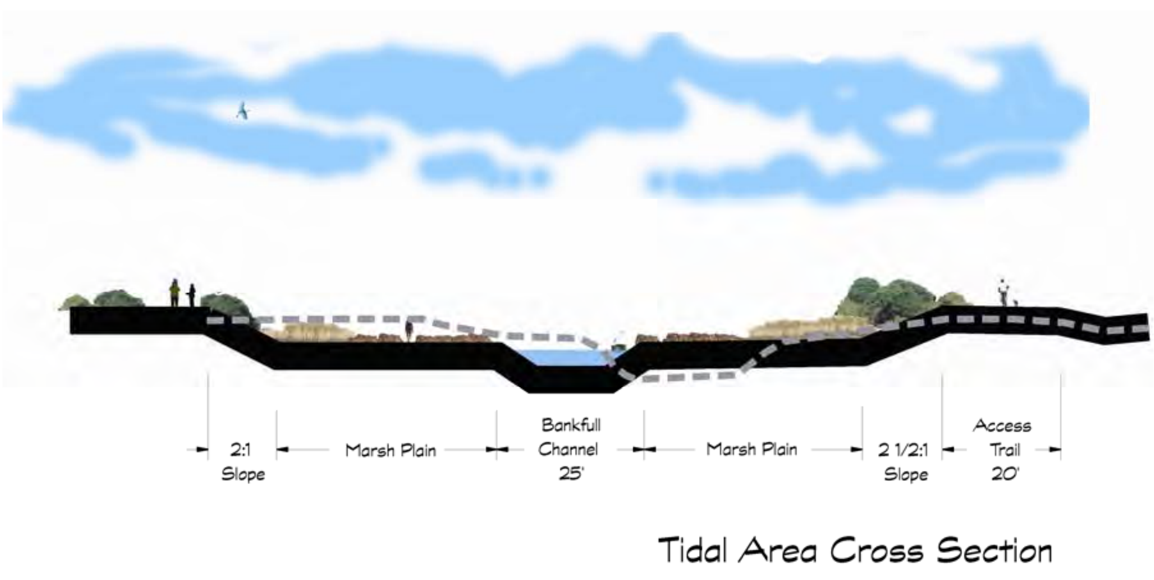

Figure 2. Schematic diagram of Lower Pinole Creek Restoration Plan – tidal area

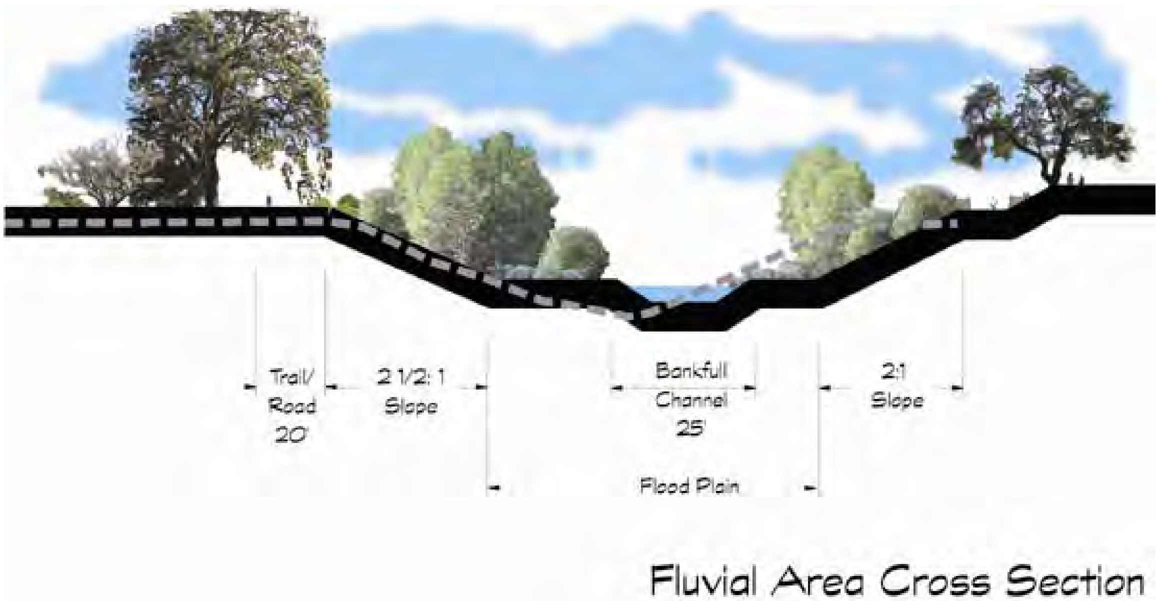

Figure 3. Schematic diagram of Lower Pinole Creek Restoration Plan – fluvial area

It was originally intended for the Lower Pinole Creek restoration plans to be incorporated into the Army Corps of Engineers, Section 1135 Program. However, due to a dearth of funding for the 1135 Program, Pinole Creek was removed from consideration in 2003. Local stakeholders determined that other sources of funds should be sought to ensure that the momentum of the planning effort was not lost. In addition, flood modeling conducted by the CCCFCD added new urgency by showing that channel conditions near the railroad crossing provide only 1 in 13-year (RI) capacity. This indicated a high risk for flood damages to occur in the communities of Pinole and Hercules.

It was decided that the restoration should begin with a section of creek where the project proponents could demonstrate the benefits and means of restoration. The "demonstration" project would show the restoration approach, maintain existing levels of maintenance cost for CCCFCD, and be implementable upstream in later phases. Using this criteria, project proponents chose the lower reach of the flood control project as the proposed restoration site. The lower reach had an elevated flood risk and the fact that it was tidally influenced would reduce the amount of vegetation management required by the CCCFCD to maintain flood conveyance. Restoration further upstream would likely require a local revenue source to maintain it. The demonstration project would be able to show the benefit of upstream restoration to help convince the local community to provide that local revenue source.

Pinole Creek Demonstration Project Design

Figure 4. Schematic design of Pinole Creek Demonstration Project

The Pinole Creek Demonstration Project originally intended to:

- Restore three acres of marshplain habitat along 2,000 feet of channel in lower Pinole Creek;
- Remove one of two maintenance access roads in the flood control right-of-way;
- Improve the remaining maintenance access road to provide a Class I bikeway, ADA accessible linear park, creek access points, and interpretive elements;
- Remove the levee near the mouth of the creek and restore the tidal marsh and hydrologic connectivity to the creek;
- Construct a pedestrian boardwalk over the restored marsh to maintain public access to Bayfront Park located on the shore of San Pablo Bay;
- Remove a vehicle bridge (closed to vehicle traffic) and a 4′ wide pedestrian bridge which cause hydraulic constrictions and debris jams;
- Replace the pedestrian bridge to maintain access to Bayfront Park;
- Construct a pedestrian bridge to provide access for Hercules residents;
- Construct a small boat dock and launch point at the mouth of the creek.

In 2006, RDG and the City of Pinole developed a grant application for submittal to the California Resources Agency’s River Parkways Grant Program. The Resources Agency awarded the City $2.65M to implement the Pinole Creek Demonstration Project.

The City hired RDG to serve both the City of Pinole and the CCCFCD as the prime consultant and project manager on the Pinole Creek Demonstration Project. RDG provided restoration planning, design, engineering, permitting, and project coordination. The City, CCCFCD, and RDG comprised the Project Team. Design decisions were made by the project team but also reviewed by the watershed council.

Design Changes

Between the award of the grant and the construction of the project, several changes were made to the project design in response to physical changes, budget constraints, flood modeling, and increased knowledge of the creek and surrounding areas.

UPRR Bridge
The original design involved removing all four bridges and replacing three of them with longer span bridges to accommodate flood flows. The project was in negotiations with the UPRR to replace their bridge with a longer bridge in the same location. Without notification, the UPRR replaced their bridge with a new bridge of the same length under an emergency permit issued by the Coast Guard. The new bridge does not accommodate higher flood flows and will continue to constrict the channel.

Railroad Avenue Bridge
Despite this, the main flood constraint is still the Railroad Avenue Bridge. The ownership of the bridge was brought into question during project planning and no one claimed responsibility for it. Consequently, the project proceeded without removing the Railroad Avenue Bridge. The Resources Agency held $1 million of the $2.65 million grant to pay for the future removal of the bridge.

Since the bridges will remain in for the time being, the project was essentially bifurcated at the bridges. To accommodate for the bridges remaining in place, the project added floodwalls to provide the required level of flood protection. Due to the added cost of the floodwalls and other unforeseen cost increases, the project focused on the upstream reach and reserved work downstream at the mouth for a later phase of work.

Flood Modeling/Flood Walls
In 2009, FarWest Engineering modeled the proposed restoration plan as part of the CCCFCD risk and uncertainty analysis submitted to the Army Corps. The study, included in the appendix, modeled the project with the bridges remaining in (per discussion above). The study determined the minimum levee elevation required to preserve the channel (in its restored state) to the level of flood control provided by the original Army Corps project.

Since the railroad and Railroad Avenue bridges will continue to restrict flood flows through the lower Pinole Creek flood control channel, the project constructed sheetpile flood walls between the UPRR bridge and approximately 1,800 feet upstream. The floodwalls vary in height but average close to 3.5 feet in height with a maximum height of approximately five feet. These flood walls, combined with an increased channel cross section, provide the 1 in 50 year (RI) flood protection.

If the bridges are removed in the future, the project will provide greater flood protection than the original project allowing additional restoration (greater roughness) upstream.

Final Design
The resource agency permit applications described the final design of the project:

To achieve the federally mandated level of flood protection, the project will remove a significant portion of the right of way dedicated to maintenance access roads and remove engineered fill located on the historic marsh plain. Low floodwalls or levees will be installed along the outside limits of the flood control facility right-of-way to provide flood protection against the 50 year storm event as defined by the Army Corps of Engineers. The project area will be re-vegetated with tidal and upland native species. On the left bank, the existing pedestrian/maintenance access road will be improved to meet CalTrans Class I bikeway standards. A series of parkway amenities will follow the trail and will include interpretive elements describing the local natural history and community restoration efforts.

The excepts from the schematic design, grading, and planting plan below show the project as designed in section and plan view.

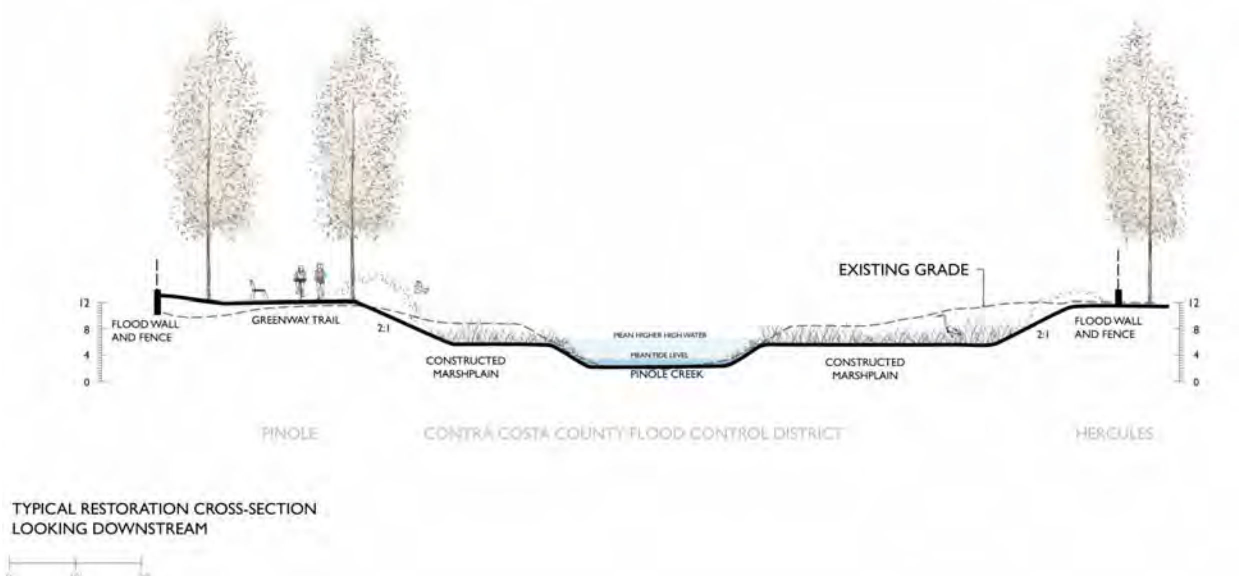

Figure 5. Schematic of Pinole Creek Demonstration Project in Section

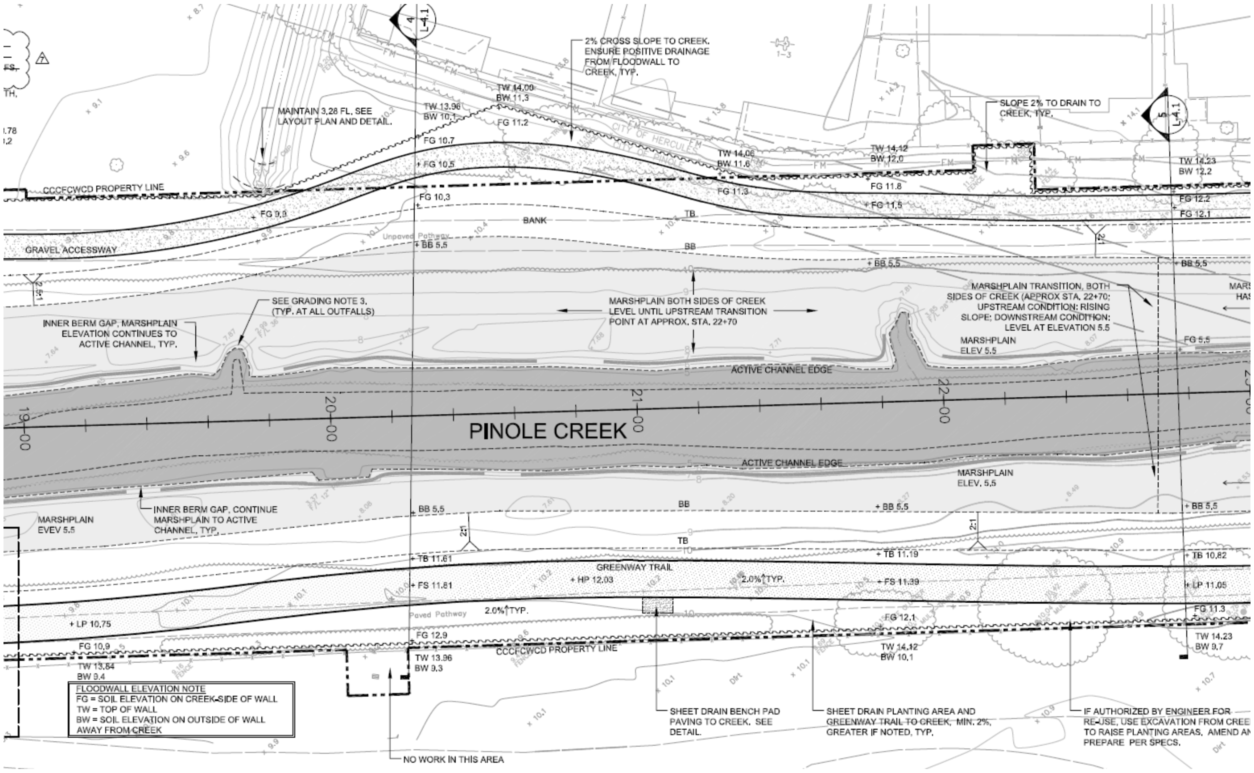

Figure 6. Excerpt from Pinole Creek Demonstration Project Grading Plan

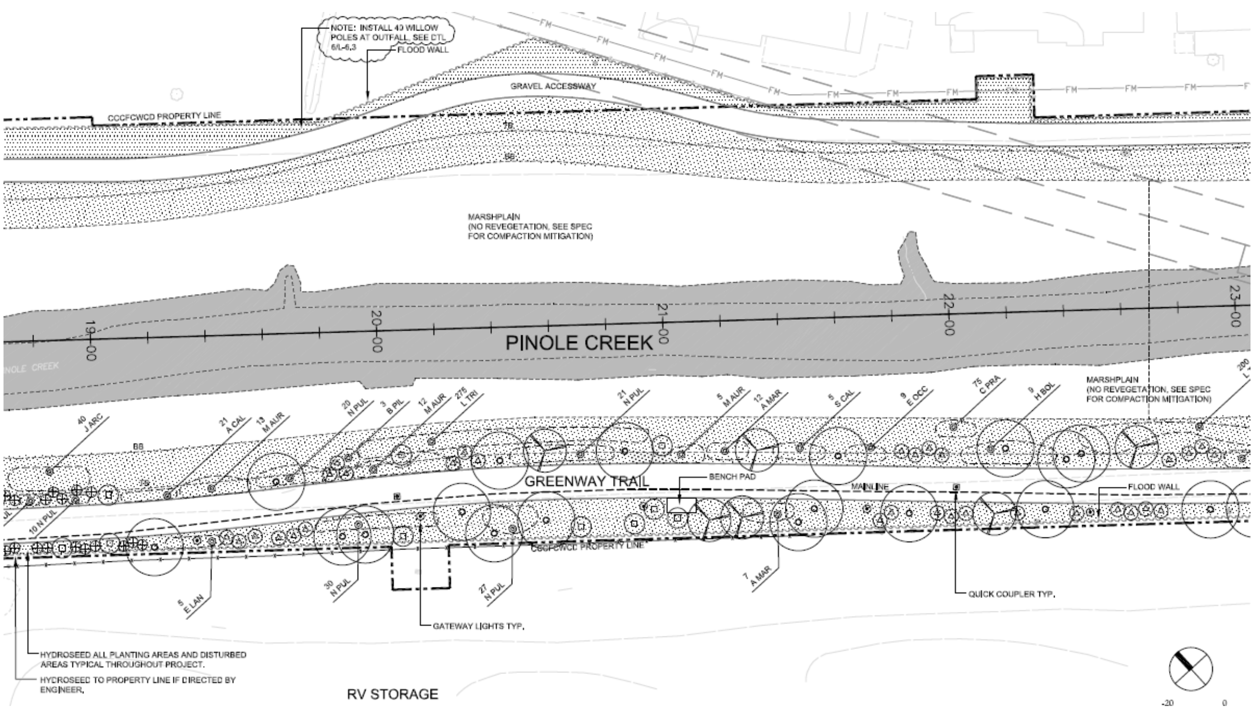

Figure 7. Excerpt from Pinole Creek Demonstration Project Revegetation Plan

Construction

Construction commenced in the summer of 2010 and was completed by early 2011. The project was built as designed with the exception of minor landscape detailing at Railroad Avenue and adjustments to the alignment of the access road and floodwall on the right bank upstream of the Chelsea Wetland to keep these improvements within the CCCFCD property.

Photo 4. Construction Photographs

Monitoring

Two separate post-construction monitoring efforts measure the success of the Pinole Creek Demonstration Project. The San Francisco Estuary Institute (SFEI) completed a pre- and post- restoration monitoring effort in 2012. Post-restoration measurements were compared to pre-restoration measurements to evaluate potential improvements in water quality, habitat, and other site conditions. SFEI performed pre- and post restoration rapid condition assessment (CRAM assessments), a physical habitat assessment, bioassessment sampling, and photo-monitoring to document changes resulting from the project. This evaluation intended to aid in assessing costs and benefits for improved flood protection and wildlife enhancement, and recreational uses.

RDG and the Friends of Pinole Creek Watershed have completed two of five years of permit-required post-project monitoring. The monitoring team surveys three cross sections, measures vegetation survival and native plant cover, and performs photo-monitoring to document post-project success.

SFEI Monitoring Results
The limited time series (two data points) constrains SFEI's ability to detect significant changes in either water quality or benthic marcoinvertebrate (BMI) populations. Changes in water quality between the two data points are more likely explained by tidal cycle than changes to the channel. As the project modified the floodplains but not the channel bed, the BMI results were statistically similar between the pre- and post conditions. SFEI indicates that BMI changes should be measureable five to seven years after restoration.

The monitoring showed a measurable improvement in physical habitat conditions. The most significant improvements were to channel flow status and sediment deposition due to an increased degree to which water covers the entire available channel substrate. An increase in tidally submerged area, riparian vegetation area, and other channel modifications increased the amount and quality of physical habitat available to aquatic organisms.

The CRAM assessments showed improvements resulting from an increase in native riparian vegetation, an increase in channel stability, and an increasingly complex plant community. The CRAM scores were reduced slightly by active mowing or other management within and along portions of the channel, reducing native plant communities and increasing the extent of non-native plant cover.

Channel cross-sections showed only minor adjustments in channel form downstream of the project but obviously significant changes for the two cross-sections within the project area. Photo-monitoring results confirm the increase in tidal floodplain and corresponding vegetation changes (decrease in weeds, increase in tidal marsh vegetation), as well as changes to riparian vegetation along the upper left bank and regional trail.

The SFEI monitoring report is included as an appendix to this report.

RDG/FOPCW Monitoring Results
The resource agency permits governing the project construction require the City of Pinole to complete five years of geomorphic and vegetation monitoring. The City has hired RDG and the Friends of Pinole Creek Watershed to complete this monitoring. RDG and FOPCW survey three cross sections to measure changes in channel geomorphology and monitor vegetation to ensure the success of restoration plantings

and other native vegetation in the project area. RDG and FOPCW have completed two years of monitoring.

The surveyed cross-sections occupy the same cross-sections as the SFEI monitoring and the results are similar. The vegetation monitoring covers container plants, marshplain cover, and oak seedlings. The resources agency permits require a 65% survival rate of the container plants. 2011 and 2012 monitoring detected very low rates of survival of container plants, and perennial and grass species in the survey plots. California sagebrush, toyon, monkeyflower, coffeeberry, and California wild rose all under performed.

The low survival rates of shrubs and perennial species could result from a combination of different factors. Maintenance mowing is likely the main cause of high mortality of shrubs. Mowing appears to be encroaching into the restoration area and impacting the shrubs. The time of year may be impacting the detection of grasses. Similarly, the perennial grasses could be present but not detected. Finally, the monitoring is comparing the planting plan with the plants currently found on-site. As there is no record of what was actually planted, it may be that some of these plants were never installed.

The Friends of Pinole Creek Watershed and RDG have responded to the perceived under-performance and in the winter of 2013 planted over 200 additional shrub species in the restoration area along the regional trail. If successful, these improvements will be evident in the 2013 vegetation monitoring.

Next Steps

The Pinole Creek Demonstration Project was designed as a model and stimulus for further restoration in the Pinole Creek watershed. It was always intended to be the first phase of restoration. Several elements of the full Pinole Creek vision remain to be implemented. Some new elements have arisen in the past few years that were not originally imagined as part of the project.

Upstream Restoration

The Pinole Creek Demonstration project restored approximately 1,100 feet of Pinole Creek upstream of the bridges. Tidal influence extends approximately 1,800 feet upstream of the lower bridges. This is a critical number because the vegetative communities and thus the CCCFCD's maintenance change at this point. In the freshwater areas of the creek, restoration will involve allowing shrubby and woody riparian vegetation to grow in the channel. The CCCFCD (or another party) will need to maintain these by hand to prevent them from infringing on flood protection. The CCCFCD is unable to fund maintenance in addition to what they already provide so maintenance funding will have to come from a local revenue source or another entity, such as the City of Pinole, will need to assume responsibility for channel maintenance under a license agreement with the CCCFCD. Other cities in Contra Costa County have assumed similar responsibilities for restored segments of CCCFCD flood control channels.

Mouth of the Creek
Future phases of the project will include restoration work at the mouth and downstream of the bridges. This will include features originally intended as part of the Pinole Creek Demonstration Project such as removing the levee near the mouth of the creek and restoring the Bayfront tidal marsh and hydrologic connectivity to the creek; and constructing a small boat dock and launch point at the mouth of the creek.

Beach Nourishment
The Bay Conservation and Development Commission, the Nature Conservancy, and others have placed new emphasis on the ecological role of beaches and the amount of lost beach habitat along the Bay. The mouth of Pinole Creek provides an opportunity for the restoration of over 1,500 feet of beach habitat through beach nourishment. Beach nourishment involves placing rock groins that run perpendicular to the shoreline to trap sand and sediment and stabilize beach habitat along the bay. This beach nourishment can be included as part of the restoration of the creek mouth or exist as a separate restoration project.

Railroad Avenue Bridge
The Resources Agency withheld $1 million of project funds to remove the Railroad Avenue Bridge. The current plan, agreed to by the Resources Agency, the State Water Board, the City of Pinole, and Contra Costa County is to remove the bridge and, along with the EBRPD, replace it with a new, longer span pedestrian bridge that will double as emergency vehicular access. PG&E, Kinder Morgan, UPRR, and the cities of Hercules and Pinole will remove various utility lines that are suspended from the Railroad Avenue Bridge, allowing for its removal.

Chelsea Wetlands Restoration
The Chelsea Wetlands Restoration Project is located at the lower reach of Pinole Creek. The project site is a vacant 11-acre parcel immediately adjacent to Pinole Creek that was historically part of a large tidal marsh complex that fringed San Pablo Bay. The site was diked off and a large portion of it filled sometime in the late 19th/early 20th century during the development of the area. Today, the site is bordered by a housing development, a road, the Union Pacific rail line, and a levee along Pinole Creek.

The project goals of the Chelsea Wetlands Restoration Project are to:

- Restore on-site tidal marsh habitats to reflect historic conditions
- Provide flood storage benefits to the cities of Pinole and Hercules
- Provide passive recreational opportunities along the existing San Francisco Bay Trail

The project will achieve these goals by excavating the site to appropriate marsh elevations and reintroducing tidal exchange through improved culvert connections with Pinole Creek. The project was an integral part of the Pinole Creek Vision Plan.

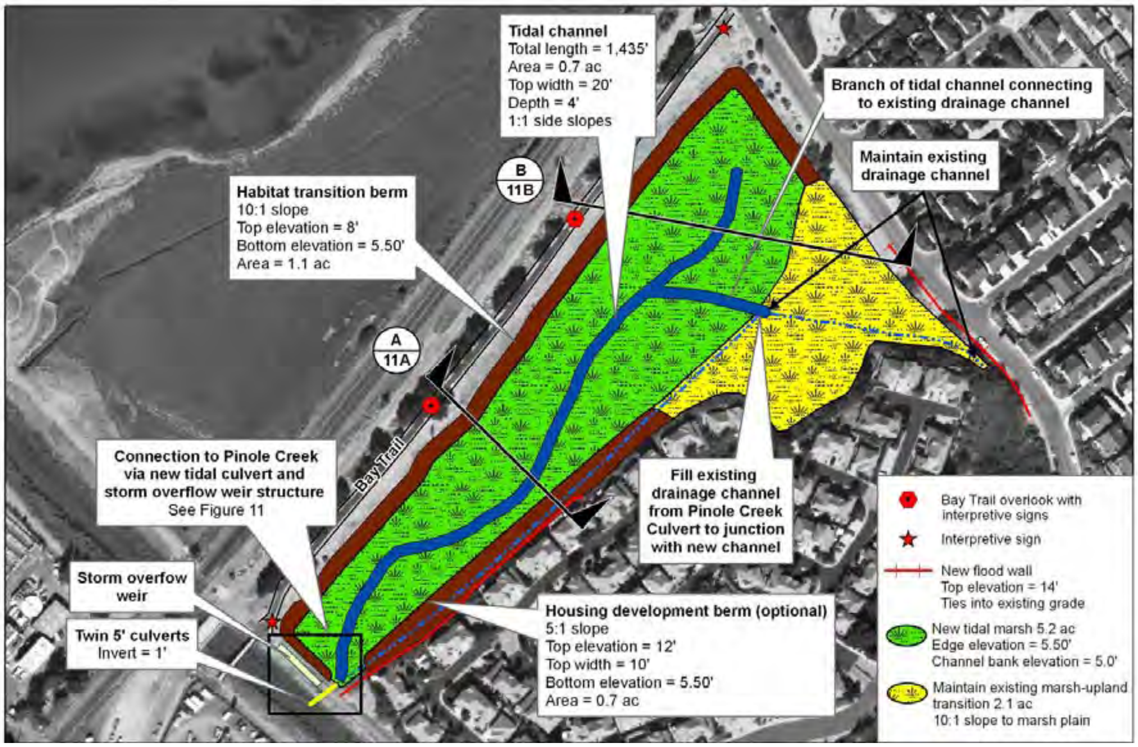

Figure 8. Chelsea Wetlands Restoration Plan (excerpted from WWR, 2009)

Some of the expected benefits include providing high tide roosting habitats for migratory shorebirds and waterfowl and support for species such as the salt marsh harvest mouse, burrowing owl, white tailed kite, northern harriers, and possibly Chinook salmon and steelhead (nursery habitat). The Chelsea Wetland Restoration Project will not only enhance aquatic habitat but also improve public access, improve water quality, and provide for greater flood capacity. The Project will provide flood attenuation benefits to the Pinole Creek watershed by serving as an offline detention basin.

The City of Hercules received grant funding from multiple sources: $1.83 million from the California River Parkways Program; $145,000 from the Green Infill Clean Storm Water Initiative (EPA/ABAG); $56,200 from the Contra Costa County Fish and Wildlife Propagation Fund, and $40,000 from the San Francisco Foundation. In 2012, due to internal difficulties unrelated to the project, the City of Hercules could no longer manage the River Parkways Program grant. Ducks Unlimited assumed management of the design and permitting phase of the project and construction should begin in 2014.

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RDG, 2008. San Francisco Bay Area Joint Aquatic Resource Permit Application - Pinole Creek Restoration Demonstration. August 8.

WWR, 2009. Draft Conceptual Restoration Plan – Chelsea Wetlands. Prepared for the City of Hercules. April 15.

Resources for Additional Information

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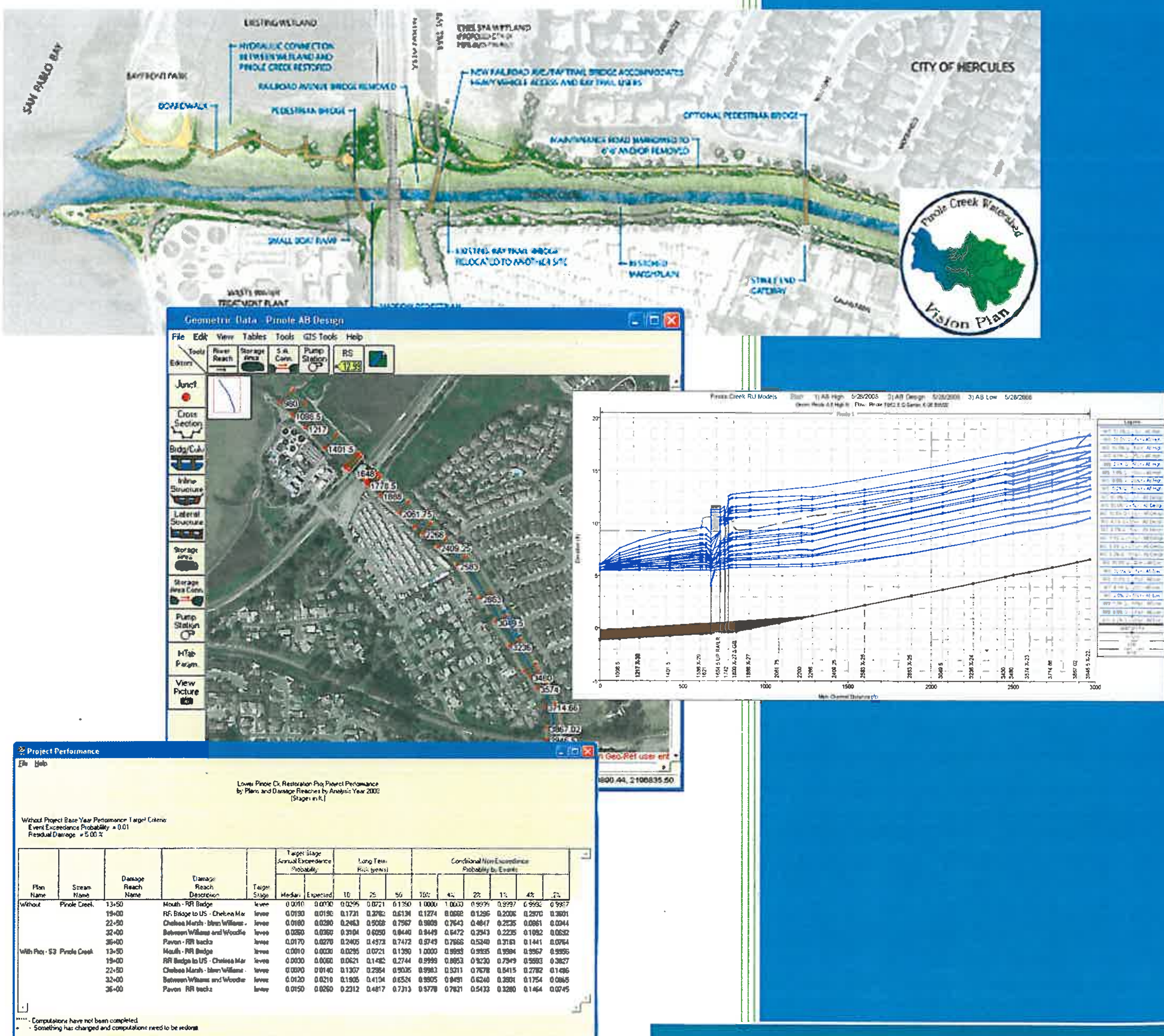
Appendix 1 – County Flood Modeling-R/U Memo

Contra Costa County
Flood Control
& Water Conservation District

Lower Pinole Creek Demonstration Project Risk and Uncertainty Analysis



February 18, 2009

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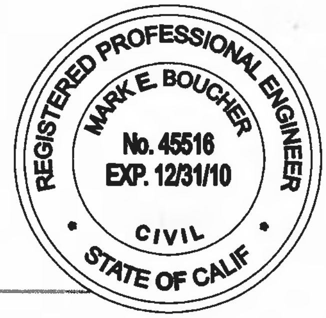
This report was prepared by or under the supervision of the Registered Professional Engineer indicated below:



2/18/09

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Acknowledgements

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ABBREVIATIONS

cfs	cubic feet per second
CNP	Conditional Non-Exceedance Probability
Corps	U.S. Army Corps of Engineers
FC District	Contra Costa County Flood Control and Water Conservation District
Elev.	Elevation
FDA	HEC-FDA computer program used for RU analysis
ft	Feet
HEC	Hydrologic Engineering Center, US Army Corps of Engineers[1]
LOB	Left overbank (a HEC-RAS term)
NAVD 88	North American Vertical Datum of 1988
NGVD29	National Geodetic Vertical Datum of 1929
RAS	HEC-RAS computer program used for open channel flow analysis
RDG	Restoration Design Group
ROB	Right overbank (a HEC-RAS term)
RU	Risk and Uncertainty

[1] http://www.hec.usace.army.mil/

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Lower Pinole Creek Demonstration Project Risk and Uncertainty Analysis

February 18, 2009

INTRODUCTION

The Pinole Creek watershed covers approximately fifteen square miles of west Contra Costa County's Briones Hills that drain into San Pablo Bay north of Point Pinole. The general plan for the watershed is comprised of approximately 80% open space, park, agricultural, and watershed land uses. The remaining area is a mixture of residential, transportation, commercial, and industrial uses.

The watershed can be divided into three general zones, each with distinct physical characteristics and geomorphologic processes.

- The upper portion of the watershed is known as the headwaters and has channels that are rocky and steep. It is primarily owned and managed by the East Bay Municipal Utility District (EBMUD). This area is an erosional zone supplying sediment to the downstream channel.

- The middle portion of the watershed is a transition zone because sediment from the hills is being transferred to the lower portions of the creek. The channel slope is moderate in between the steep headwater channels and the low meandering downstream channels.

- The lower reaches of the creek, which pass through the cities of Pinole and Hercules, meander through a broad alluvial floodplain representing the accumulation of sediment. Occasionally, the high flows overtop the banks and flood the lower watershed areas.

The US Army Corps of Engineers (Corps) constructed a flood protection project on lower Pinole Creek in the mid 1960's. The Contra Costa County Flood Control and Water Conservation District (FC District) is the local sponsor that owns and maintains the flood protection improvements.

The City of Pinole and The Friends of Pinole Creek have a vision to enhance Pinole Creek and make it an amenity to the community. They produced a vision plan [2] that includes the following objectives:

- Improved flood capacity and protection.

- Enhanced recreational amenities and improvements to Pinole Creek (the Pinole Creek Greenway) and the Bay Trail.

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[2] "Pinole Vision Watershed Vision Plan," Urban Creeks Council of California & Restoration Design Group, LLC, 2005. (http://www.urbancreeks.org/Current_Projects.html#Pinole)

- Preservation and restoration of natural habitats.
- Provision of public educational opportunities.
- Creation of opportunities for future restoration projects.

To this end, the proposed **Pinole Creek Restoration Greenway Project** (Project) would remove sediment and native soils, modifying levees and channel banks in some areas along the creek to create new areas of marshplain and floodplain to improve overall flood stage capacity. The project would restore marshplain and floodplain areas along the creek to more natural conditions to create new and enhanced wildlife habitat.

The ultimate project would also include new bridge crossings, trails, a boardwalk on the north side of the creek near the Bay shoreline, and other recreational amenities to improve the creek's recreational value. The new bridges would replace existing bridges that currently impede flows. The proposed project is described in two segments: work located bayward of the Union Pacific Railroad (UPRR Bridge), and work under and upstream of the UPRR Bridge.

The City of Pinole with assistance from their consultant Restoration Design Group, LLC (RDG)[3], was awarded a California Proposition 50 River Parkways Grant to construct a demonstration project. The demonstration project is intended to show the community the potential for transforming Pinole Creek into an environmental and recreational amenity if the full Project is implemented and to generate support for the Vision Plan.

Purpose and Overview

The purpose of this report is to explain the assumptions, data sources, and procedures used to analyze the proposed Project performance on a risk and uncertainty (RU) basis. Future phases of the Project will require separate analyses.

This report presents the hydraulic and RU analyses performed by the FC District. The Corps required this analysis because the original improvements were accomplished using federal funding and the Corps has begun to use RU analysis on all of its projects. The Corps San Francisco office was instrumental in guiding the FC District through this analysis.

Risk and Uncertainty Analysis Overview

The goal of the RU analyses was to determine the minimum levee elevation required for the proposed project. The proposed levee elevations are to provide the same protection as the original 1960's project provided. The level of protection or "performance" of the proposed project was characterized using the conditional non-exceedance probability (CNP); CNP is an output of the RU analysis.

CNP is, fundamentally, the probability that the water surface will not exceed a certain elevation (e.g., levee top) during statistically based storm runoff events. That is, if the CNP is calculated to be 0.90 at a certain analytical cross section, we are 90% sure that the levee will not be overtopped at that location. The RU analysis is a complex analysis that attempts to factor in as

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[3] Restoration Design Group, LLC, 2560 Ninth Street, Suite 216 / Berkeley, California 94710, tel. (510) 644-2798, www.restorationdesigngroup.com

many uncertainties as possible. For this analysis, we specifically tried to account for the following uncertainties:

- Statistical variability in flow rates.
- The range of possible channel roughness conditions due to vegetation (Manning's n-values).
- Uncertainty in design tide (for beginning water surface elevation in channel models).
- Possibility of sedimentation (accumulation or removal of sediment).

Target Conditional Non-Exceedance Probability

The Corps designed the original 1965 project for the 2% annual exceedance probability (2% AEP[4]) flow of 2,600 cfs. Per a 1962 Report[5], this reach of the project did not have a freeboard requirement, but was only required to contain the design storm flows. However, RU analysis replaces the simple application of a uniform freeboard depth above a design water surface elevation to establish levee elevations with a statistical based determination of levee elevation.

The current written standards for RU analysis have been developed mostly from the perspective of providing adequate flood protection performance based on Federal Emergency Management Agency (FEMA) levee certification requirements. For example, the current FEMA levee certification requires 3.0 feet of freeboard above the base flood (100-year or 1% AEP) water surface elevation and a CNP of at least 0.90. The freeboard can be reduced to 2.0 feet if the CNP is at 0.95.

This Project does not fit the mold of the FEMA levee certification requirements. It was originally designed for the 1965 2% AEP flows and is not being modified with the intent to provide 1% AEP FEMA level protection. After clarifying discussions with the Corps, we selected the CNP of the original project to be the target CNP for the proposed Project. That is, the proposed project must meet or exceed the CNP of the original project. Therefore, the As-Built conditions needed to be analyzed to determine the target CNP first, and then the proposed conditions needed to be analyzed and iteratively designed to meet the target CNP.

Procedure Overview

The Corps Hydraulic Engineering Center (HEC) in Davis, California developed a program named "Flood Damage Analysis" (HEC-FDA). This program greatly simplifies the calculations required for performing the RU analysis. The FC District used HEC-FDA to perform the RU analysis on the As-Built project to determine the target CNP.

Data and tools used for the As-Built condition HEC-FDA runs were:

- Flows from the discharge frequency curve from the 1962 Report.
- HEC-RAS (open channel) model based on the As-Built plans of the 1965 project.

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[4] Historically the 2% AEP storm is referred to as the 50-year flow.

[5] "Detailed Project Report, Local Flood Protection Project, Pinole Creek," Contra Costa County, California; U.S. Army Engineer District, San Francisco, CA; November1962 (1962 Report).

- The top of bank or levee elevations from the As-Built plans.

RDG, the City of Pinole's consutant for the Project, designed the proposed creek modifications and provided the HEC-RAS model for the proposed conditions. The FC District verified the model and performed the RU analysis on the proposed modifications and established the levee heights required to meet or exceed the As-Built performance.

Data and tools used for the proposed condition HEC-FDA runs were:

- Flows from the discharge frequency curve from the 1962 Report.
- HEC-RAS model prepared by RDG for the proposed conditions and modified by the FC District to adjust n-values for varying conditions.
- The top of bank or floodwall elevations from initial HEC-RAS runs for the proposed creek modifications model. The FC District iteratively revised the proposed levee elevations in HEC-FDA to achieve the target CNP.

The FC District understands this analysis of Pinole Creek to be the first RU analysis performed in Contra Costa County for a flood control project. This type of comparison between the As-Built and proposed projects using the RU analysis is also a new process to the Corps.

Model and Plan Terms

This document contains reference to several different combinations of conditions (As-Built, proposed, worst, best, design, etc.) and to reduce the confusion of terms, they are outlined below and used consistently within this document.

Design Condition: The term "design condition" refers to the HEC-RAS model and outputs used in HEC-FDA that reflect the specific design shown in the construction plans and the design report(s) that supported those respective designs. This can refer to either record or proposed plans and reports.

Worst Conditions: The term "worst conditions" refers to a modification of the Design Condition that tries to account for differences in the design parameters that affect the results by making the water surface profiles **higher** in elevation.

Best Conditions: The term "best conditions" refers to a modification of the Design Condition that tries to account for differences in the design parameters that affect the results by making the water surface profiles **lower** in elevation.

As-Built: The term "As-Built" refers to the 1965 As-Built construction drawings in general. It includes the design, worst, and best conditions of the original design.

Proposed: The term "proposed" refers to the soon to be created construction drawings in general. It includes the design, worst, and best conditions of the original design.

As-Built Plan: The term "As-Built Plan" refers to the HEC-FDA analysis plan that includes information from the As-Built design condition, worst condition, and best condition.

Proposed Plan: The "Proposed Plan" refers to the HEC-FDA analysis plan that includes information from the proposed design condition, worst condition, and best condition.

HYDROLOGY

The HEC-RAS modeling and RU analysis were performed using the hydrology of the original project in the 1962 Report. No additional hydrology analysis was needed based on the goals of the project.

The 1962 Report discussed stream flow records from a gauge operated by the East Bay Municipal Utility District with 20 years of data (1939-1959). The 1962 Report discussed major storm events, unit hydrograph derivation, and standard project storm flood. The original designers used a design discharge of 2,600 cfs for this project. At that time, that flow rate was equivalent to the 2% AEP storm or 50-year storm.

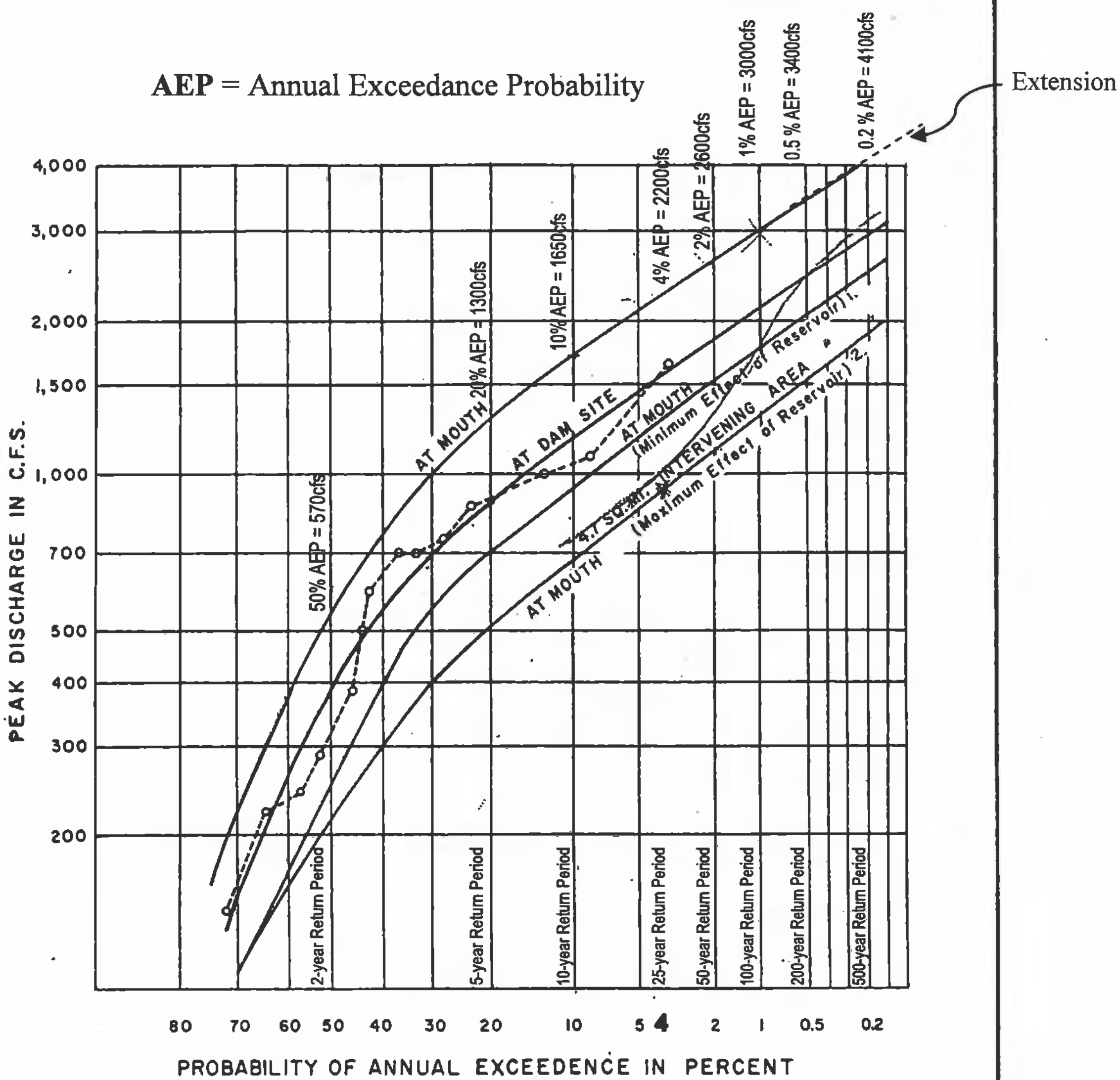
EIGHT FLOOD SERIES

The flow rates for the eight flood series are needed for the RU analysis in HEC-FDA. The eight flow rates were taken from **Appendix A** of the 1962 Report. A table on page A-6 of that report contained five of the flows. The rest of the flows were taken from Plate A-3 of the 1962 Report. The eight flood series used is shown in **Table 1**. A copy of Plate A-3 with the flow rates identified is shown in **Figure 1**. The 0.2% AEP was estimated by using a line to extend the flow frequency curve slightly past the limits of the chart.

Table 1 — Eight Flood Series for the Risk and Uncertainty Analysis

Annual Exceedance Probability (AEP)	**Flow Rate** (cubic feet per second)	**Return Period** (Return Frequency) (Years)
50%	570 cfs	2
20%	1,300 cfs	5
10%	1,650 cfs	10
4%	2,200 cfs	25
2%	2,600 cfs	50
1%	3,000 cfs	100
0.5%	3,400 cfs	200
0.2%	4,100 cfs	500

CORPS OF ENGINEERS U. S. ARMY



NOTES:

⊙ ANNUAL SERIES PEAK DISCHARGES PINOLE CREEK NEAR PINOLE (10.2 SQ. MILE) 1939-58 WATER YEARS.

1. ASSUMING SPILLWAY CREST ELEV. 300FT. M.S.L., 100FT. CREST LENGTH & FULL RESERVOIR.

2. ASSUMING NO CONTRIBUTION FROM 10.2 SQ.MI. AREA UPSTREAM OF DAM SITE.

FLOOD CONTROL
DETAILED PROJECT REPORT ON
PINOLE CREEK BASIN
CONTRA COSTA CO., CALIFORNIA
HYDROLOGY
DISCHARGE FREQUENCY CURVES

IN 3 SHEETS	20 JULY 1960	SHEET № 3
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C. OF E.		
DRAWN: D.R.B.	TO ACCOMPANY	FILE №
TRACED: O.M.K.	REPORT DATED	41-46-2
CHECKED: W.R.T.	JAN. 1962	

Plate A-3

Figure 1 — Plate A-3 from the 1962 Report.

HYDRAULIC MODELING

The following is a discussion of the HEC-RAS modeling performed for the RU analysis. For each scenario (or "Plan" as HEC-FDA calls them), three HEC-RAS geometries (and, therefore, hydraulic conditions) were needed for the RU analysis:

- Design condition geometries.
- Best condition geometries.
- Worst condition geometries.

The difference between the three geometries was generally the assumed Manning's n-value (channel roughness factors), sediment accumulation, and beginning water surface elevation.

BEGINNING WATER SURFACE ELEVATIONS

Datum Adjustment

The datum used for the original project (As-Builts) was the National Geodetic Vertical Datum of 1929 (NGVD29). The proposed project uses the North American Vertical Datum of 1988 (NAVD88). The datum shift varies between 2.35 feet and 2.80 feet depending on the location in Contra Costa County. At the project location, the datum adjustment from NGVD29 and NAVD88 is 2.66 feet.

The As-Built geometry was created in the HEC-RAS model at its original datum, and then the entire geometry was adjusted up 2.66 feet to match the NAVD88 datum using a HEC-RAS function. This allows a better comparison of the As-Built and proposed models. All results in this report are in NAVD88.

Tides

The beginning water surface elevation for the as-built design conditions from Plate 3 of the 1962 Report is the Mean Higher High Water tide elevation (MHHW) of 3.1 feet NGVD29 or **5.76** feet NAVD88.

At an April 30, 2008 meeting, the Corps staff made reference to a more recent standard for the MHHW and Highest Estimated Tide (HET). They later provided a copy of the October 1984 "San Francisco Bay Tidal Stage vs. Frequency Study" (1984 Tide Study). The October 1984 Tide Study elevations were based on "NGVD," which we assume is the same as NGVD29. Based on the adopted 100-year tide elevation contours on Plate 11 of that study, the mouth of Pinole would have a 100-year tide of 6.42 feet NGVD29 or **9.08** feet NAVD88.

In the April 30 meeting, Corps staff also mentioned an estimated sea level rise of 2 mm per year, which would be 48 mm or 0.16 feet in sea level rise since 1984. Section 7 of the 1984 Study provides a table that shows an estimate of sea level rise. **Figure 2** presents the estimated sea level rise from 1984 to 2008 to be around 0.59 feet. This Equals 179.8 mm since 1984 or 7.49 mm/year rise. [6]

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[6] [179.8/(2008-1984)] = 7.49

After some discussion with Corps staff, we agreed that, like the flow rates, the beginning water surface used in 1962, without a predicted sea level rise, should be used for our RU analysis.

To account for the uncertainty in the tide elevations, we used a differential of 0.3 feet between the design conditions models and the best and worst conditions models. **Table** 2 presents the beginning water surface elevations used in the HEC-RAS model for the design, best, and worst conditions. To that end, we used the bolded values in **Table** 2 for the As-Built design condition model and the proposed conditions (Project) design condition model.

The 1962 report states that the "highest estimated tide with low discharge in the creek" controlled the design from the mouth to station 9+50 (*approximately station19+49 on the As-Built plans*). Also, the "project design discharges coincident with the mean higher high tidal stage at the mouth of the creek"[7] controlled upstream of station 9+50. Plate 3 of the 1962 Report shows the HET to be 5.6 feet. Converting that HET to today's datum makes it 8.26 feet. For comparison, the top of the service road in the 1965 plans from San Pablo Bay to near the first railroad bridge was one foot (1 ft.) above the HET of 5.60 NGVD feet. Therefore, the minimum proposed levee height should be 9.26 NAVD88 feet. This is also shown in **Table** *2*. We recommend that all the levee elevations be at least 1.0 foot above the HET.

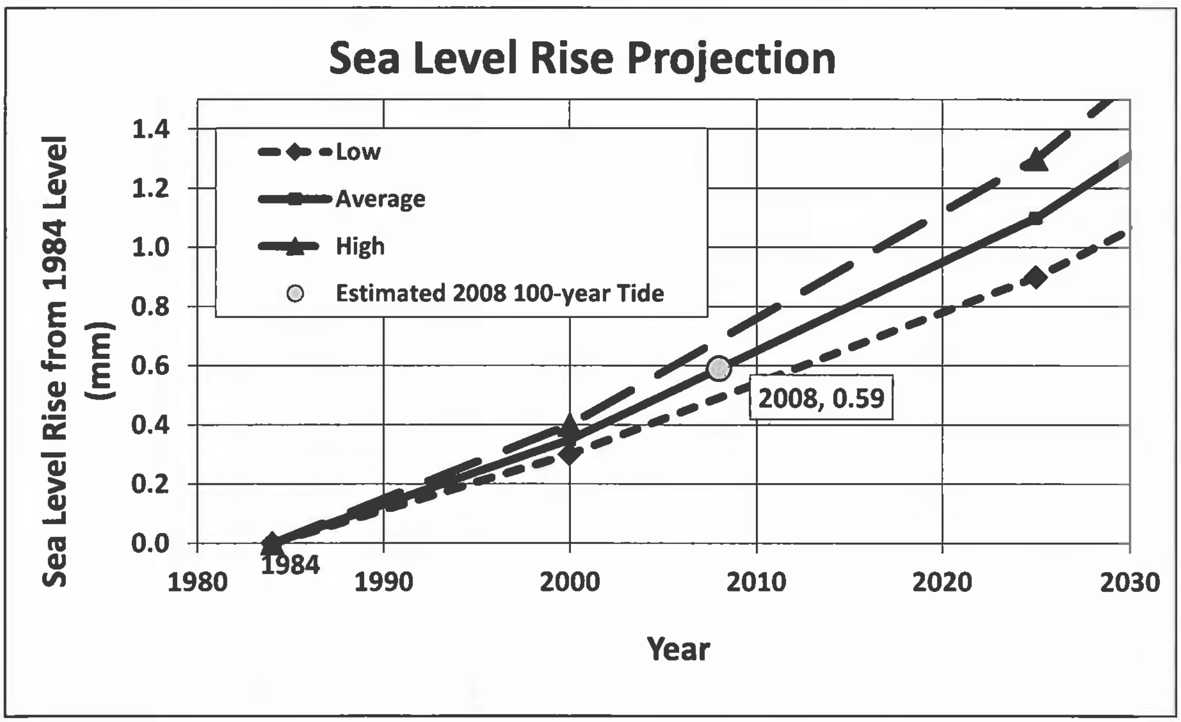

Figure 2 — Estimated Future Sea Level Rise based on table in Section 7 of the October 1984 "San Francisco Bay Tidal Stage vs. Frequency Study."

[7] From the 1962 Report

Table 2 — Tide Elevations Table

Design Value	NGVD29 [8]	NAVD88 (NGVD29 + 2.66 feet datum adjustment)	NAVD88 (adjusted for 0.59 ft sea level rise since 1984 – approximate)
Highest Estimated Tide	5.6 feet	8.26 feet	8.85 feet
Mean Higher High Water Beginning water surface elevation: **best condition** (design condition -0.3 ft)	n/a	Used **5.46 feet**	6.05 feet
Mean Higher High Water Beginning water surface elevation **design condition**	3.1 feet	Used **5.76 feet**	6.35 feet
Mean Higher High Water Beginning water surface elevation: **worst condition** (design condition +0.3 ft)	n/a	Used **6.06 feet**	6.65 feet

[8] From Plate 3 of the 1962 Report

AS-BUILT PLAN

A HEC-RAS model was created based on the "As-Built" plans entitled "Pinole Creek Channel Improvements." These plans were signed as "Approved" on April 26, 1965, and "As Constructed" June 10, 1966. Copies of these plans can be found in the FC District office. For the RU analysis, three "As-Built" models: design condition, best condition, and worst condition models were created. The best condition and worst condition models were copies of the design condition model with modifications as discussed below. The HEC-RAS models are on the CD in the back of this report.

Hydraulic Design Values (Manning's n-values)

The 1962 Report states that the design Manning's n-value ("n") for the earth channel was 0.03 with n=0.04 used in areas where riprap was used in short reaches. We used these values for both the "design" and the "best" condition models. Our reasoning is that the 1962 n-values are as low as the FC District would be comfortable using. The FC District's standard practice is to use n-values no lower than 0.035 for earth channels.

Having said that, in this study, we used n=0.025 in the Proposed Plan model in areas where the tides influence the vegetation, the saltwater keeping the vegetative growth at a minimum. Therefore, for the As-Built best conditions model, we used an n-value of 0.025 for the creek bottom in the tidal zone. In a memo by Mr. Roger Leventhal, Principal Engineer of FarWest Restoration Engineering[9] (FarWest), the tidal zone is described as approximately up to station 21+76. Therefore, from the mouth to station 20+61.75, we set the bottom of the As-Built channel n-value to be 0.025.

For the worst conditions As-Built model, we assumed the n-values could go as high as 0.05 for all cross sections. We used n=0.04 where riprap was used in short reaches.

Sedimentation Estimate

In its current condition, lower Pinole Creek has aggradated sediment and the FC District has not had the funds to remove it. In 1978, California Proposition 13 was passed and it "froze" property tax rates. At that time, the Drainage Zone Board for the Pinole Creek watershed maintenance entity (Flood Control Zone 9) had set the tax rate to 0% because there was extra money in the maintenance account. After Proposition 13 passed, there was no more revenue for maintenance. State Special District Augmentation Funds were a source of funding for a time; however, a governor later eliminated them during a state budget crisis, and they have not been replaced. The FC District has not been financially able to keep up with the special maintenance required to remove sediment.

The Operation and Maintenance (O&M) Manual calls for inspections every 90 days and that the inspection is to report any "shoals" (sediment bars) that form. It appears that the authors of the O&M manual assumed that funding would be available to remove shoals that formed.

We approached the sedimentation estimate for the As-Built worst conditions geometry by asking the questions: "What level of maintenance did the original designers expect?" and "What level of risk can we assume the original engineers accepted?" After consultation with Corps staff, we

[9] FarWest Restoration Engineering, 11 Camelot Court, Kensington, CA 94707, (510) 522-7200

decided to assume only one foot of sediment would have built-up before the FC District would have removed sediment.

Therefore, in the worst conditions geometry for the As-Built plan, we assumed one foot (1ft) of sediment on top of the As-Built channel bottom from the mouth up. We used the "Fixed Sediment Elevation" tool in HEC-RAS to fill the channel from the mouth upstream with one foot of sediment at the slope of the lower reach (0.001 ft/ft) and let that sediment intersect the channel after the grade break at station 18+00 where the slope changes to 0.00324 ft/ft upstream of station 22+00. **Figure 3** shows the depth and limits of this sediment accumulation as the shaded area in the lower part of the creek (left side of the profile).

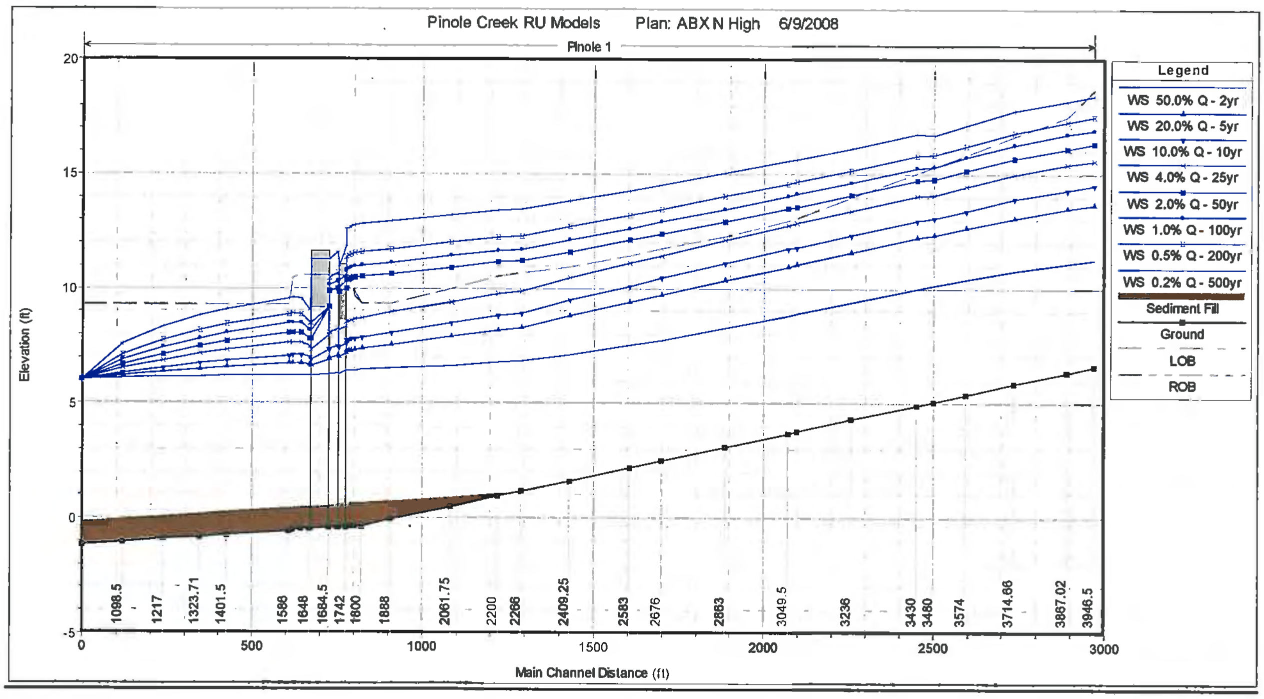

Figure 3 — HEC-RAS plot of the As-Built plan worst conditions profile showing the sedimentation assumptions.

As-Built Model Levees

In HEC-RAS, when the modeled water surface goes higher than the left or right cross section data, the model assumes there is a "glass wall" at the cross section limits of the cross section. The Corps recommended that we use this glass wall at the top of bank of the As-Built cross sections to simulate a levee. Then in HEC-FDA, we set the top of bank as the "levee" height to calculate the CNP.

Proposed Plan

FarWest created a HEC-RAS model for the Proposed Plan, following the creek geometry proposed by RDG. The Proposed Plan geometry, in general, reflects the current silted condition of Pinole Creek with modifications to the banks and service road and with the addition of floodwalls.

The intent of the Proposed Plan is to leave the silt in the lower elevations of the cross sections in place and expand the higher elevations of the cross sections to increase capacity. Raised service roads (levees) and floodwalls are proposed to provide the necessary flow containment and freeboard. The final height and configuration of the levees and floodwalls are dependent on the results of this RU analysis.

There is an 8-inch curb on the Railroad Avenue Bridge. The assumption is that this curb will be removed as part of the project to provide slightly more capacity over that bridge. The Proposed Plan HEC-RAS model can be found on the CD in the back of this report.

Interpolation

Proposed levees are on the outside limit of the cross section for station 2276.5 and the levees are on the top of bank (or creek side of the trail) for cross section 2576.5. Between these two cross sections, the trail ramps up in the upstream direction. The proposed levy is planned to continue on the outside of the cross sections until the trail ramps up to meet the top of the levee at cross section 2576.5.

Between modeled cross sections 2276.5 and 2576.5, interpolated cross sections were created using the HEC-RAS interpolation tool. The interpolation tool interpolates the levees as well as the cross section data to create new cross sections. The default result between these cross sections is an inaccurate representation of the levees because when they are interpolated, the levees cross the path.

To fix this, we adjusted the levee locations in the interpolated cross sections manually to put the modeled levee on the outside of the interpolated cross sections. Then these cross sections were renamed to remove the "*" from their names and make them non-interpolated cross sections and preserve the levee location.[10]

Hydraulic Design Values (Manning's n-values)

FarWest provided the HEC-RAS model and n-values for the Proposed Plan design geometry. We reviewed them and used our engineering judgment to evaluate and revise the n-values for the three models needed in the RU analysis.

After reviewing the HEC-RAS model provided for the Proposed Plan design conditions, we created the exhibits in **Appendix A** to keep track of and suggest revisions to the proposed n-values in the FarWest model.

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[10] The HEC-RAS interpolation function inserts an "*" at the end of the interpolated cross section names and uses that for identification and other functional purposes. Renaming the cross section to remove the "*" removes the indicator, and afterwards HEC-RAS treats the cross sections as if they were not interpolated.

The cross sections in **Appendix A** display the design, best, and worst conditions n-values used for the three different zones assuming a restoration project from the mouth to the second set of railroad tracks. The station ranges for these zones are:

Zone	Stations
Tidal Zone	below 21+76
Transition Zone	21+76 to 26+00
Fluvial Zone	26+00 and above

The design n-values for the three models for the proposed conditions were set as follows:

Design Conditions Model:

- Follow the exhibits in **Appendix A**

Best Conditions Model:

- 16+68.5 and downstream — subtract 0.005 from all n-values in the Design Condition Model.
- 17+00.5 to 28+26.5 — manually adjusted to match figures in **Appendix A.**
- 28+26.5 and upstream — subtract 0.005 from all n-values in the Design Condition Model.

Worst Conditions Model

- 16+68.5 and downstream — add 0.005 to all n-values and in the Design Condition Model, and then adjust center of channel n-values to 0.040.
- 17+00.5 to 28+26.5 — manually adjusted to match figures in **Appendix A.**
- 28+26.5 and upstream — add 0.005 to all n-values in the Design Condition Model, and then adjust center of channel n-values to 0.040.

Sedimentation Estimate

As previously mentioned, in its current condition, lower Pinole Creek has aggradated sediment over the years and the design concept is to leave that sediment in place. We assume that after more than 30-years, the bed of the creek is in equilibrium with the sediment load of the watershed.

Modeled Levee Heights

The levees for the proposed project HEC-RAS model were set high enough to contain the floodwaters for all of eight flood series' flows. We did this per the recommendation of the Corps staff. We discuss this in more detail later in this report.

Model Runs

Each of the six (6) HEC-RAS geometries was paired up with a steady flow data scenario that included the flows from the eight flood series in **Table 1** and the appropriate beginning water surface elevation (boundary condition) presented in **Table 2.** The models were run with the mixed flow option to check the subcritical and supercritical flow regimes. The upstream boundary condition was set as normal depth with a slope of 0.003 ft/ft matching the As-Built drawings around station 39+00. The results of the HEC-RAS runs are included with the models on the CD in the back of this report.

HEC-FDA ANALYSIS

As mentioned above, the FC District used HEC-FDA to perform the RU analysis on the As-Built project to determine the target CNP. This section explains the inputs, iterations, and results of the HEC-FDA analysis. The FDA model is on the CD in the back of this report.

HEC-FDA MODEL INPUTS

Input into the HEC-FDA model is relatively easy, but complicated to explain. Below, we explain the data inputs that are of relative importance to this analysis in the logical order of the HEC-FDA program menus.

Damage Reaches

A "damage reach" is an element used in HEC-FDA to identify creek reaches that are associated with specific flooding and flood damages. A HEC-FDA model was created to analyze six (6) damage reaches that were judged to provide representative conditions for the project. The locations of the damage reaches are listed in **Table 3** and shown on a HEC-RAS screen shot in **Figure 4**. Please note that the cross section locations shown in the HEC-RAS screen shot are only approximate relative to the areal image.

Table 4 presents the top of bank elevations that are either the top of bank from the As-Builts Plan or the top of levee for the Proposed Plan. These elevations were input as the "Top of levee stage" in the Levee Features dialogue window in HEC-FDA.

Analysis Years

Analysis Years were created as: Base Year = 1995 and Most Likely Future = 2008. Attempts to revise the 1995 year to 1965 in the program failed. This number is not critical to the results we were looking for in the model.

Study Plan Definitions

Two study plan definitions were created: one entitled "Without" and the other entitled "With Project." These titles are reflected in **Table 4.**

Table 3 — Damage Reaches Definition for the HEC-FDA Model

Damage Reach Station	Beginning Station (downstream)	Ending Station (upstream)	Damage Reach Index Station(1)	Range Represented
13+50	9+80	16+23.0	13+23.5	Mouth — RR Bridge
19+00	17+42	21+26.5	18+76.5	RR Bridge to US — Chelsea Marsh
22+50	21+26.5	24+76.5	22+76.5	Chelsea Marsh — Fawcett
26+50	24+76.5	28+76.5	26+76.5	Fawcett— Woodfield
31+00	28+76.5	33+76.5	30+76.5	Woodfield — Pavon
36+00	33+76.5	38+76.5	35+76.5	Pavon — RR tracks

(1) These are actual modeled sections in the Proposed Plan models.

Table 4 — Damage Reach Stations and Levees Elevations for the HEC-FDA Model

Damage Reach Station	As-Built (Without) Plan Index Station	Levee Elev. Used(1)	Proposed (With Project) Plan Index Station	Levee Elev. Used(2)
13+50(3)	13+23.71	9.26	13+23.5	11.00(3)
19+00	18+88	9.35	18+76.5	13.78
22+50	22+66	10.69	22+76.5	14.23
26+50	26+76	11.72	26+76.5	14.48
31+00	30+76.42	13.09	30+76.5	15.10
36+00	35+74	15.85	35+76.5	17.10

(1) The levee used for the As-Built Plan is the lowest top of bank for the cross section.
(2) The levee used for the Proposed Plan is the lowest levee elevation that would cause the Proposed Plan to have the same or higher CNP by events as the same damage reach in the As-Built Plan.
(3) For this Damage Reach, the CNP of the As-Built Plan could not be met. This is due to several factors as described in the text.

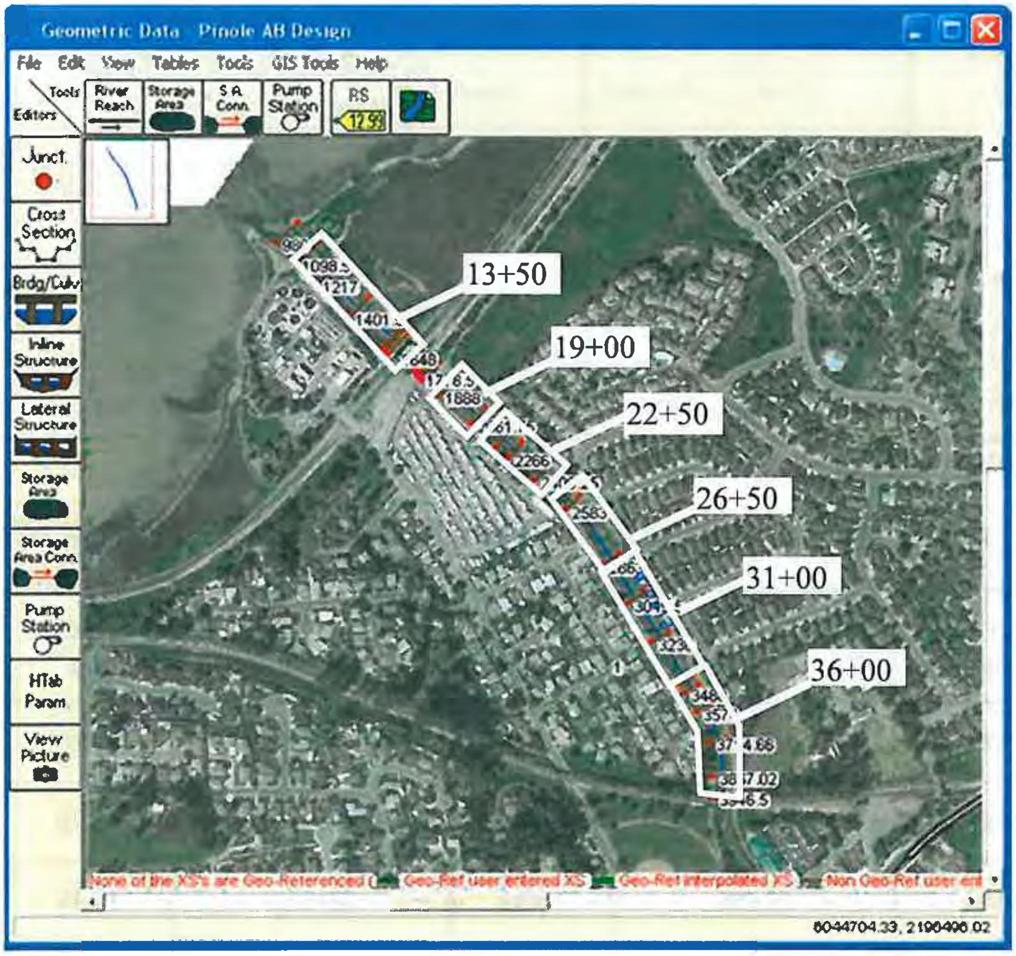

Figure 4 — HEC-RAS Geometry View with Damage Reaches Identified.

Study Water Surface Elevations

The study water surface elevations for the design conditions for both the As-Built and Proposed plans were exported from HEC-RAS to *.wsp files and imported into HEC-FDA as the "As-Built" and "Proposed" for the "Without" and "With Project" FDA plans.

Exceedance probability function with uncertainty

The "Analytical-Exceedance Probability Method" was chosen for the "Exceedance Probability Function with Uncertainty" option. The 0.5, 0.1, and 0.01 AEP flow rates from **Table 1** were input into the analytical option dialogue window shown in **Figure 5**. The equivalent Record Length was set at 20 years per Table 4-5 of EM 1110-2-1616[11], because the rainfall-runoff-routing model in the 1962 Report was calibrated to several events recorded at a short-interval event gauge in the watershed. The "Exceedance Probability Function" plot from HEC-FDA is also shown in **Figure 5**.

Stage Discharge Function with Uncertainty

In FDA, each Damage Reach for each Analysis Year and each Plan (Without and With Project) requires input of the water surface elevations (stages) and standard deviation of error. The stages can be brought in from the *.wsp data imported during the "Study Water Surface Elevations" step above. For each damage reach, these water surface profiles must be brought in first before inputting the Standard Deviation of Error values since the import process erases the Standard Deviation of Error values.

Section 5-7 of EM 1110-2-1619 "Sensitivity Analysis and Professional Judgment" states that professional judgment may be applied to establish the upper and lower bounds on stage for a given discharge. This can be done by estimating the worst and best conditions in the channel calculating the difference between the worst (upper) and best (lower) water surface elevations and dividing the difference by four (4). This resulting number can be used as the estimate of the standard deviation of error in the water surface elevation.

This procedure was accomplished as described above and explained here. For each of the HEC-RAS runs, a HEC-RAS Profile Output Table was used to copy the results to a spreadsheet to allow easy calculation of the difference between worst and best conditions models for the respective As-Built and proposed plans. The spreadsheet was programmed to calculate ¼ of the difference between the water surface elevations for the worst and best condition models as the "estimated standard deviation of error." The spreadsheets used for this project are on the CD in the back of this report. They are also presented in **Table 7** and **Table 8** showing only the data for the six (6) cross sections selected to represent the six damage reaches.

These standard deviation numbers were manually input into the HEC-FDA model under the "Stage Discharge Function with Uncertainty" dialogue window as the standard deviation of error.

The normal distribution type was selected under the "Distribution Type" option and "Enter by Ordinate" was selected under the "Define Uncertainty" option.

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[11] EM 1110-2-1616, Engineering and Design, Risk-Based Analysis for Flood Damage Reduction Studies, USACOE, 1 August 1969.

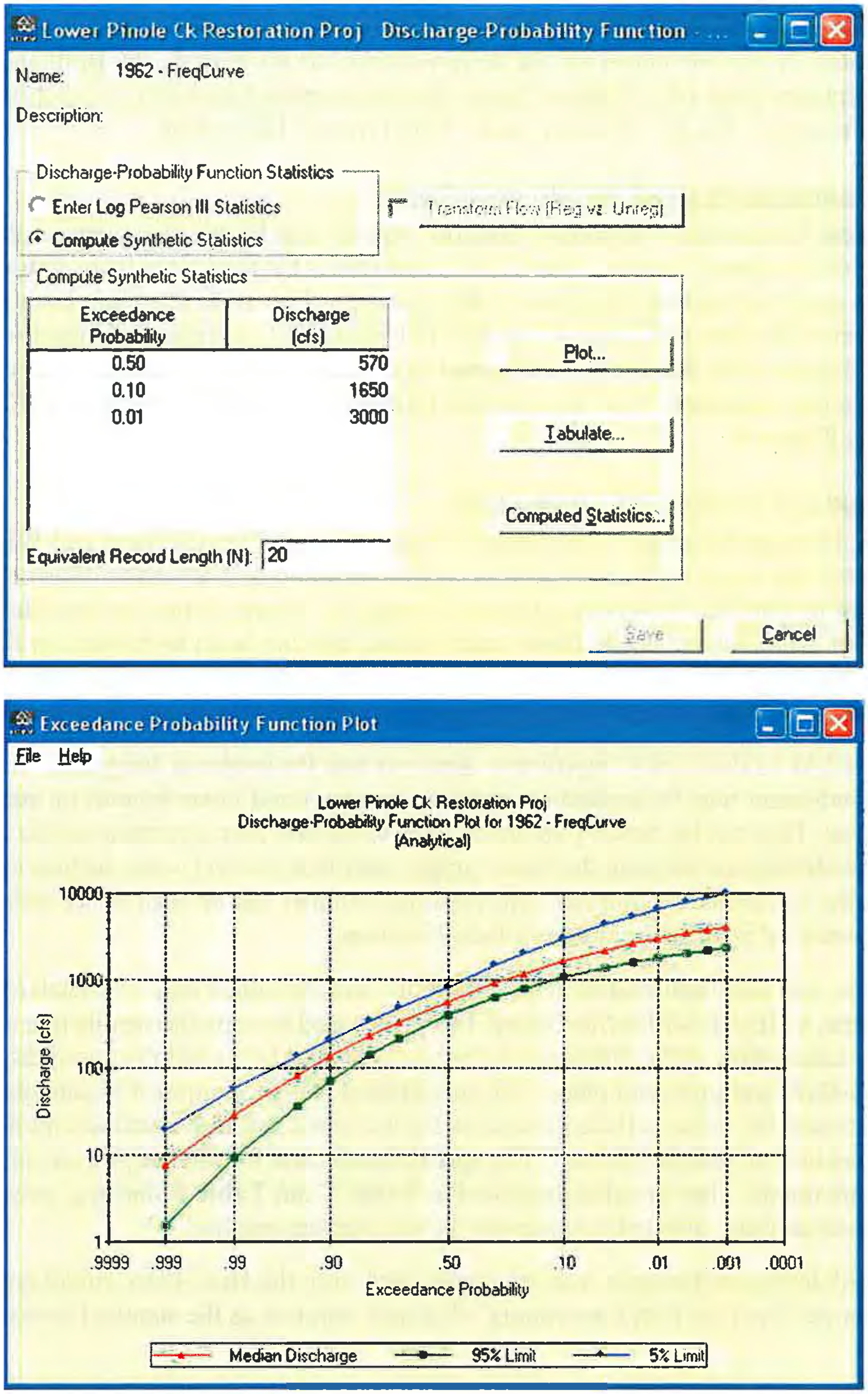

Figure 5 — Exceedance Probability Function with Uncertainty Input and Graph (screen shots from HEC-FDA).

HEC-FDA Levee Features

Table 4 above lists the levee elevations used in the final run in HEC-FDA for each of the damage reaches in each Plan.

HEC-FDA Economic Information

The HEC-FDA model was run to determine the CNP for each case (As-Built and Proposed) not for economics. For this reason, no economic information is needed for the analysis. However, to allow the model to be run, some "dummy" economic information needed to be present.

A default damage category named "Blank" with the default description, "Blank place holder not doing any damage analysis," was input under the Economics\Study Damage Categories menu. Then each plan was run under the Economics\Compute Reach Stage—Damage Function with Uncertainty menu. This allowed the model to run and calculate the CNP.

HEC-FDA Performance Runs

After all the data was input, the model was run to calculate the performance of both the As-Built and the Proposed Plans using the "Evaluation of Plans by Analysis Year" function. Choosing and selecting all of the plans under this option ran the "Monte Carlo" RU analysis and the results were viewed under the "Evaluation\Results\Project Performance" option.

Iterations to Determine Levee Elevations

Through an iterative process, the levee elevations in HEC-FDA for the Proposed Plan were raised and lowered until the analysis showed that the Proposed Plan had slightly better performance (higher CNP) than the As-Built plan. We were able to accomplish this in all damage reaches except for damage reach 13+50. No matter how high we raised the levee, even up to elevation 18.0, which is higher than most elevations in the model, we were unable to meet or exceed the performance of the As-Built model. This is discussed in more detail later in the report.

The final levee elevations for the Proposed Plan are shown in **Table 4** above under the column heading "Levee Elev. Used."

For the iterative process, approach, we ultimately abandoned, was to change the levee heights in the HEC-RAS models as the levee heights were changed in HEC-FDA. There is some good reasoning in this approach. If the levees were lower in the one part of the model and water allowed to spread out, then the water surface would be lower in the upstream part and would not exceed the levee heights as often. Therefore, putting the levee in the model high enough to contain all modeled flows (as mentioned above under **Proposed Plan**) might overestimate the required heights of the levees. However, the number of iterations dramatically increases if we do this. Our approach is conservative, recommended by the Corps, and greatly reduces the modeling effort.

The diagram in **Figure 6** is a general flow chart of the modeling and RU analysis process. It shows that we would have to change three HEC-RAS models to set the levees equal to the levee heights in HEC-FDA every time we iterate the levee height. To do this for each iteration, we would have to:

In HEC-RAS:

- Modify the levee elevations in three HEC-RAS models.
- Run the three HEC-RAS models.
- Export the design water surface profile from HEC-RAS.
- Import the design water surface profile into HEC-FDA.
- Export all three profiles (worst, design, and best) into a spreadsheet to estimate the standard deviation of error.

In HEC-FDA:

- Change the target levee elevations for each damage reach.
- Reset the water surfaces for the eight flood series for each damage reach (data is in HEC-FDA, but needs to be "assigned" to the damage reach).
- Manually enter the estimated standard deviation of error for each damage reach (eight numbers per damage reach).
- Run the HEC-FDA model.

This iterative process becomes unwieldy, and as the number of manual manipulations increases, so does the chance of error. As mentioned above, this approach was abandoned after discussing the procedures with the Corps.

Following the Corps' suggestion to raise the Proposed Plan levees to contain all flows, greatly speeds up the RU analysis by not having to iterate the levee height in the HEC-RAS model. Doing this likely resulted in slightly higher and more conservative levee elevations.

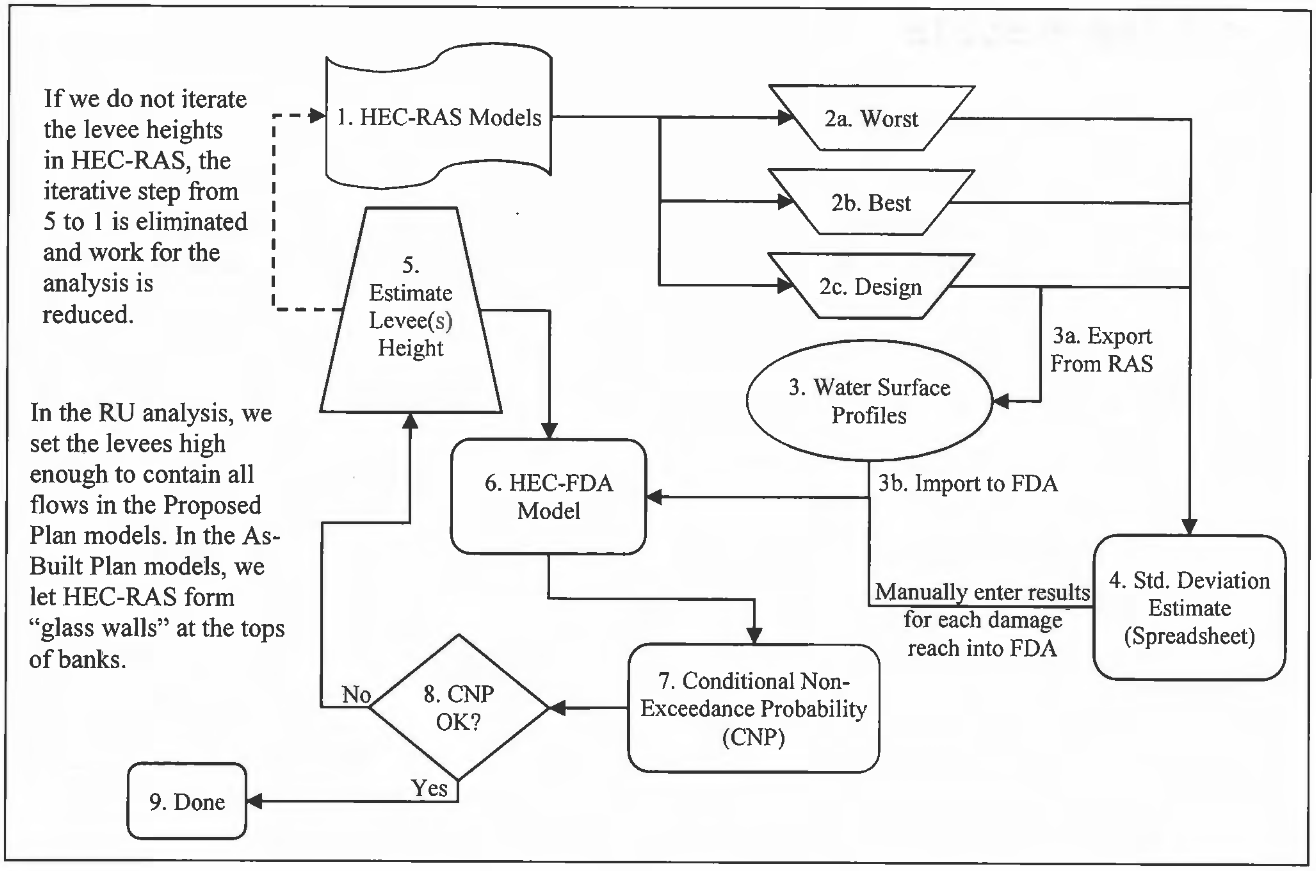

Figure 6 — Risk and Uncertainty Process — The iterative process to determine levee elevations.

HEC-FDA RESULTS

The results of the HEC-FDA RU analysis are included on the CD in the back of this report and provided in **Table 5** and **Table 6**.

Comparison of the As-Built Plan Top of Bank and the Proposed Plan Levee Elevations

Figure 7 shows the As-Built Plan and the eight flood series water surface profiles. **Figure 8** shows the Proposed Plan with the levee elevations from **Table 4** and the eight flood series water surface profiles from the Proposed Plan HEC-RAS models assuming the levees are high enough to contain all flows.

On these figures, we have placed ovals indicating two points of comparison: points "A" and "B."

- Point "A" on both profiles is where the 0.2% and 0.5% AEP flows cross the top of bank in the As-Built Plan model and the top of proposed levee in the Proposed Plan model.
- Point "B" on both profiles is where the 1.0% AEP flow is just below the top of bank or top of proposed levee.

From these profiles, it appears that the levee elevations in **Table 4** could have been estimated or determined graphically instead of using RU analysis. The similar vertical relationship between the various AEP water surface profiles and the top of bank or levee should be expected. This also demonstrates that the proposed levee elevations in **Table 4** are reasonable. That is, assuming the HEC-RAS models are accurate, the proposed levee elevations are adequate to meet the target performance of the proposed project.

As a side note, a graphical solution may be a viable way to estimate or check the results of an RU analysis where the performance target of the proposed project is to meet or exceed the performance of a historic condition. Obviously, we would have to analyze a significant number of diverse plans to be confident enough to replace a complete RU analysis and accept the graphical solution.

CNP for Damage Reach 13+50

In comparing the HEC-RAS profiles at the mouth of the creek in **Figure** 9 and **Figure 10**, we can see the different hydraulic conditions occurring in the two modeled channels. Much of this is due to the existing sediment in the Proposed Plan. The differences are discussed below.

- **Figure 9** shows all eight profiles for the As-Built Plan with the water surface profiles and the critical depths.

  This plot shows that all of these profiles start above critical depth at the boundary conditions water surface elevation. The As-Built Plan water surface profiles do not vary at the most downstream section and the profiles are very close together vertically, even as they diverge going upstream.

- **Figure 10** shows all eight profiles for the Proposed Plan with the water surface profiles and the critical depths.

  This plot shows that most of the design condition profiles start just below critical depth. Only the 50% AEP (2-year storm) profile does not start below critical depth. The Proposed Plan profiles start to spread out vertically and continue to diverge, though the divergence slows more quickly than that of the As-Built Plan profiles. They do not start at the boundary conditions water surface elevation.

We believe that because the Proposed Plan profiles start at very different elevations, the CNP for damage reach 13+50 cannot be met. This means that the RU analysis cannot be used to set the levee height for this damage reach.

The intent of the original As-Built design was to provide protection for flows up to 2,600 cfs without freeboard. Looking at the existing freeboard of the Proposed Plan, the 2% AEP (50-year) storm is almost contained by the left overbank (LOB). The right overbank (ROB) contains up to the 0.5% AEP (200-year) storm. The areas to the north of the creek in damage reach 13+50 are marsh and do not need to be protected due to the negligible risk. To the south, there is a sewage treatment plant that needs to be protected. We proposed that a levee elevation of 11.0 be used for damage reach 13+50. This will exceed the design protection level of the original design (50-year flows with one foot of freeboard per the 1962 Report) and provide more freeboard than the upstream damage reaches.

Before this elevation is selected as the design levee elevation, a review of the sewage treatment plan should be done to see if such a levee would actually trap floodwaters on the sewage treatment plant site. Our modeling shows that flow from the 1% AEP storm comes close to overtopping the railroad tracks. We need to be sure that if water escapes the channel and somehow floods the sewage treatment plant site, that the levee does not prevent the return of over-bank floodwaters to the creek and impound water to a depth that exceeds the flooding depth caused by flooding directly from the adjacent Pinole Creek channel.

Table 5 — HEC-FDA Results – Target Stage Annual Exceedance Probability (AEP) and Long Term Risk

Plan Name	Stream Name	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)		
					Median	Expected	10	25	50
Without	Pinole Creek	13+50	Mouth - RR Bridge	levee	0.0010	0.0030	0.0295	0.0721	0.1390
		19+00	RR Bridge to US - Chelsea Marsh	levee	0.0090	0.0180	0.1685	0.3696	0.6026
		22+50	Chelsea Marsh - Fawcett	levee	0.0060	0.0120	0.1146	0.2623	0.4558
		26+50	Fawcett-Woodfield	levee	0.0050	0.0110	0.1082	0.2489	0.4358
		31+00	Woodfield -Pavon	levee	0.0040	0.0080	0.0803	0.1887	0.3418
		36+00	Pavon – RR Tracks	levee	0.0010	0.0030	0.0302	0.0738	0.1422
With Project	Pinole Creek	13+50	Mouth - RR Bridge	levee	0.0010	0.0030	0.0295	0.0722	0.1393
		19+00	RR Bridge to US - Chelsea Marsh	levee	0.0100	0.0170	0.1581	0.3496	0.5770
		22+50	Chelsea Marsh - Fawcett	levee	0.0060	0.0120	0.1134	0.2599	0.4523
		26+50	Fawcett - Woodfield	levee	0.0050	0.0110	0.1043	0.2408	0.4236
		31+00	Woodfield - Pavon	levee	0.0030	0.0070	0.0645	0.1536	0.2836
		36+00	Pavon –RR Tracks	levee	0.0010	0.0030	0.0298	0.0729	0.1404

Table 6 — HEC-FDA Results – Conditional Non-Exceedance Probability (CNP)

Plan Name	Stream Name	Damage Reach Name	Damage Reach Description	Conditional Non-Exceedance Probability by Events					
				10%	4%	2%	1%	0.40%	0.2%
Without	Pinole Creek	13+50	Mouth - RR Bridge	1.0000	1.0000	0.9999	0.9997	0.9993	0.9988
		19+00	RR Bridge to US - Chelsea Marsh	0.9947	0.8839	0.6733	0.4320	0.1943	0.0942
		22+50	Chelsea Marsh - Fawcett	0.9991	0.9481	0.8084	0.5950	0.3208	0.1766
		26+50	Fawcett-Woodfield	0.9991	0.9518	0.8230	0.6221	0.3538	0.2062
		31+00	Woodfield -Pavon	0.9995	0.9713	0.8841	0.7334	0.4998	0.3479
		36+00	Pavon – RR Tracks	1.0000	0.9996	0.9977	0.9929	0.9829	0.9743
With Project	Pinole Creek	13+50	Mouth - RR Bridge	1.0000	1.0000	0.9996	0.9987	0.9965	0.9945
		19+00	RR Bridge to US - Chelsea Marsh	0.9970	0.9017	0.6966	0.4499	0.2006	0.0958
		22+50	Chelsea Marsh - Fawcett	0.9992	0.9498	0.8114	0.5974	0.3237	0.1788
		26+50	Fawcett - Woodfield	0.9994	0.9569	0.8324	0.6319	0.3586	0.2071
		31+00	Woodfield - Pavon	0.9999	0.9837	0.9178	0.7854	0.5479	0.3768
		36+00	Pavon –RR Tracks	1.0000	0.9998	0.9986	0.9951	0.9869	0.9797

Summary and Recommendations

An RU analysis for Pinole Creek was completed using the As-Built plans and design flows of the original 1965 project. The results from that As-Built RU analysis served as the target CNPs that used then used to set levee heights for the proposed project. We could not make the lowest damage reach (13+50) meet the CNP target, most likely due to the tidal effects, and recommend a levee height based on reasonable hydraulic assumptions. We also recommend the review of the general flooding potential of the sewage treatment plant on the south side of that damage reach to see if the recommended levee height would trap floodwaters entering the sewage treatment plant property.

The levee elevations for Pinole Creek should be designed and constructed to conform to **Table 4** and **Figure 8** and be at least one (1) foot above the HET. If the project is designed in accordance with these recommendations, it will have a CNP equal to or greater than the original 1960's Corps project.

Table 7 — As-Built Plan: Estimate of the Standard Deviation of Error in the Water Surface Elevation

Reach	River Sta	Profile	Q Total	As-Built Design Stage	As-Built Worst	As-Built Best	Difference	Est. Standard Deviation
1	1323.71	50.0% Q - 2yr	570	5.79	6.15	5.49	0.66	0.165
1	1323.71	20.0% Q - 5yr	1300	5.89	6.48	5.60	0.88	0.220
1	1323.71	10.0% Q - 10yr	1650	5.97	6.71	5.68	1.03	0.258
1	1323.71	4.0% Q - 25yr	2200	6.14	7.13	5.86	1.27	0.318
1	1323.71	2.0% Q - 50yr	2600	6.30	7.46	6.02	1.44	0.360
1	1323.71	1.0% Q - 100yr	3000	6.49	7.81	6.23	1.58	0.395
1	1323.71	0.5% Q - 200yr	3400	6.70	8.17	6.46	1.71	0.428
1	1323.71	0.2% Q - 500yr	4100	7.15	8.80	6.94	1.86	0.465
1	1888	50.0% Q - 2yr	570	6.03	6.50	5.77	0.73	0.183
1	1888	20.0% Q - 5yr	1300	6.72	7.52	6.53	0.99	0.248
1	1888	10.0% Q - 10yr	1650	7.16	8.08	7.01	1.07	0.268
1	1888	4.0% Q - 25yr	2200	7.94	8.95	7.84	1.11	0.278
1	1888	2.0% Q - 50yr	2600	8.54	10.63	8.49	2.14	0.535
1	1888	1.0% Q - 100yr	3000	9.18	11.11	9.19	1.92	0.480
1	1888	0.5% Q - 200yr	3400	11.25	11.69	11.24	0.45	0.113
1	1888	0.2% Q - 500yr	4100	12.43	12.90	12.42	0.48	0.120
1	2266	50.0% Q - 2yr	570	6.13	6.82	5.87	0.95	0.238
1	2266	20.0% Q - 5yr	1300	7.00	8.27	6.83	1.44	0.360
1	2266	10.0% Q - 10yr	1650	7.50	8.93	7.35	1.58	0.395
1	2266	4.0% Q - 25yr	2200	8.30	9.87	8.19	1.68	0.420
1	2266	2.0% Q - 50yr	2600	8.90	11.20	8.83	2.37	0.593
1	2266	1.0% Q - 100yr	3000	9.51	11.71	9.49	2.22	0.555
1	2266	0.5% Q - 200yr	3400	11.38	12.29	11.36	0.93	0.233
1	2266	0.2% Q - 500yr	4100	12.53	13.44	12.52	0.92	0.230
1	2676	50.0% Q - 2yr	570	6.77	7.75	6.66	1.09	0.273
1	2676	20.0% Q - 5yr	1300	8.30	9.70	8.27	1.43	0.358
1	2676	10.0% Q - 10yr	1650	8.92	10.44	8.90	1.54	0.385
1	2676	4.0% Q - 25yr	2200	9.77	11.44	9.75	1.69	0.423
1	2676	2.0% Q - 50yr	2600	10.32	12.36	10.31	2.05	0.513
1	2676	1.0% Q - 100yr	3000	10.85	12.89	10.84	2.05	0.513
1	2676	0.5% Q - 200yr	3400	12.02	13.45	12.01	1.44	0.360
1	2676	0.2% Q - 500yr	4100	13.05	14.50	13.04	1.46	0.365
1	3076.42	50.0% Q - 2yr	570	7.82	8.89	7.80	1.09	0.273
1	3076.42	20.0% Q - 5yr	1300	9.59	11.03	9.58	1.45	0.363
1	3076.42	10.0% Q - 10yr	1650	10.23	11.80	10.23	1.57	0.393
1	3076.42	4.0% Q - 25yr	2200	11.09	12.83	11.09	1.74	0.435
1	3076.42	2.0% Q - 50yr	2600	11.64	13.57	11.64	1.93	0.483
1	3076.42	1.0% Q - 100yr	3000	12.15	14.11	12.15	1.96	0.490
1	3076.42	0.5% Q - 200yr	3400	12.93	14.66	12.93	1.73	0.433
1	3076.42	0.2% Q - 500yr	4100	13.81	15.65	13.80	1.85	0.463
1	3574	50.0% Q - 2yr	570	9.32	10.38	9.32	1.06	0.265
1	3574	20.0% Q - 5yr	1300	11.12	12.62	11.12	1.50	0.375
1	3574	10.0% Q - 10yr	1650	11.77	13.41	11.77	1.64	0.410
1	3574	4.0% Q - 25yr	2200	12.61	14.47	12.61	1.86	0.465
1	3574	2.0% Q - 50yr	2600	13.16	15.15	13.16	1.99	0.498
1	3574	1.0% Q - 100yr	3000	13.65	15.71	13.65	2.06	0.515
1	3574	0.5% Q - 200yr	3400	14.19	16.24	14.19	2.05	0.513
1	3574	0.2% Q - 500yr	4100	14.95	17.14	14.95	2.19	0.548

Table 8 — Proposed Plan: Estimate of the Standard Deviation of Error in the Water Surface Elevation

Reach	River Sta	Profile	Q Total	Proposed Design Stage	Proposed Worst	Proposed Best	Difference	Est. Standard Deviation
1	1323.5	50.0% Q - 2yr	570	6.21	6.57	5.93	0.64	0.160
1	1323.5	20.0% Q - 5yr	1300	7.45	7.8	7.25	0.55	0.138
1	1323.5	10.0% Q - 10yr	1650	7.93	8.31	7.71	0.6	0.150
1	1323.5	4.0% Q - 25yr	2200	8.58	8.98	8.35	0.63	0.158
1	1323.5	2.0% Q - 50yr	2600	8.98	9.39	8.75	0.64	0.160
1	1323.5	1.0% Q - 100yr	3000	9.35	9.77	9.1	0.67	0.168
1	1323.5	0.5% Q - 200yr	3400	9.68	10.13	9.42	0.71	0.178
1	1323.5	0.2% Q - 500yr	4100	10.21	10.7	9.92	0.78	0.195
1	1876.5	50.0% Q - 2yr	570	7.34	7.73	7.07	0.66	0.165
1	1876.5	20.0% Q - 5yr	1300	9.21	9.67	8.98	0.69	0.173
1	1876.5	10.0% Q - 10yr	1650	10.09	10.68	10.01	0.67	0.168
1	1876.5	4.0% Q - 25yr	2200	12.13	12.67	11.74	0.93	0.233
1	1876.5	2.0% Q - 50yr	2600	13.2	13.45	13.09	0.36	0.090
1	1876.5	1.0% Q - 100yr	3000	13.78	14.04	13.65	0.39	0.097
1	1876.5	0.5% Q - 200yr	3400	14.31	14.57	14.17	0.4	0.100
1	1876.5	0.2% Q - 500yr	4100	15.16	15.45	15.01	0.44	0.110
1	2276.5	50.0% Q - 2yr	570	7.59	8.02	7.32	0.7	0.175
1	2276.5	20.0% Q - 5yr	1300	9.48	10.01	9.21	0.8	0.200
1	2276.5	10.0% Q - 10yr	1650	10.33	10.98	10.2	0.78	0.195
1	2276.5	4.0% Q - 25yr	2200	12.26	12.84	11.86	0.98	0.245
1	2276.5	2.0% Q - 50yr	2600	13.31	13.62	13.17	0.45	0.113
1	2276.5	1.0% Q - 100yr	3000	13.9	14.21	13.74	0.47	0.118
1	2276.5	0.5% Q - 200yr	3400	14.43	14.75	14.26	0.49	0.123
1	2276.5	0.2% Q - 500yr	4100	15.28	15.64	15.11	0.53	0.133
1	2676.5*	50.0% Q - 2yr	570	7.91	8.38	7.62	0.76	0.190
1	2676.5*	20.0% Q - 5yr	1300	9.81	10.43	9.48	0.95	0.238
1	2676.5*	10.0% Q - 10yr	1650	10.64	11.37	10.42	0.95	0.238
1	2676.5*	4.0% Q - 25yr	2200	12.47	13.12	12.02	1.1	0.275
1	2676.5*	2.0% Q - 50yr	2600	13.48	13.89	13.28	0.61	0.153
1	2676.5*	1.0% Q - 100yr	3000	14.06	14.48	13.85	0.63	0.158
1	2676.5*	0.5% Q - 200yr	3400	14.6	15.02	14.37	0.65	0.163
1	2676.5*	0.2% Q - 500yr	4100	15.44	15.9	15.21	0.69	0.173
1	3076.5	50.0% Q - 2yr	570	8.33	8.88	7.98	0.9	0.225
1	3076.5	20.0% Q - 5yr	1300	10.37	11.05	9.93	1.12	0.280
1	3076.5	10.0% Q - 10yr	1650	11.15	11.93	10.79	1.14	0.285
1	3076.5	4.0% Q - 25yr	2200	12.72	13.47	12.2	1.27	0.318
1	3076.5	2.0% Q - 50yr	2600	13.65	14.21	13.34	0.87	0.218
1	3076.5	1.0% Q - 100yr	3000	14.24	14.81	13.89	0.92	0.230
1	3076.5	0.5% Q - 200yr	3400	14.78	15.36	14.42	0.94	0.235
1	3076.5	0.2% Q - 500yr	4100	15.65	16.26	15.29	0.97	0.243
1	3576.5	50.0% Q - 2yr	570	10.31	10.7	10.1	0.6	0.150
1	3576.5	20.0% Q - 5yr	1300	12.29	12.95	12.05	0.9	0.225
1	3576.5	10.0% Q - 10yr	1650	13.1	13.76	12.79	0.97	0.243
1	3576.5	4.0% Q - 25yr	2200	14.22	14.94	13.73	1.21	0.303
1	3576.5	2.0% Q - 50yr	2600	14.96	15.6	14.49	1.11	0.278
1	3576.5	1.0% Q - 100yr	3000	15.51	16.08	15.04	1.04	0.260
1	3576.5	0.5% Q - 200yr	3400	15.94	16.52	15.51	1.01	0.253
1	3576.5	0.2% Q - 500yr	4100	16.62	17.28	16.15	1.13	0.283

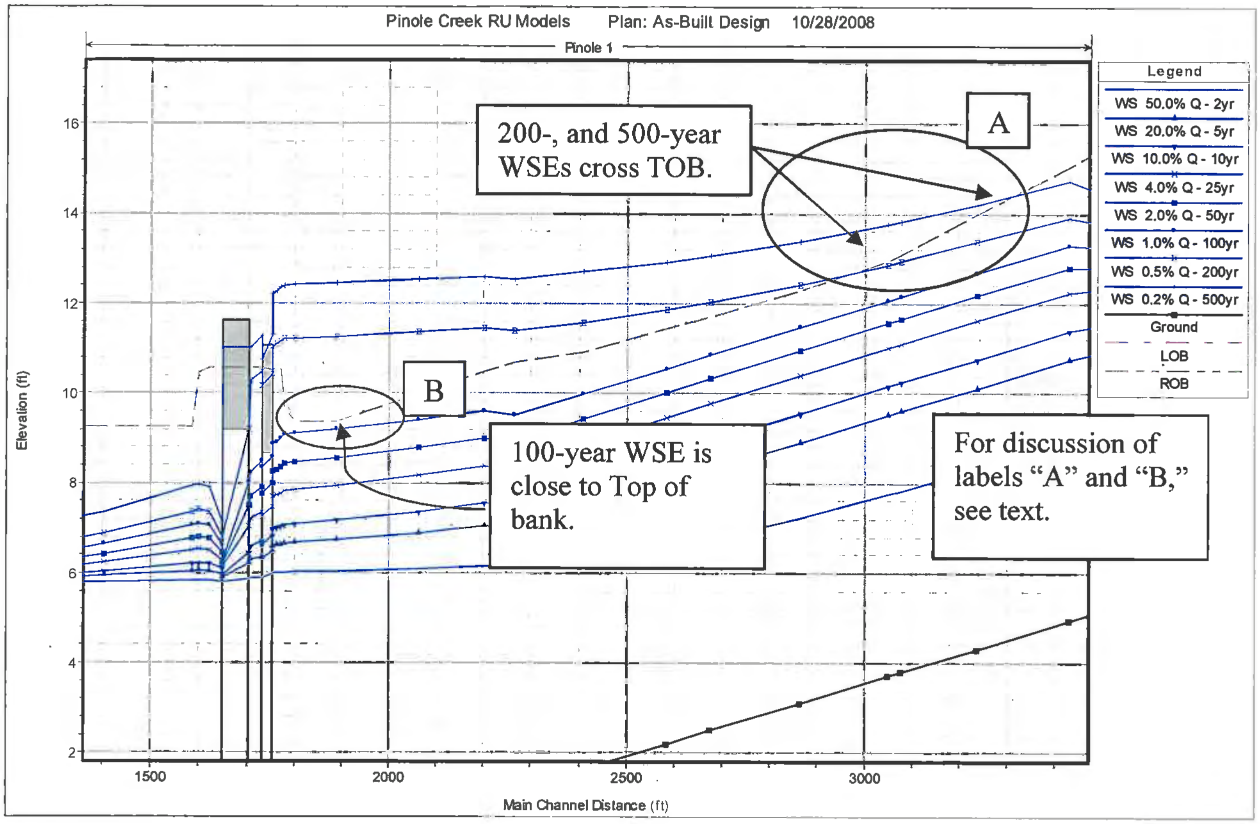

Figure 7 — HEC-RAS Profile of the As-Built Plan Design Conditions with Top of Bank Profile.

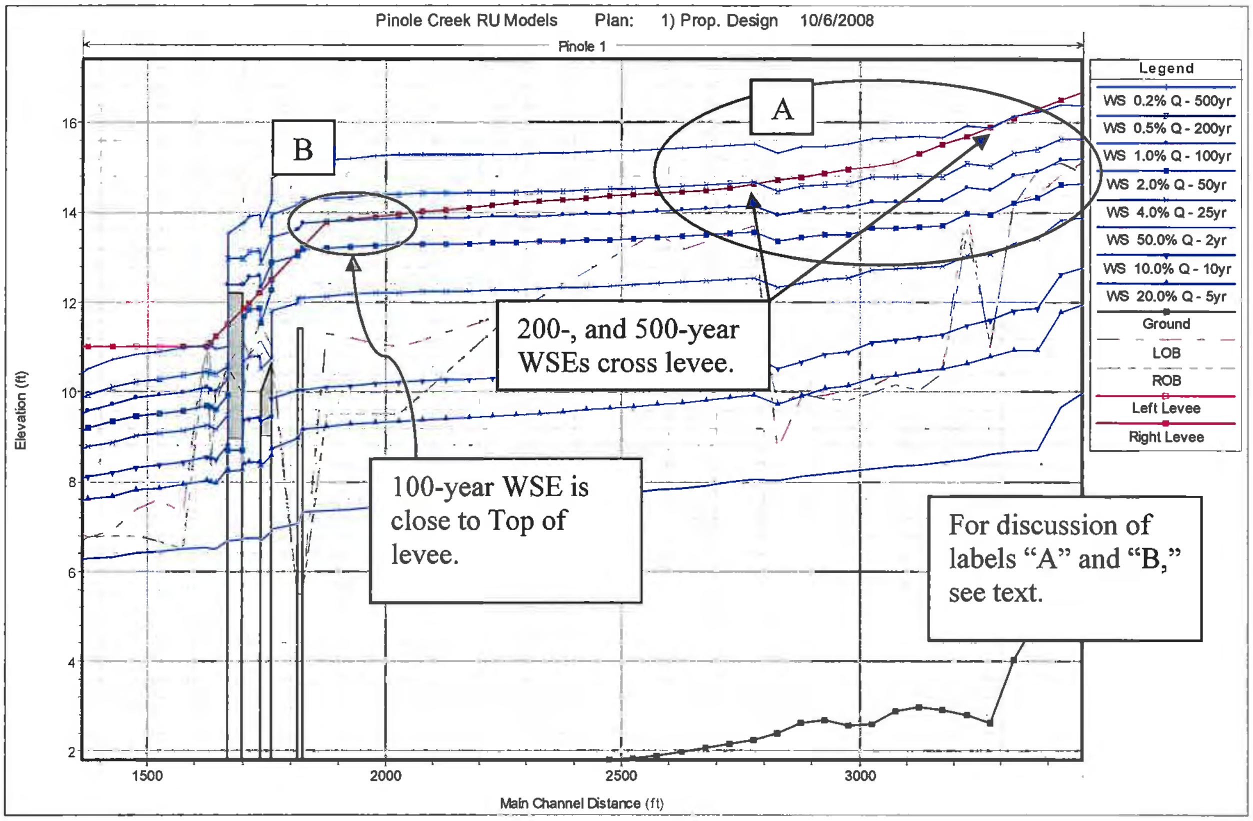

Figure 8 — HEC-RAS Profile of the Proposed Plan Design Conditions with Levees set at Recommended Height.

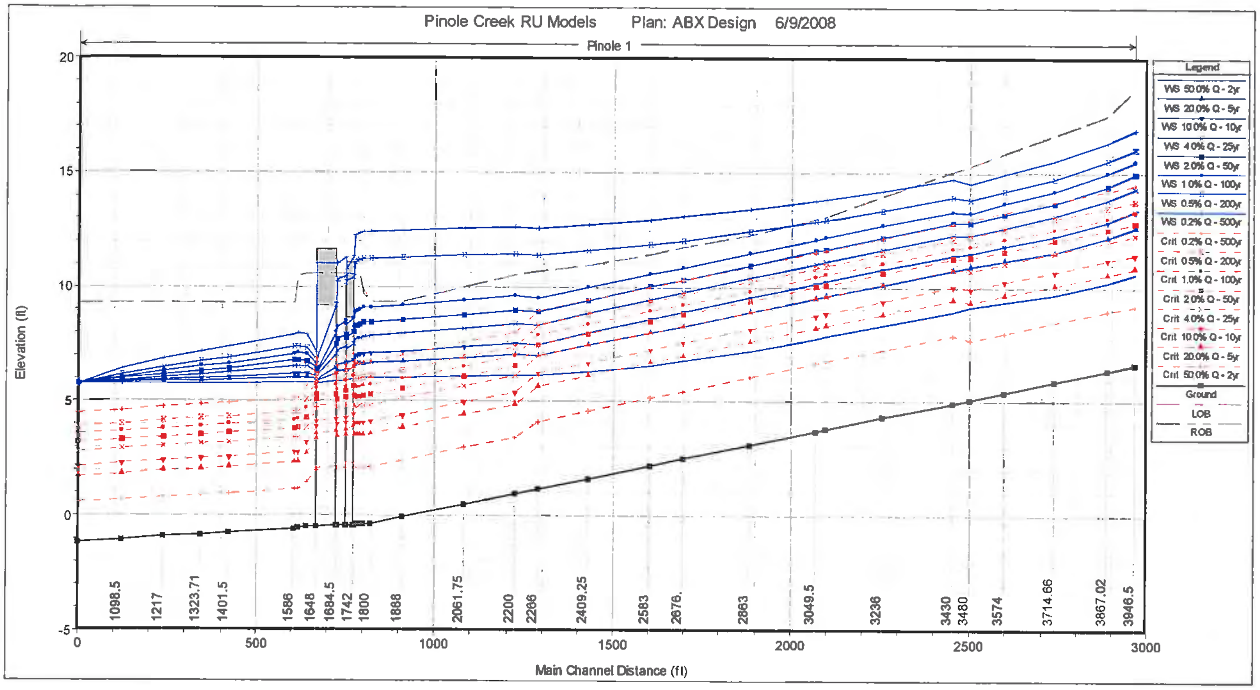

Figure 9 — HEC-RAS Profile of the As-Built Plan Design Conditions.

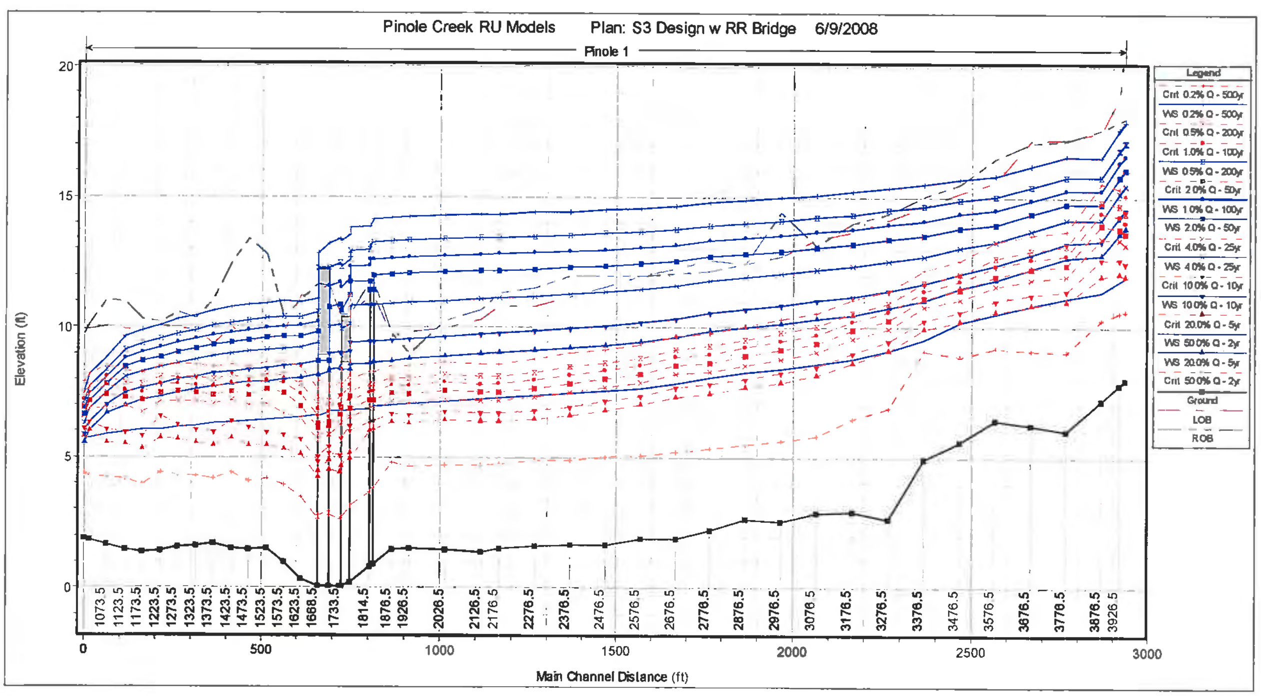

Figure 10 — HEC-RAS Profile of the Proposed Plan Design Conditions.

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APPENDIX A — Exhibits

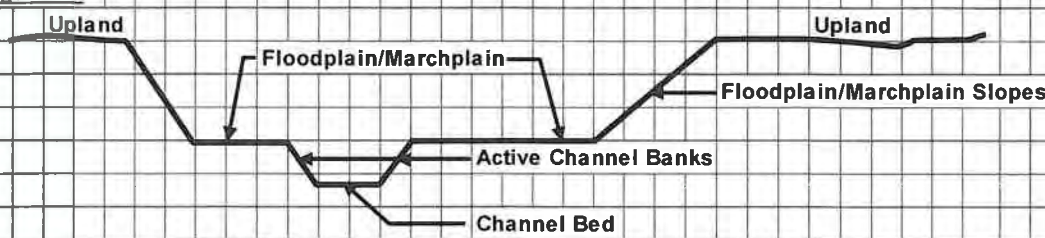
CONTRA COSTA COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT

Computation Sheet

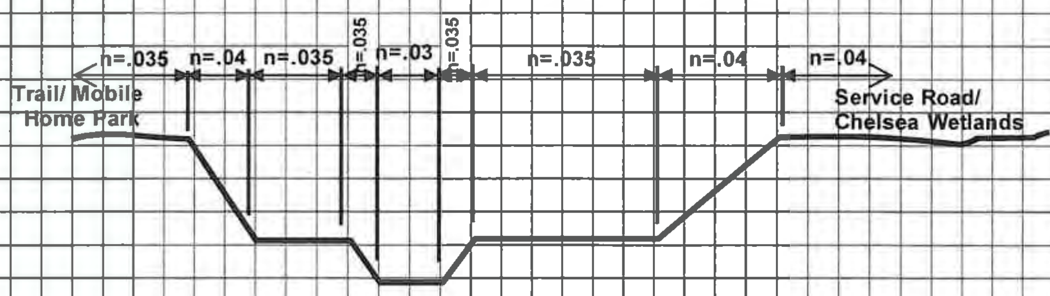
Subject: Manning's N-Values for Pinole Creek Cross Sections Project Number: 6D-8497

By: VR Date: 1/15/2008 Checked by: Date:

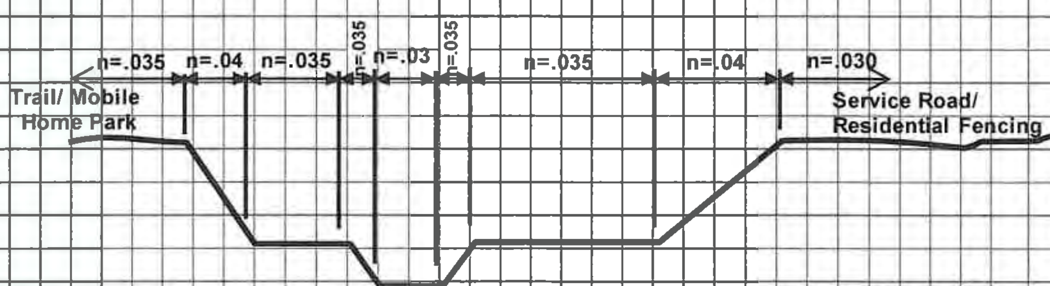
Design Case



Proposed Pinole Creek Cross Section (TYP)



Proposed Pinole Creek Cross Section at Tidal Zone (TYP)



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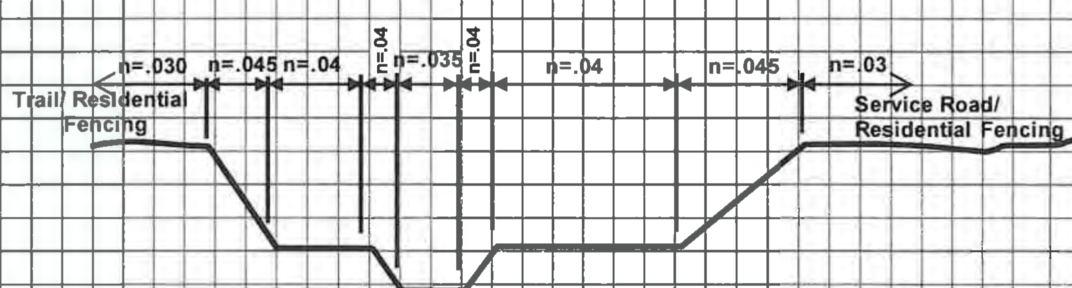


Proposed Pinole Creek Cross Section at Fluvial Zone (TYP)

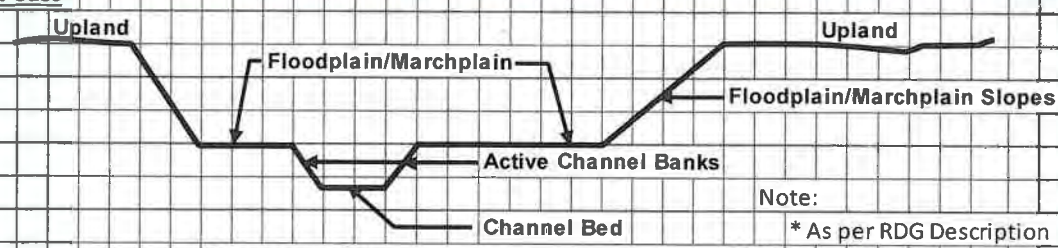
CONTRA COSTA COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT

Computation Sheet

Subject: Manning's N-Values for Pinole Creek Cross Sections Project Number: 6D-8497

By: AR Date: 1/15/2008 Checked by: ____ Date: ____

Best Case



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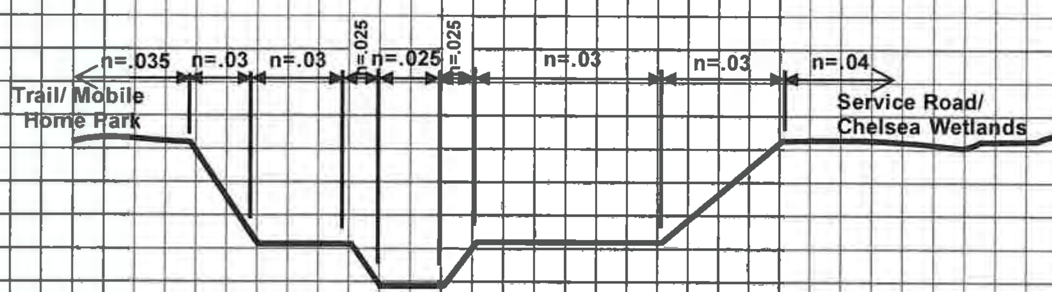

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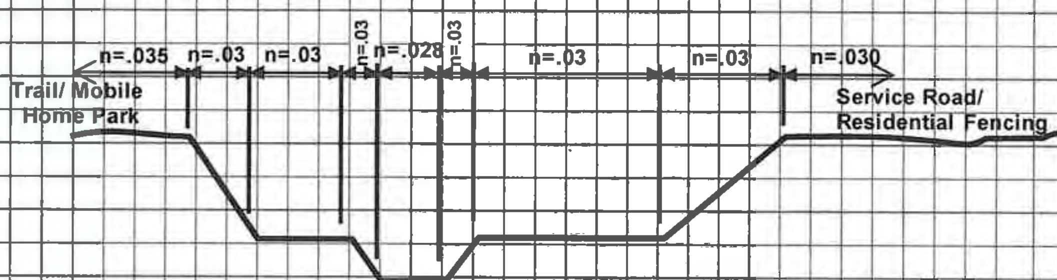

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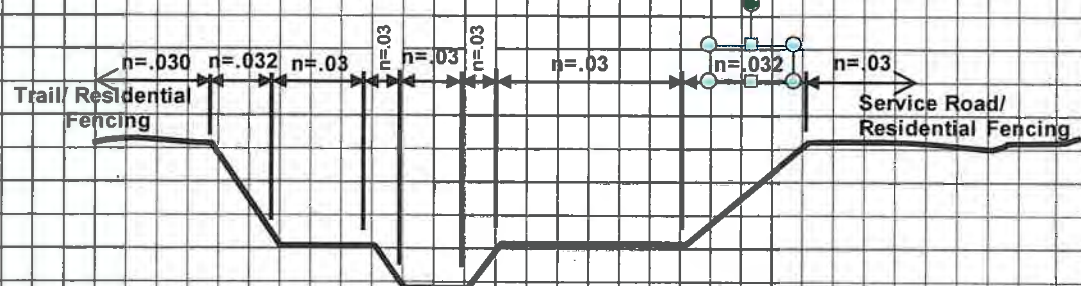


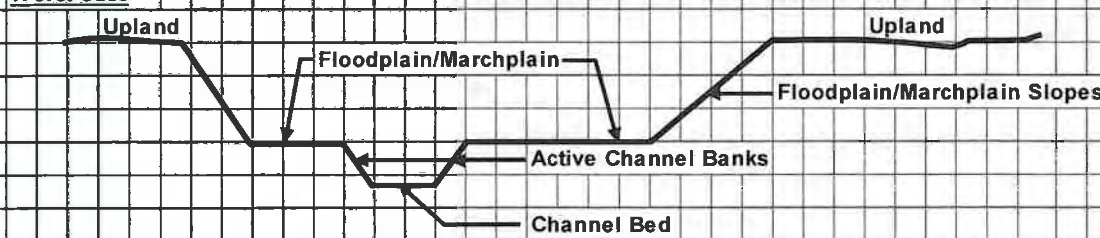
Proposed Pinole Creek Cross Section at Fluvial Zone (TYP)

CONTRA COSTA COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT

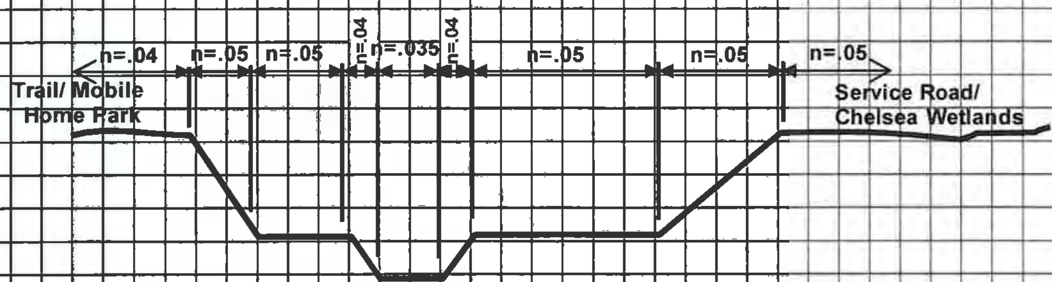
Computation Sheet

Subject: Manning's N-Values for Pinole Creek Cross Sections Project Number: 6D-8497
By: AR Date: 1/15/2008 Checked by: Date:

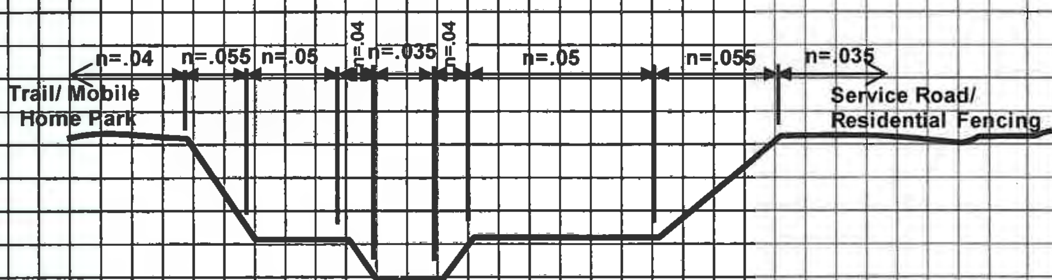
Worst Case



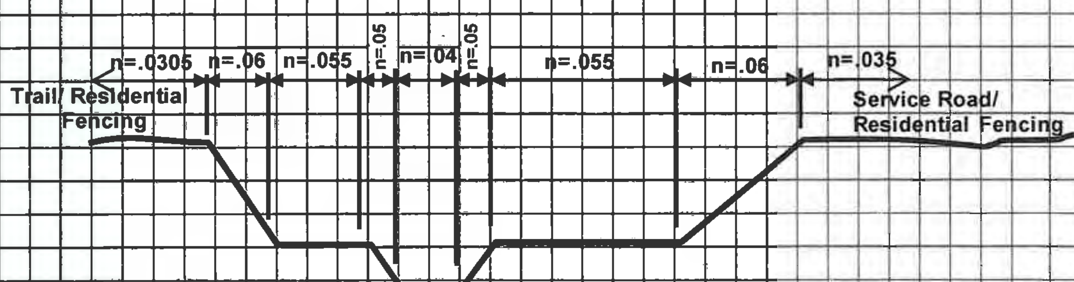
Proposed Pinole Creek Cross Section (TYP)



Proposed Pinole Creek Cross Section at Tidal Zone (TYP)



Proposed Pinole Creek Cross Section at Transition Zone (TYP)



Proposed Pinole Creek Cross Section at Fluvial Zone (TYP)

*Must consider Prop 13 and its effects

APPENDIX B — DATA DISK

Appendix 2 – SFEI Report

DRAFT

Pinole Creek Habitat Assessment

Additional Task to Green Infill for Clean Stormwater Project

Prepared by

Nicole David, Sarah Pearce, and David Gluchowski

SFEI

August 31, 2012

Background and Overview

The lower portion of the Pinole Creek Flood Control Channel was restored in 2011/12 with the goals of establishing and enhancing a healthy, functioning riparian corridor, increasing the floodplain area, and increasing diversity and abundance of aquatic and terrestrial species. Pre-restoration measurements were compared to post-restoration measurements to evaluate potential improvements in water quality, including comparing results to Water Quality Objectives listed in Chapter 3 of the Water Quality Control Plan for the San Francisco Bay Basin. In addition to water quality measures, other data including rapid condition assessment (CRAM assessments), Physical Habitat Assessment (PHab), bioassessment sampling, and photos were collected to document the improvements that were achieved. This evaluation also aids in assessing costs and benefits for improved flood protection and wildlife enhancement, as well as recreational uses.

Water Quality

Limited water quality measurements were taken in Pinole Creek. These included dissolved oxygen, temperature, pH, electrical conductivity, and turbidity. Sampling was conducted at two locations: the Railroad Bridge and near Orleans Street on the southern bank of Pinole Creek (Table 1a and b). Salinity and electrical conductivity were both higher during the sample collection in 2012, after the restoration, and indicated the incoming tide at the time of sampling. Dissolved oxygen was slightly higher at Railroad Bridge in 2012, likely due to the lower temperature measured at this location too. Turbidity decreased at both sites by about 50%, which could point toward an improvement in water clarity due to the construction but could also be attributed to clearer water pushing in from San Francisco Bay. A longer time series of water quality data would be needed to better describe the changes in water quality characteristics.

Table1a. Water Quality Measurements at Railroad Bridge.

Railroad Bridge

Date	8/10/2009	8/13/2012	Units
Dissolved Oxygen	6.1	6.6	mg/L
Water Temperature	21.7	17.5	°C
pH	7.8	7.1	NA
Conductivity	7.726	32.38	µS/cm
Salinity	4.28	20.28	ppt
Turbidity	28.5	14.2	NTU

Table1b. Water Quality Measurements near Orleans Street.

Orleans Street			
Date	8/10/2009	8/13/2012	Units
Dissolved Oxygen	6.5	6.5	mg/L
Water Temperature	23.2	18.0	°C
pH	7.8	7.1	NA
Conductivity	6.401	30.52	µS/cm
Salinity	3.5	18.9	ppt
Turbidity	14.7	7.9	NTU

Bioassessment

As expected, the evaluation of benthic invertebrates before and after the restoration did not show any statistically significant changes in abundance or species diversity. This is likely because the channel bed was not significantly altered, as compared to the floodplain surface and plant assemblage on that surface. The total number of individuals counted in the 2009 samples was 758 while the individuals counted in 2012 totaled 804. In 2009, these individuals were spread over 18 species and in 2012, 19 species were identified. New species that were not seen in 2009 were *Gnorimosphaeroma oregonensis*, *Gnorimosphaeroma insulare*, and *Balanus spp.* Two genera present in 2009 but not seen in the 2012 samples were *Tanaidacea* and *Sphaeromatidae*.

The slight change in invertebrate numbers was very likely not associated with the restoration work, but rather with interannual variation, tidal cycle variation, or the difference in sediment sampled with each grab. However, the occurrence of *Gnorimosphaeroma oregonensi*, the native pill bug, could be an indication that the overall habitat quality is improving.

A more distinct difference in invertebrate composition would be expected five to seven years after the restoration effort, once the planted trees are more mature and shading some areas of the creek banks and water. Even though the change in diversity and abundance of invertebrates in the collected sediment was not significant, the slight increase from pre- to post- restoration may indicate a slight recovery as the outcome of habitat improvement.

Physical Habitat Assessment

Physical habitat assessment (PHab) was conducted at two sites along Pinole Creek, corresponding to locations where bioassessment samples were collected. The sampling sites and PHab sites were also within the reach of CRAM assessment areas. Physical habitat quality assessment forms (outlined in QAPP) were used. Ten parameters were evaluated for each site and scores from 0 to 20 were assigned to each habitat characteristic (Table 2). The GPS coordinates (WGS 84) for PHab and bioassessment sites were

PC#1(Railroad Bridge): Lat 38.01249 Long -122.29478, PC#2 (near Orleans Street): Lat 38.01090 Long -122.29247. Both sides of the creek were taken into consideration when the scores were assigned (Table 2).

Table 2. Physical Habitat Assessment comparing 2009 to 2012 scores of two sites at Pinole Creek.

Parameter		PC#1		PC#2	
		2009	2012	2009	2012
1. Epifaunal Substrate/Available Cover		6	6	8	8
2. Embeddedness		1	2	7	6
3. Velocity/Depth Regimes		1	1	8	4
4. Sediment Deposition		3	16	5	16
5. Channel Flow Status		15	20	10	20
6. Channel Alteration		5	5	8	4
7. Frequency of riffles (or bends)		3	1	10	1
8. Bank Stability	Left Bank	9	8	5	7
	Right Bank	9	8	5	7
9. Vegetative Protection	Left Bank	7	9	5	8
	Right Bank	7	9	5	4
10. Riparian Vegetative Zone Width	Left Bank	1	4	2	4
	Right Bank	1	6	2	6
		68	95	80	95

Overall the scores in 2012 were higher than in 2009, suggesting an improvement in habitat quality. At Railroad Bridge (PC#1) the total score increased from 68 to 95 and from 80 to 95 for the Orleans Street site (PC#2). The biggest improvements were made in channel flow status and sediment deposition, due to an increased degree to which water covers the entire available channel substrate. The attribute of channel flow status is a measure of how much of the potential habitat is available to aquatic organisms based on the amount of water present in the channel at the time of assessment. When water does not cover much of the stream bed, the amount of substrate available for aquatic organisms is limited relative to times when flow is higher. For PC#2, the increased influence and filling of the channel by tidal water contributes to the increased score. Also the riparian vegetative zone width increased at both sites due to the widening of the floodplain of the creek. The Sediment Deposition score increased because the sites are fairly stable in terms of not marked by significant sediment deposition. Although the reach was tidal and had a veneer of mobile fine sediment across the entire active channel width, the net amount of deposition in the channel was constant, without deposition or erosion, and thus the pools that were present were not negatively affected by excess deposition. The Velocity/Depth Regime for PC#2 decreased because of the slight channel geometry alteration, allowing the slower velocity tidal water to have a larger influence in this reach, as compared to previously. This also affected the Frequency of Riffles, reducing the number of riffles (one) because the reach transitioned from being dominantly fluvial to having a greater effect (more inundation) by tidal water. The Channel Alteration score for PC #2 also decreased due to additional boulders placed along the banks to prevent meandering.

CRAM Assessments

The California Rapid Assessment Method for wetlands (CRAM) was conducted to determine the existing condition of wetlands associated with the Pinole Creek Green Infill/Restoration Project. SFEI staff assessed six total assessment areas: three on Pinole Creek, and three in the Chelsea Marsh area (Table 1). CRAM assessments were conducted at three different locations along Pinole Creek: the Railroad Bridge (Pinole Creek #1), half-way between the bridge and Orleans Street (Pinole Creek #2), and near Orleans Street (Pinole Creek #3). The three Assessment Areas (AAs) are contiguous with one another, so that the entire reach between the Railroad Bridge and Orleans Street was assessed. Although scores for Pinole Creek were collected in 2009 using both the Riverine and Perennial Estuarine modules (v 5.0.2), they were originally only reported in the progress update using the Perennial Estuarine module. In 2012, again data was collected using both modules (v 6.0). However, based upon discussions with CRAM developers and comparisons of scores collected using different modules, we suggest that for this site it is more appropriate to use the Riverine module. Thus, scores reported below are all using the Riverine module, updating 2009 scores to version 6.0 for consistency. Scores for the Chelsea Marsh were only collected using the Perennial Estuarine module, despite most of the area being upland. Thus, the scores for these areas are currently very low, however when the area is restored to tidal marsh, the scores will reflect that improvement.

Table 3. Summary of CRAM Scores at Pinole Creek Sites from August 2009 and 2012. Scores for Pinole Creek are reported using the Riverine module (v. 6.0), while scores from Chelsea Marsh are reported using the Perennial Estuarine module (v. 6.0). na= not assessed.

Assessment Area	Overall CRAM Score		Buffer and Landscape Context Attribute		Hydrology Attribute		Physical Structure Attribute		Biotic Structure Attribute	
	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012
Pinole Creek #1	62	71	80	80	75	83	38	38	56	83
Pinole Creek #2	57	70	68	75	75	83	38	38	47	86
Pinole Creek #3	60	65	68	75	75	83	38	50	58	53
Chelsea #1	56	na	58	na	58	na	38	na	69	na
Chelsea #2	56	na	58	na	67	na	38	na	61	na
Chelsea #3	57	na	60	na	67	na	38	na	64	na

Scores are interpreted as statistically different when the overall CRAM score differs by 6 or more points, and the attributes are considered different when they differ by 10 or more points. For the Pinole Creek assessments, the Overall CRAM score increased for each AA, however only #1 and #2 can be interpreted as statistically different. Interpreting the first Attribute, the Buffer and Landscape Context Attribute, AA #1 did not change, while AAs #2 and #3 both increased. This was primarily due to the increase in Buffer Condition, changing from a buffer that was largely not vegetated to a buffer planted with many native plant species. The Hydrology Attribute consistently increased for all three AAs, due to an increase in the Channel Stability metric score. In 2009, each of the AAs showed signs of slight aggradation or degradation, whereas in 2012 the channel was stable. The Physical Structure Attribute remained constant for AAs #1 and #2, and increased for AA #3, primarily due to increased physical patch types on the floodplain surface. The Biotic Structure Attribute increased significantly for AAs #1 and #2, and decreased slightly for AA #3. In the downstream two AAs, the number of plant layers and the number of co-dominant species both increased. Also, the Horizontal Interspersion and the Vertical Biotic Structure increased, indicating a better, more complex plant community present on the floodplain surface after restoration. For AA #3, we found that the number of co-dominant species and the percent invasion worsened in 2012, along with the Horizontal Interspersion. The right bank side of the creek in this AA appeared to be either affected by a flood event, or managed, with a large non-vegetated area present, and most of the remaining floodplain surface that was vegetated had been mowed. This management appeared to be limiting the plant community potential along that bank.

For the Chelsea Marsh assessments, we found that the Overall CRAM score was low in 2009, with all three AAs scoring in the 50s. The AAs had low Physical Structure Attribute scores, and moderate scores for the other three Attributes. These scores were low because much of the AA is currently not actually wetland, but instead a mosaic of upland non-native and invasive species. Only the tidal channel and immediate banks along the south side of the AAs is actually perennial estuarine wetland. While the Buffer and Landscape Attribute score may not change due to future restoration, we hypothesize that the other three Attributes will all increase due to restoration of the area to tidal marsh. The CRAM scores for this area will also likely increase with time since restoration was completed, as the marsh and its vegetation mature.

Channel Cross Sections

Three cross sections were measured on Pinole Creek following methods outlined in the QAPP. These section locations were chosen to re-occupy previous cross-section locations, and allow for analysis of channel geometry change through time. Previous surveys were conducted by Urban Creeks Council staff in November 2002, and again by SFEI staff (for a SFSU class project) in November 2006. Field notes from previous surveys helped to identify the exact survey locations. Sections were plotted looking downstream.

Section 28 is located between Railroad Avenue and the railroad tracks, and is the furthest downstream of the three cross sections. In 2002 and 2006, the section was surveyed 1 m downstream of Railroad Avenue, however for this survey, we surveyed 1 m upstream of the railroad tracks (approximately 6 m downstream from the previous surveys). Drew Goetting of Restoration Design Group requested that this location be surveyed because it will capture the channel dimensions with the new (constructed in approximately 2008) railroad bridge, helping to better inform the designs for the Pinole Creek Demonstration Project. In 2009, this section illustrated the small benches that had formed in the tidal channel, dominated by *Spartina sp.* Although these sections cannot be directly compared, the general channel dimensions seem to be approximately the same. This section will be valuable for future comparison because it is tied into the railroad bridge elevation.

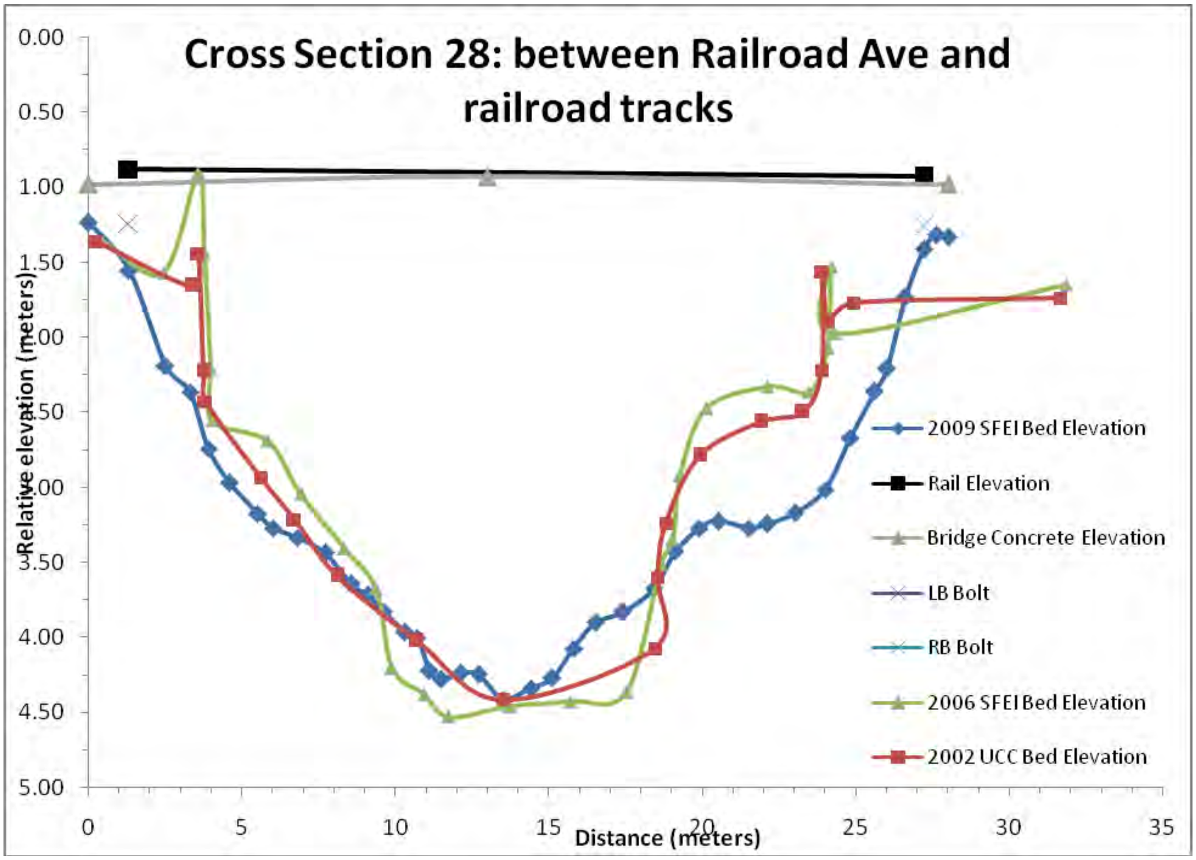


Figure 1a. Cross-section survey of Pinole Creek at the Railroad Bridge in August 2009.

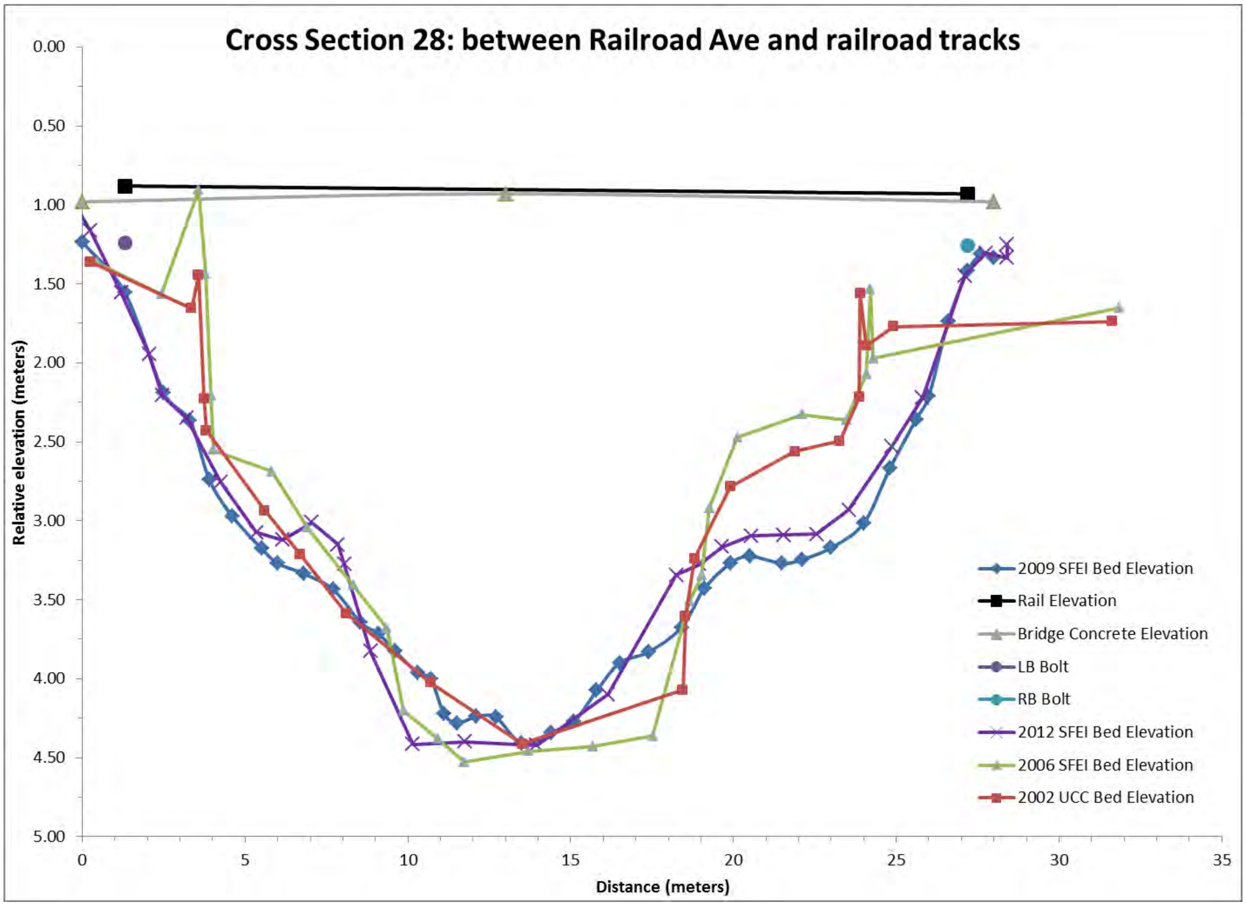


Figure 1b. Cross-section survey of Pinole Creek at the Railroad Bridge in August 2012.

The channel has remained similar in its dimensions between 2009 and 2012, with only minor modifications in its shape; we observed slight sediment deposition on the right and left bank marsh plain surfaces, and minor widening of the main channel, but the channel bed has remained at the same elevation. This cross section has the potential to significantly change in the future if during a large flood a debris jam occurred on any of the bridges that are present in this immediate reach.

Section 27 is located 3m upstream of the Bay Trail pedestrian bridge, upstream of Railroad Avenue. This section was surveyed both in 2002 and 2006. In 2009, we were able to locate the left bank rebar, but unable to locate the right bank rebar due to an accumulation of loose gravel from path maintenance activities. The channel at this location has a vertical left bank held up by the clay-rich tidal sediments, and a narrow floodplain surface inset from the paths on either side. This floodplain is dominated by two saline estuarine plant species (*Salicornia sp.*, *Jaumea sp.*) and upland grasses and weeds. The channel has experienced some changes since 2002; both the left and right bank floodplain surfaces have aggraded approximately 10 to 20 cm. Between 2002 and 2006, the bed incised approximately 40 cm, likely during the New Year's Eve 2005 flood event. Since 2006, the bed has aggraded approximately 10 cm. And the right bank path has changed significantly since 2002, due to path maintenance and installation of the Bay Trail pedestrian bridge.

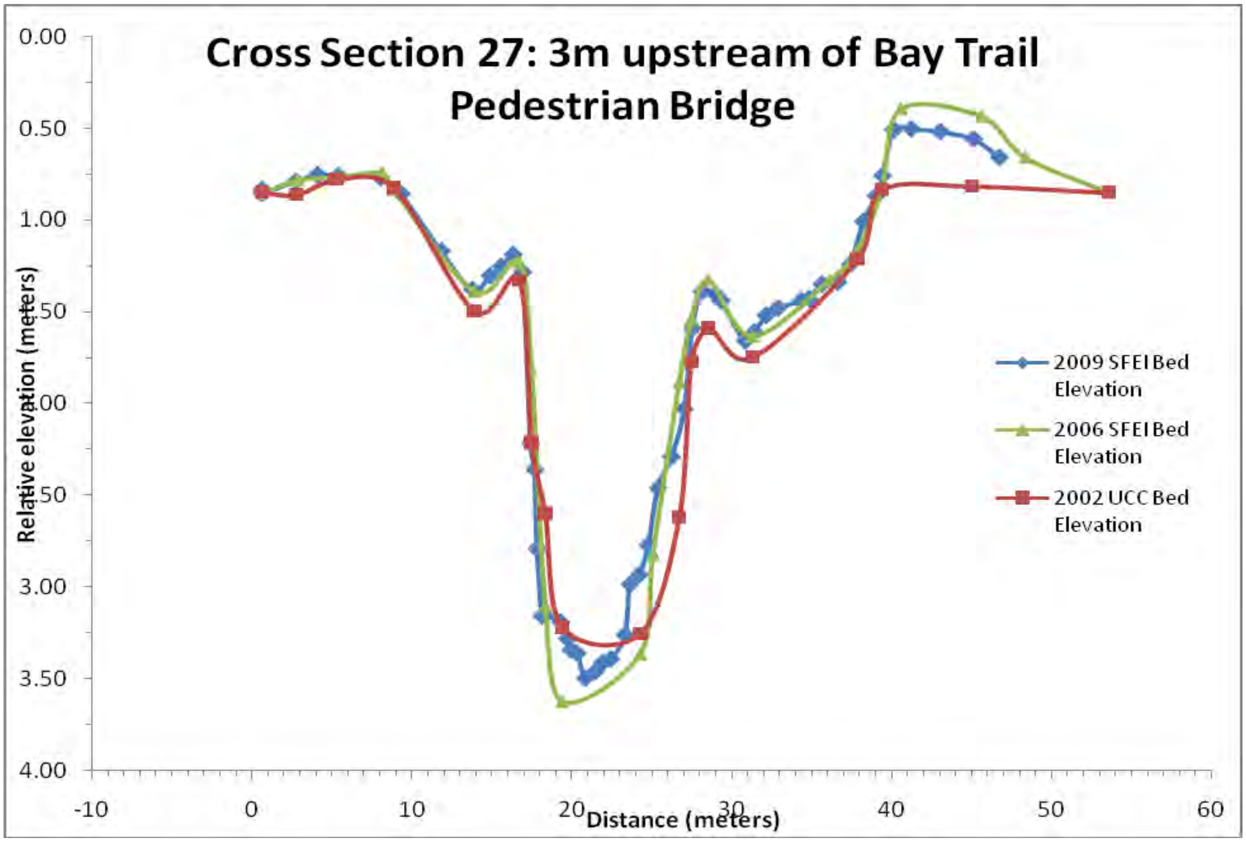


Figure 2a. Cross-section survey of Pinole Creek at the pedestrian bridge in August 2009.

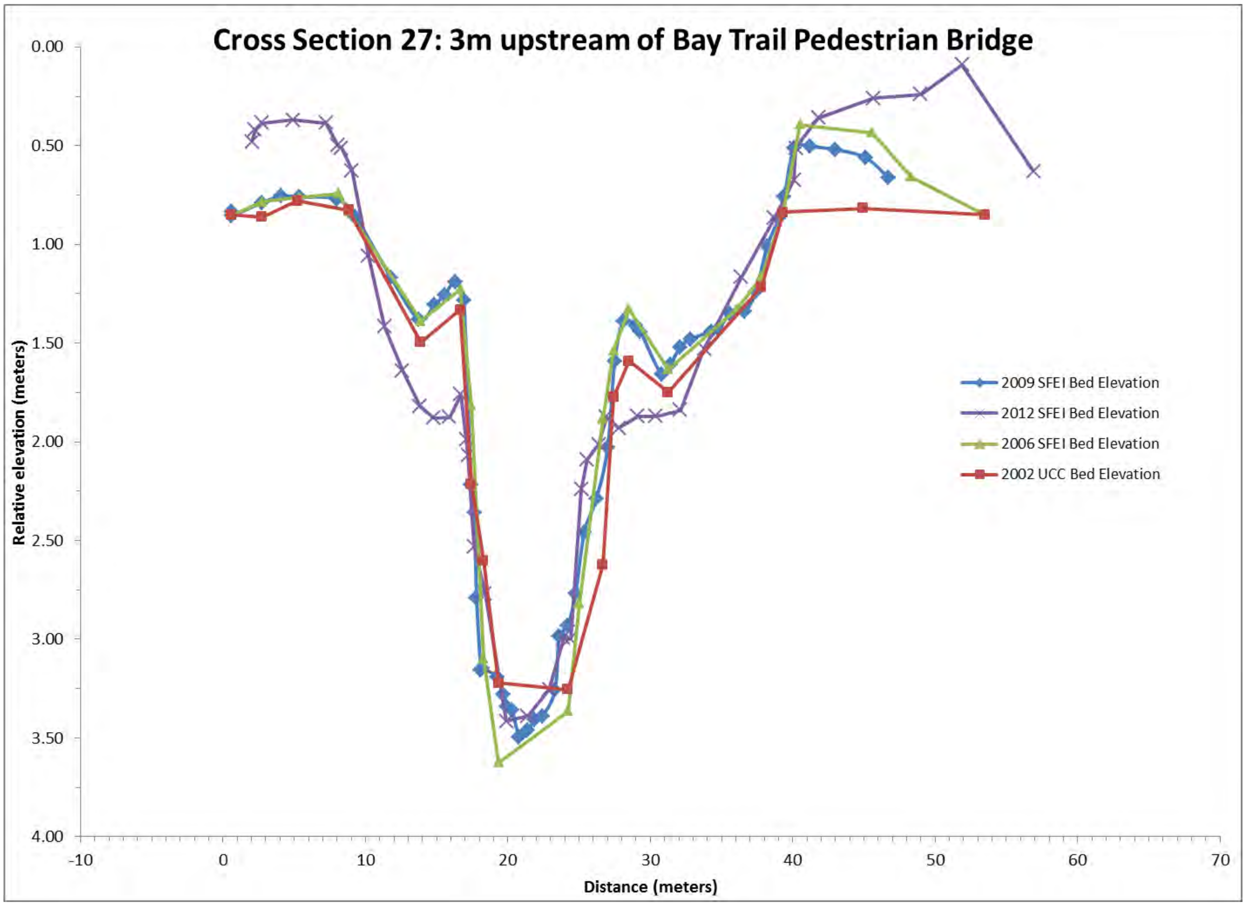


Figure 2b. Cross-section survey of Pinole Creek at the pedestrian bridge in August 2012.

Since 2009, the active channel dimensions have remained nearly the same at this cross section, with only minor deposition of sediment on the bed (8 cm). The main difference in the section is the constructed lower marsh plain elevation on both the right and left banks, as well as the raising of the path elevations. This section does have the ability to incise or aggrade during large flood events, however the post-restoration lower floodplain surface provides the channel with greater capacity, and allows flood water to spill onto the surface, reducing shear stress on the bed, thus increasing stability of the channel geometry.

Section 26 is located just downstream of Orleans Drive, and is the furthest upstream of the three cross sections. This section was not surveyed in 2006. Although we were unable to locate either rebar monument in 2009, based upon the field notes, we were within 1 m of the previous section location. The channel has a fairly flat-bottomed bed, vertical banks, and a floodplain surface that is inset from the paths. This floodplain surface is dominated by upland grass and weed species. The channel in this location has not changed significantly since 2002; overall it appears that the bed elevation has not changed. In addition, the right bank floodplain surface shows minor aggradation (<10 cm), while the data quality on the right bank floodplain limits our ability to quantify any change.

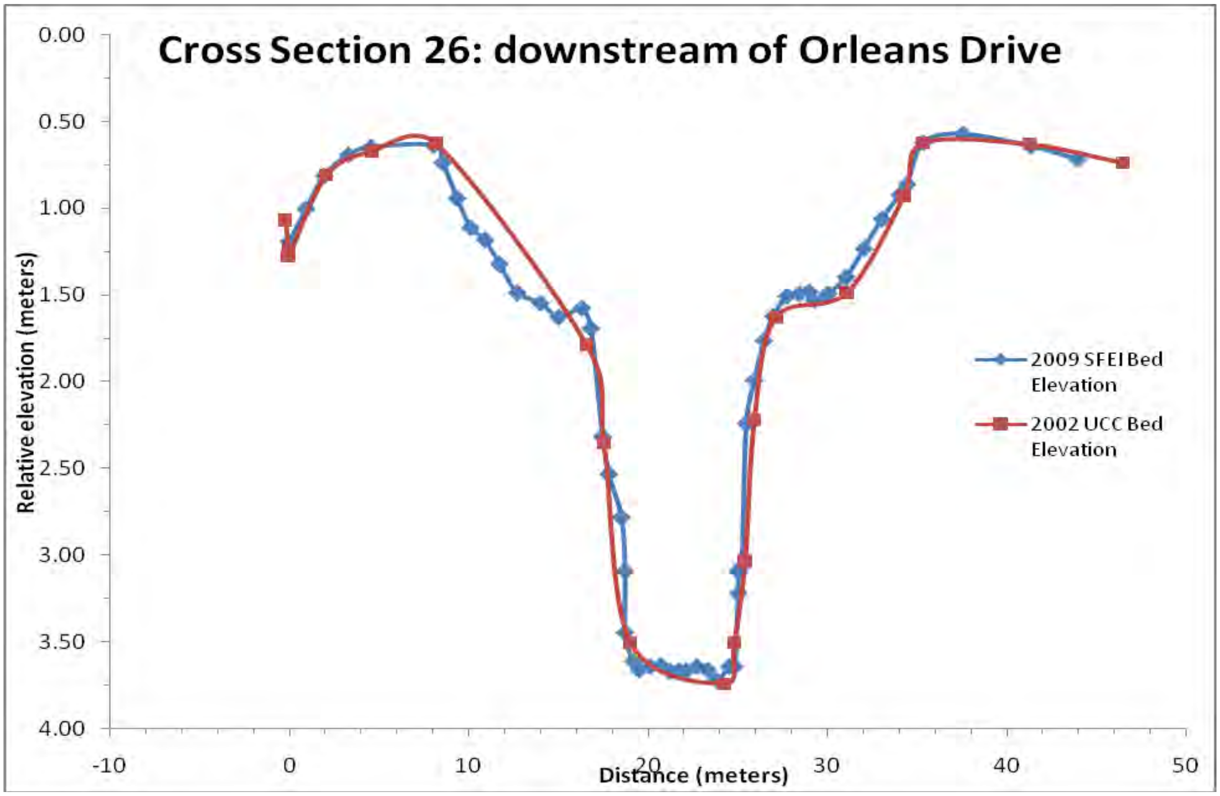


Figure 3a. Cross-section survey of Pinole Creek at Orleans Drive in August 2009.

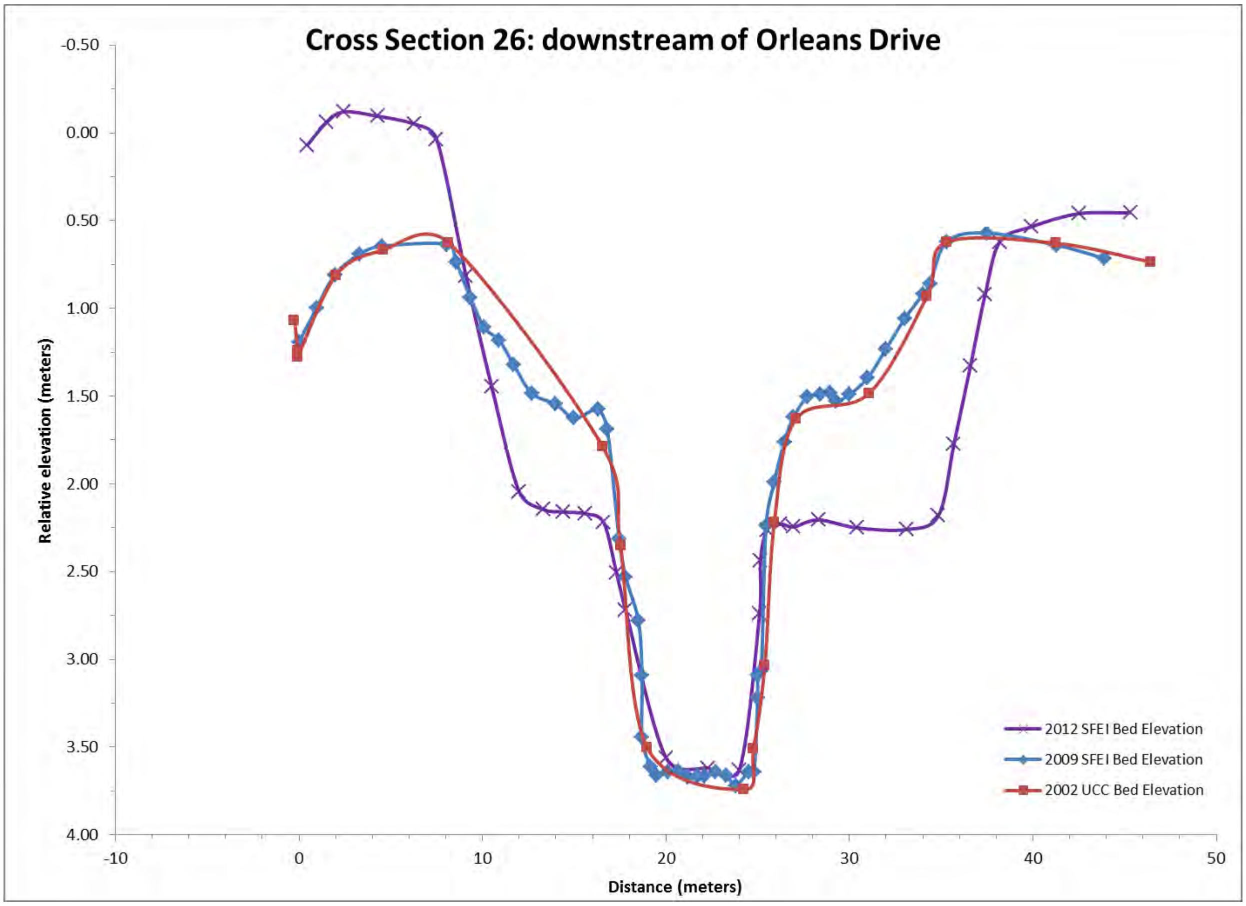


Figure 3b. Cross-section survey of Pinole Creek at Orleans Drive in August 2012.

In 2012, we observed that the active channel dimensions have remained the same, with no bed elevation change. The constructed lower marsh plain elevation is very distinct as a result of the restoration work, as is the extra flood protection on the left bank because the path was raised during the restoration. Similarly to the previous cross section, the lower post-restoration floodplain surface has increased capacity and increased stability of the active channel during larger flood events.

Photo Documentation

In addition to the measurements and data collected as described earlier, photo documentation of the site during data collection in 2009 and 2012 can assist in visualizing the physical and vegetative changes that have occurred. Figures 4 through 13 below show many different perspectives of Pinole Creek and Chelsea Marsh. Changes associated with the restoration primarily affected the floodplain (Figures 4 through 7). Prior to restoration, the floodplain was at a higher elevation, and was dominated by upland grass and weed species. Post-restoration, the elevation is lower, allowing tide water to inundate the surface more regularly, thus changing the vegetation community to one dominated by more saline-tolerant species. The CRAM assessments for the reach near Orleans Street (Pinole Creek #3) scored lower than the other two assessments, primarily due to the Biotic Structure; Figure 8 shows areas of barren ground and mowed vegetation on the right bank floodplain surface that contributed to these lower scores. Figures 9 and 10 show the Chelsea Marsh area, and the lack of change that has occurred between 2009 and 2012. Additional photos taken after the marsh restoration occurs would highlight the significant changes that will likely take place. Figures 11 through 13 document the pre- and post-restoration conditions at each cross section location. For each location, the low flow channel geometry has not significantly changed.

Figure 4. Pinole Creek #1 Assessment Area, looking downstream. 2009 condition on the left, with mowed upland grasses and weeds; 2012 condition on the right, dominated by tidal marsh species.

Figure 5. Pinole Creek #2 Assessment Area, looking upstream. 2009 condition on the left; 2012 condition on the right. Notice the change in plant community that has occurred, particularly on the left bank (right side of the photograph).

Figure 6. Pinole Creek #3 Assessment Area, looking downstream. 2009 condition on the left; 2012 condition on the right.

Figure 7. Pinole Creek #3 Assessment Area, looking at the left bank. 2009 condition on the left; 2012 condition on the right. Notice the increased amount and complexity of vegetation on the floodplain surface, the planted trees along the edge of the path, and the very similar condition of the channel bank.

Figure 8. Pinole Creek #3 Assessment Area, looking upstream. Note the barren (foreground) and mowed (background) condition of the floodplain surface.

Figure 9. Chelsea Marsh #1 Assessment Area, looking east. 2009 condition on the left; 2012 condition on the right. Note the unchanged character of the upland area.

Figure 10. Chelsea March #2 Assessment Area, looking east. 2009 condition on the left; 2012 condition on the right. Note the unchanged character of the tidal channel.

Figure 11. Channel cross section at Orleans Drive, looking at the right bank. 2009 condition on the left; 2012 condition on the right.

Figure 12. Channel cross section at Pedestrian bridge, looking at the right bank. 2009 condition on the left; 2012 condition on the right.

Figure 13. Channel cross section at the Railroad bridge, looking at the right bank. 2009 condition on the left; 2012 condition on the right.

Observation Summary

The goal of this project was to collect pre- and post-restoration data on Pinole Creek and Chelsea Marsh, to allow for quantification of the benefits of creek restoration, specifically water quality and habitat improvements. Secondarily, the project also wanted to assess the benefits of restoration on flood protection, wildlife enhancement, and recreational uses. To achieve this goal, multiple types of data were collected that would illustrate the pre- and post-restoration conditions. We find:

1) Water quality samples largely reflect the tidal cycle at the time of sampling. A longer time series of water quality would be needed to better describe the changes in water quality characteristics.

2) The evaluation of benthic invertebrates before and after the restoration did not show any statistically significant changes in abundance or species diversity. Although the presence of some species may suggest that the restoration did have positive benefits upon the creek in that reach.

3) Overall the scores for Physical Habitat assessments in 2012 were higher than in 2009, suggesting an overall improvement in habitat quality despite the score for some components decreasing slightly.

4) The CRAM assessments indicate that two of the three assessment areas statistically increased the condition, while the third assessment increased its overall condition score, but not at a statistically-relevant level. For the three Assessment Areas, every Attribute score either

remained the same or increased its score, with the lone exception of the Biotic Structure Attribute for AA #3.

5) Channel cross sections show that at none of the three locations has the channel significantly incised or aggraded since pre-restoration. The furthest downstream section, at the Railroad bridge, is the only section to show slight changes in channel width, but these changes have caused essentially no change in cross sectional area. In other words, areas of widening have been counter-balanced on the opposite bank by deposition and extension of the floodplain surface. The largest change observed is lowering of the floodplain elevation.

6) Photo documentation highlights the changes in the vegetation community associated with lowering the elevation of the floodplain surface. Vegetation changed from primarily upland grasses and weeds to a community dominated by saline-tolerant species.

7) While data on flood protection, wildlife enhancement, and recreational uses was not collected here, we do anecdotally suggest that flood protection has likely improved due to the additional channel capacity created by lowering the floodplain elevation and by constructing the floodwalls. More wildlife likely uses the channel now that the vegetation is more dense and complex, adding structure and cover that was not previously provided by the creek. And while in the field collecting data, field staff continually observed many people using the paths along both sides of the creek for walking, running, biking, and nature-watching.

8) While monitoring associated with this project is complete, this suite of data will prove useful for stakeholders that wish to continue monitoring the project into the future as it matures and evolves.

Appendix 3 – PCD 2012 Monitoring Report

2012 ANNUAL MONITORING REPORT
PINOLE CREEK DEMONSTRATION RESTORATION PROJECT

PINOLE, CA

RWQCB Site Number: 02-07-C0944
ACOE File Number: 2007-00831S

Prepared for: City of Pinole
2131 Pear St.
Pinole, CA 94564

Prepared by: Restoration Design Group
2612 Eighth Street, Suite B
Berkeley, California 94710

October 2012

Contents

1. Introduction

This report summarizes the results from the second year of monitoring the vegetation, channel morphology, and channel stability of the Pinole Creek Demonstration Project in Pinole, California. The Pinole Creek Demonstration Project was completed in the fall of 2010.

Monitoring for the Pinole Creek Demonstration Project is compliant with the City of Pinole's permits issued by the Regional Water Quality Control Board (Site No. 02-07-C0944) and the Army Corps of Engineers (ACOE File No. 2007-00831S). The regulatory requirements concerning monitoring are included in the Appendix.

2. Monitoring Goals and Objectives

The primary ecological goal of the Pinole Creek Demonstration Project was to improve riparian habitat in the tidal reach of Pinole Creek. The project improved riparian habitat by expanding the tidal marsh plain, reestablishing native tidal marsh vegetation and planting native riparian plants along 1,000 feet of the Pinole Creek flood control channel.

To evaluate success in meeting project goals, monitoring focuses on components:

- **Channel Morphology and Stability.** Monitor topographic changes at select cross-sections in the main stem of the channel. Results are supported by photo-monitoring.
- **Vegetation.** Monitor restoration vegetation to assess the success of marsh plain and riparian habitat establishment. Results are supported by photo-monitoring.

In order to carry out the monitoring plan, channel morphology and vegetation will be monitored for 5-10 years to identify changes. Not all changes are considered detrimental; considerable reconfiguration of physical features may be expected. As long as they do not adversely affect conveyance, bank stability, structural integrity, or habitat quality, intervention may not be required. Evolution of the physical features is expected to occur following construction.

3. Monitoring Methods

Channel Morphology and Stability

Annual surveys for a minimum of 5 years at three cross sections and fixed photo-monitoring will assess channel morphology and stability (see RWQCB Conditions for details on photo-monitoring). Cross-section locations extend from the floodwalls through the channel.

The channel and designated project limit areas have been and will continue to be examined for any problems and areas of excessive erosion. The inspections include visual examination of field conditions, photos, and topographic surveys in order to determine any trends.

The topographic cross sections have been compared to previous surveys in order to assess changes and make recommendations, if necessary. The key concerns are incision or deposition in the channel to a degree that could impair channel stability or habitat quality. If necessary, the report will make recommendations to rectify any problems in consultation with the City of Pinole and appropriate agencies.

Vegetation Monitoring

The vegetation planting component is a key element of the project as it is anticipated to provide habitat value in the context of creek and wetland restoration. The monitoring program is designed to collect the data necessary to determine if success is being achieved at all stages of plant growth and determine if adjustments are necessary.

The Pinole Creek Demonstration Project created tidally-influenced floodplain. This area is self-sowing. The banks of the flood channel above the tidal limits were planted with container plants.

The initial 5-year establishment period will involve intensive efforts to establish native plantings and to have native plantings out-compete undesirable invasive non-natives. Monitoring will be conducted annually for 5 years.

The performance standard for flood channel bank riparian areas is to achieve a riparian canopy of diverse riparian species, which functions with the stream channel to provide shade, bank stability, and a food source for aquatic organisms. Quantitatively, this is expressed in the table below.

Element	**Performance Criteria**	**Year(s)**
Riparian Vegetation	65% survival of container plants (by species)	1-5

RDG will monitor a sample of the container plants (trees and shrubs) that corresponds with the channel stability transects within the project.

The performance standard for tidal marsh plain is to achieve a vegetative community that is similar to that of the adjacent tidal marsh plains that it is designed to mimic (pickleweed dominated with saltgrass, jaumea, or alkali heath).

Element	**Performance Criteria**	**Year(s)**
Marsh Vegetation Cover	10% cover	1
Marsh Vegetation Cover	Positive progress toward 50% cover	2-5
Marsh Vegetation Cover	50% cover	5
Marsh Vegetation Natives	75% of cover native	1-5

4. Monitoring Results and Discussion

Channel Monitoring

2011 Discussion

The San Francisco Estuary Institute performed the pre-project cross sections in 2009. Project construction necessarily obliterated the benchmarks. The plotting of the Urban Creek Council cross-sections against the post-project (2011 and 2012) cross sections is estimated (see

appendix).

The cross sections demonstrate the impact of project construction on the flood control channel. The 2011 cross sections show expanded tidal marsh plain in XS-2 and XS-3. XS-1 is downstream of the project area. The 2011 cross section is larger (deeper) than the 2009 cross section. This could be due to a number of factors including waves of sediment from previous storms moving out to the bay or readjusting, increased channel size due to the increased tidal prism created by the upstream project, or a slight change in the location of the cross section. Project monitoring will continue to observe this cross section for adjustments.

The cross sections and site inspections revealed no channel morphology issues of concern. RDG does not recommend any adjustments at this time.

2012 Discussion
In 2012, both SFEI and RDG/Friends of Pinole Creek Watershed surveyed the three cross sections. Both 2012 surveys and the 2011 RDG/FOPCW surveys are shown plotted with the 2009 pre-project surveys completed by SFEI. The 2012 cross sections show that the project is stable. The 2012 cross sections show that XS-1 (just downstream of the project) is a similar depth as the 2009 conditions. In 2011, the survey suggested that the channel had deepened. While the hypotheses above relating to waves of sediment moving through the system or increased channel size due to increase tidal prism may still be true, the 2011 survey may also suffer from surveyor error. The other three surveys suggest that the cross section is stable. Project monitoring will continue to observe this cross section for adjustments.

The cross sections and site inspections revealed no channel morphology issues of concern. RDG does not recommend any adjustments at this time.

Note: In 2011, the US Army Corps of Engineers placed a survey marker on the left bank abutment of the pedestrian bridge. This allowed RDG to tie the surveys into actual elevations (shown in figures in the Appendix).

Vegetation Monitoring

2011 Discussion
Riparian vegetation monitoring was conducted in July 2011. It is unknown whether the plant species and quantities specified on the construction drawings were actually planted at the site. There is no immediate post-project survey of planting locations. While the number of plants observed compared to the construction drawings indicates an average survival rate of 77%, in fact there were very few evident plant mortalities, suggesting that the survival rate exceeds the performance criteria for this year. In subsequent years, the number of plants observed will be compared to the number of plants observed in the year prior, giving a more accurate assessment of survival of container plants.

The table below indicates survival by species of container plants in the channel bank riparian areas and upland zones along the path.

Table 1. Survival of Container Plants (Trees and Shrubs), Year One

Tree & Shrub Species		Specified	# found	% Survival July 2011
Aesculus californica	Buckeye	3	2	*67%*
Heteromeles arbutifolia	Toyon	8	3	*38%*
Mimulus aurantiacus	Monkeyflower	3	2	*67%*
Muehlenbergia rigens	Deer Grass	5	8	*160%*
Populus fremontii	Fremont Poplar	4	4	*100%*
Quercus agrifolia	Coast Live Oak	11	8	*73%*
Rhamnus californica	Coffeeberry	28	17	*61%*
Rosa californica	California Wild Rose	28	23	*82%*
Salix laevigata, lasiolepis, lasiandra	Willow sp.	12	6	*50%*
TOTAL # OF INDIV.		**102**	**73**	*77%*

Bare soil in the channel bank riparian area was less than 5%. The area was seeded with native species and many of those low-growing perennials and grasses are well established.

Monitoring results of the marsh vegetation cover in the tidal floodplain exceeded expectations with a 38% vegetative cover observed in July 2011. Results are indicated in the table below.

Table 2. Native Vegetation Cover in the Tidal Marsh Plain

% Vegetation Cover	Midpoint	Observations	Product
1-5%	2.5	2	5
5-25%	15	3	45
26-50%	37.5	12	450
51-75%	62.5		0
76-95%	85	2	170
96-100%	97.5	1	97.5
Average Cover		**20**	**38%**

Non-native species in the tidal marsh plain accounted for less than 5% of the vegetation cover. Only one segment contained more than 5% of invasive species cover and most were closer to 1%. The one segment with 75% of Birdfoot trefoil is right at Orleans Street where there is a storm drain outfall. Birdfoot trefoil is a nitrogen-fixing pioneer plant with seedlings that grow slowly and do not compete well with other vegetation. Additionally, there are a few Cocklebur plants upstream of the tidal inundation.

An informal December follow-up revealed that there is generally more vegetative cover than in July indicating continued progress toward full cover. The native species composition in December is similar to that found nearby in older marsh tidal plains: pickleweed, cordgrass, saltgrass, and grendelia.

Based on the results above, RDG does not recommend adding or modifying plantings this year.

However, during its December 2011 follow up, RDG noted that some of the smaller upland plantings between the pathway and Pinole Creek appear to have been recently mowed. RDG recommends working with the City, flood control district, and Friends of Pinole Creek Watershed to ensure that mowing in the restoration area is conducted properly and does not impair growth of restoration plantings.

2012 Discussion

Riparian vegetation monitoring was conducted in July 2012. Container plants monitoring indicates that there has some mortality during the previous year. The tree species performed well, with a net increase in numbers. This increase is likely due to missed observations in 2011. The shrub species did particularly poor this past year. This is most likely caused by mowing the shoulder of the trail. There is a potential that irrigation schedules and competition from weedy species also played a significant role as well. It is recommended that mulch be added around the plants to help mark the plant locations as well as improve moisture retention and weed suppression. Additional container plants should also be installed to augment the plants remaining. The results of the perennial and grass species monitoring also shows poor results, although the low stature of these species makes detection at the time of survey problematic. The number of observed plants is undoubtedly an underestimate.

Restoration Design Group and Friends of Pinole Creek Watershed are currently devising a plan to add container plants for the deficient species during the winter of 2013.

The following table documents the survival by species of container plants in the channel bank riparian areas and upland zones along the path.

Table 1. Survival of Container Plants, Year Two

Tree Species		Specified	July 2011 #	July 2011 % Survival	July 2012 #	July 2012 % Survival
Aesculus californica	Buckeye	3	2	*67%*	3	*100%*
Populus fremontii	Fremont Poplar	4	4	*100%*	4	*100%*
Quercus agrifolia	Coast Live Oak	11	8	*73%*	11	*100%*
Salix laevigata, lasiolepis, lasiandra	Willow sp.	12	6	*50%*	8	*67%*
TOTAL # OF INDIV.		**30**	**20**	*67%*	**26**	*87%*

Shrub Species		Specified	#	% Survival	#	% Survival
Artemisia californica	California Sagebrush	21	11	*52%*	0	*0%*
Baccharis pilularis	Coyote Brush	3	3	*100%*	3	*100%*
Heteromeles arbutifolia	Toyon	8	3	*38%*	3	*38%*
Mimulus aurantiacus	Monkeyflower	3	2	*67%*	0	*0%*
Rhamnus californica	Coffeeberry	28	17	*61%*	10	*36%*
Rosa californica	California Wild Rose	28	23	*82%*	6	*21%*
TOTAL # OF INDIV.		**91**	**59**	*65%*	**22**	*24%*

Perennial & Grass Species		Specified	#	% Survival	#	% Survival
Anaphalis margaritacea	Pearly Everlasting	5	5	*100%*	0	*0%*
Baccharis douglasii	Salt Marsh Baccharis	7	0	*0%*	0	*0%*
Carex praegracilis	Meadow Sedge	75	5	*7%*	3	*4%*
Juncus arcticus	Wire Rush	40	0	*0%*	0	*0%*
Muehlenbergia rigens	Deer Grass	5	8	*160%*	8	*160%*
Leymus triticoides	Creeping Wildrye*	335				
Nassella Pulchra	Purple Needlegrass	30	30	*100%*	18	*60%*
Scrophularia californica	California Bee Plant	21	14	*67%*	0	*0%*
TOTAL # OF INDIV.		**183**	**62**	*34%*	**29**	*16%*

* Also in seed mix. Prolific on-site. 2012 estimate exceeds amount specified.

Bare soil in the channel bank riparian area was less than 5%. The area was seeded with native species and many of those low-growing perennials and grasses are well established.

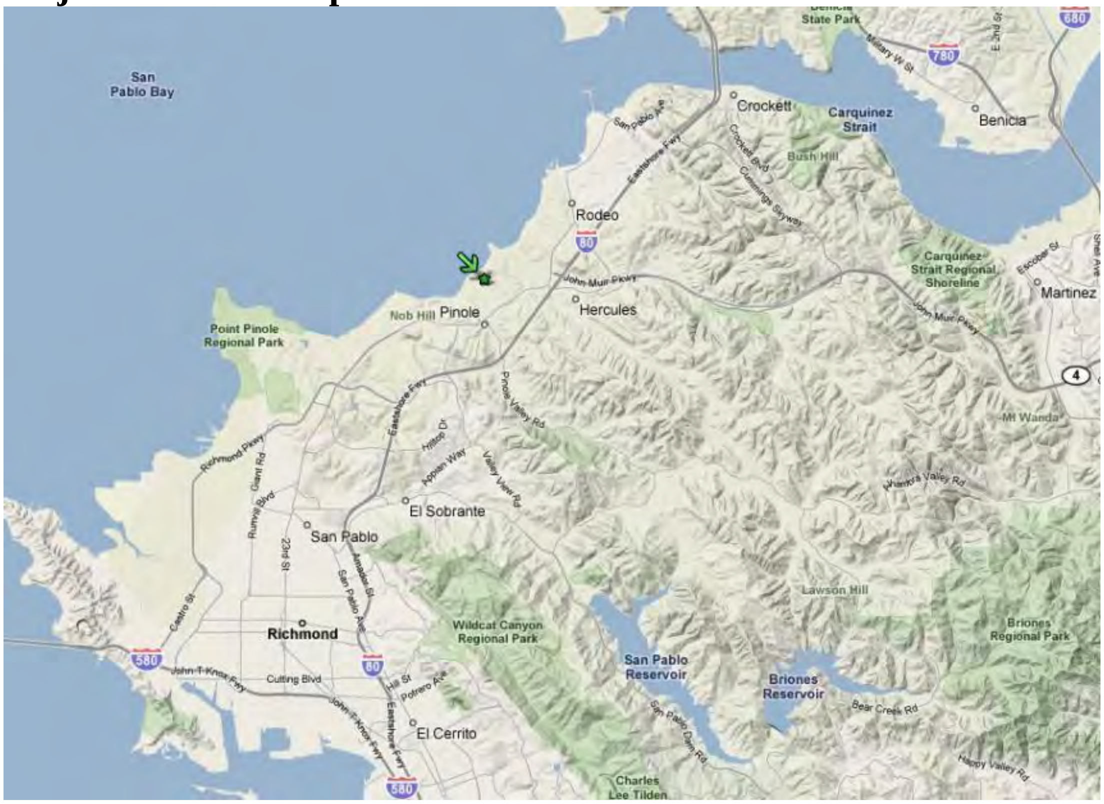
Monitoring results of the marsh vegetation cover in the tidal floodplain exceeded expectations with a less than 20% bare soil observed in July 2012 or greater than 80% cover. That's up from 38% cover in the first year and greater than the 50% cover required after 5 years. The native species composition is similar to that found nearby in older marsh tidal plains: pickleweed, cordgrass, saltgrass, and grendelia.

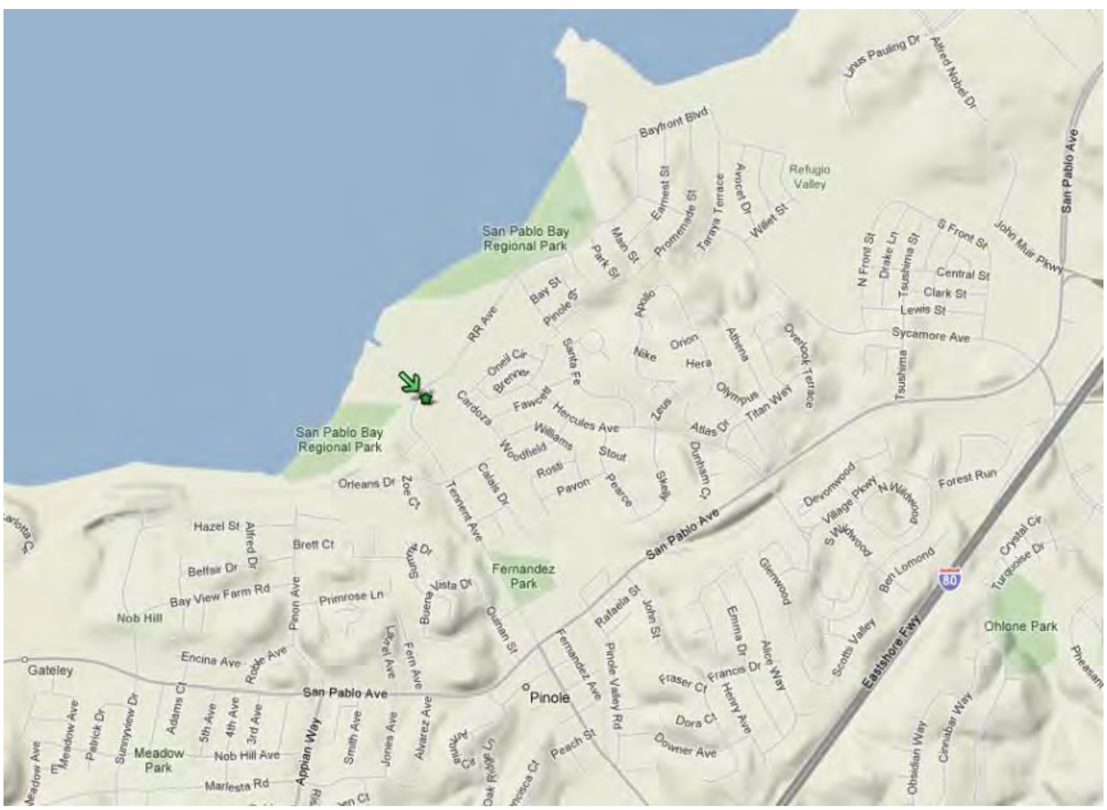
Native plants covered 60% of the marsh plain demonstrating progress toward 75% native cover at the end of 5 years. In 2012, non-native species in the tidal marsh plain accounted for 25% of the vegetation cover. Almost all of this cover was lotus plant. This is up from 5% in 2011.

Based on the results above, RDG does not recommend adding or modifying plantings this year. It is hoped, as native cover becomes more established, that it will out-compete the lotus.

Appendix

Project Location Map



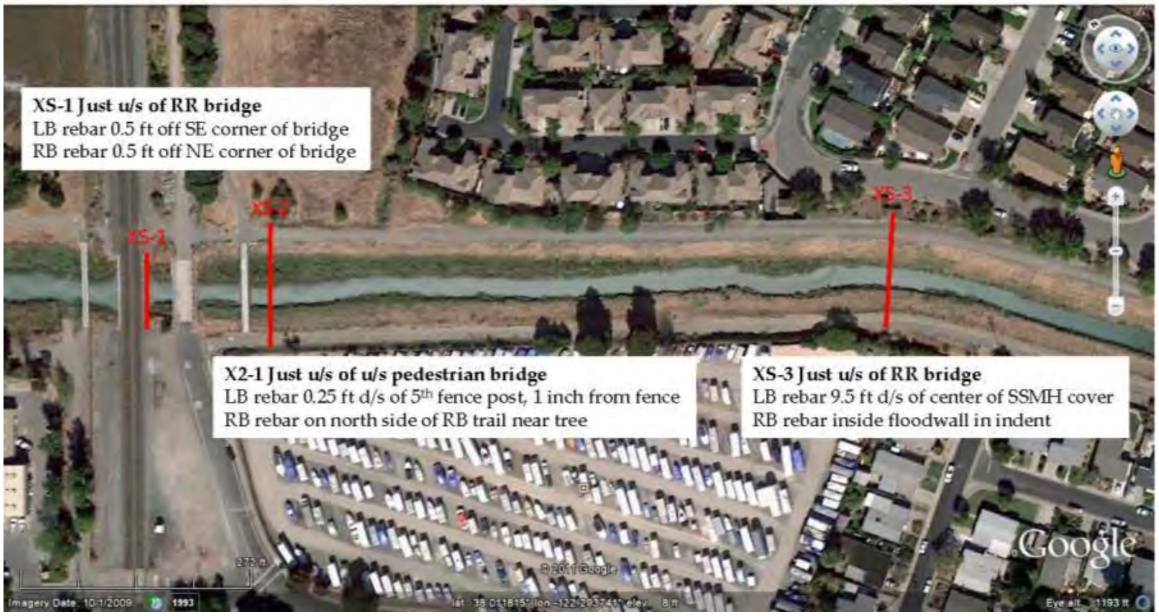


Pinole Creek demonstration project vicinity maps (Pinole, CA)

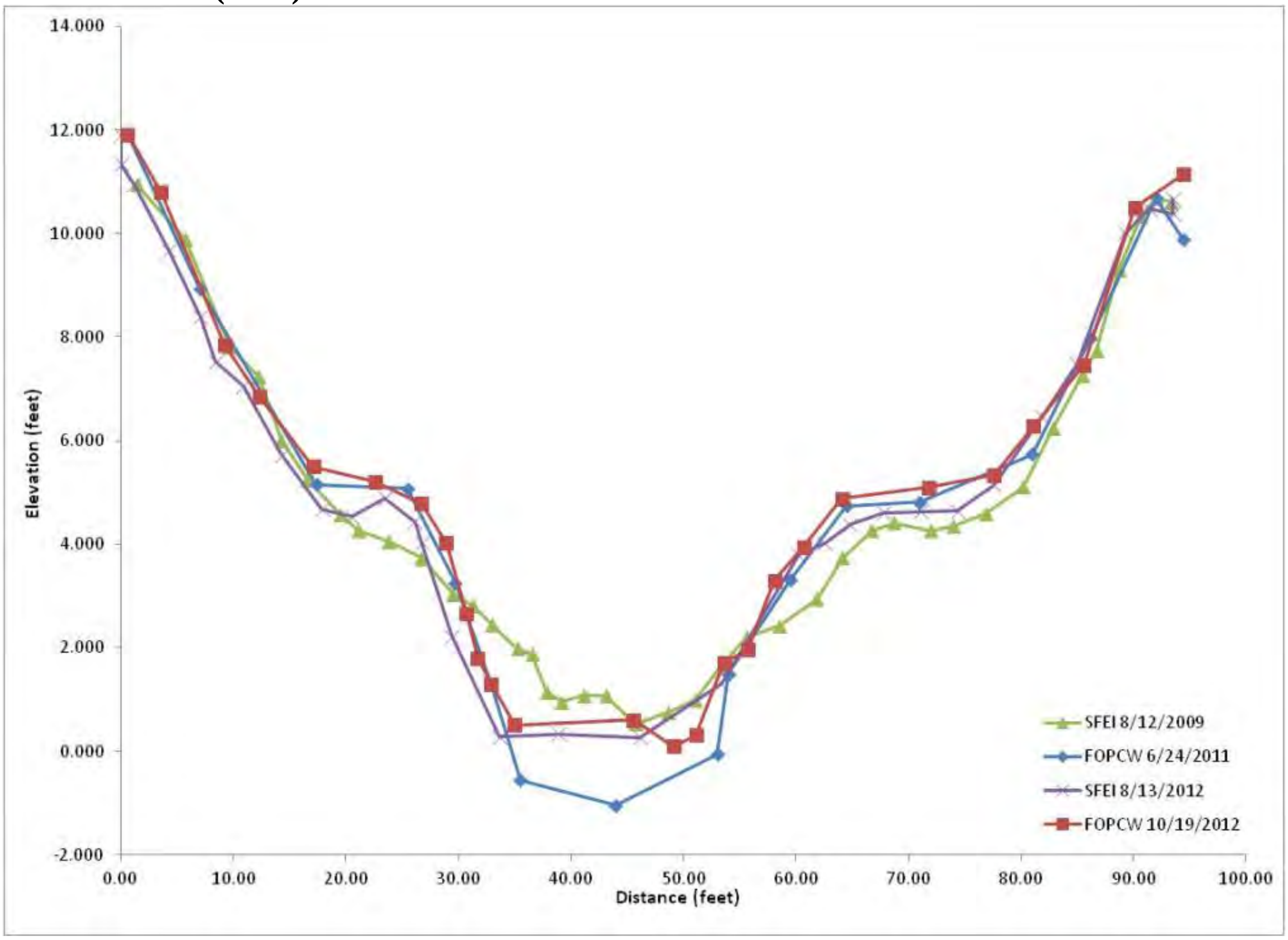
2010 Google Aerial Photo of Pinole Creek at the San Pablo Bay

Transect Locations

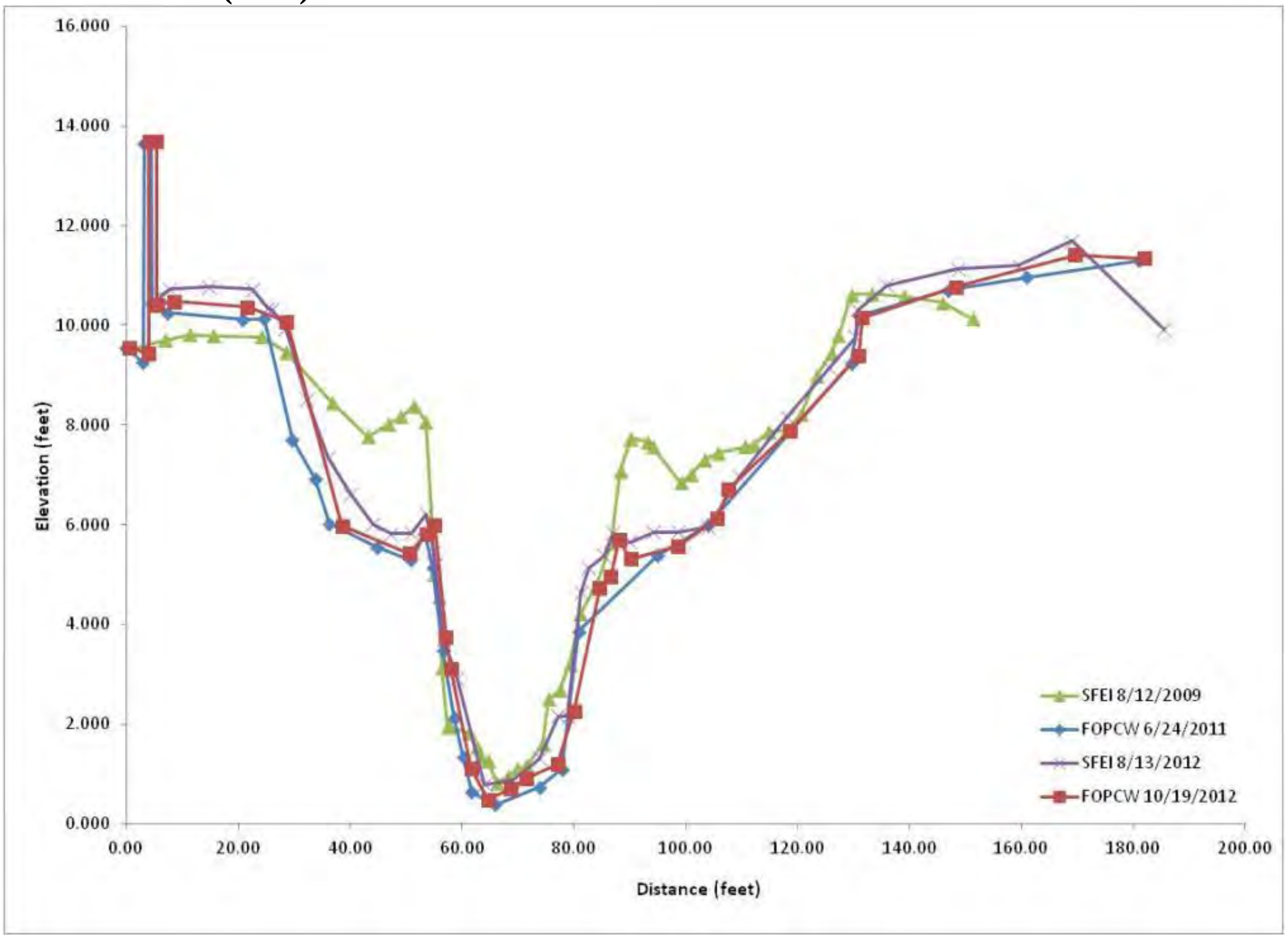
Pinole Creek Monitoring – XS Map



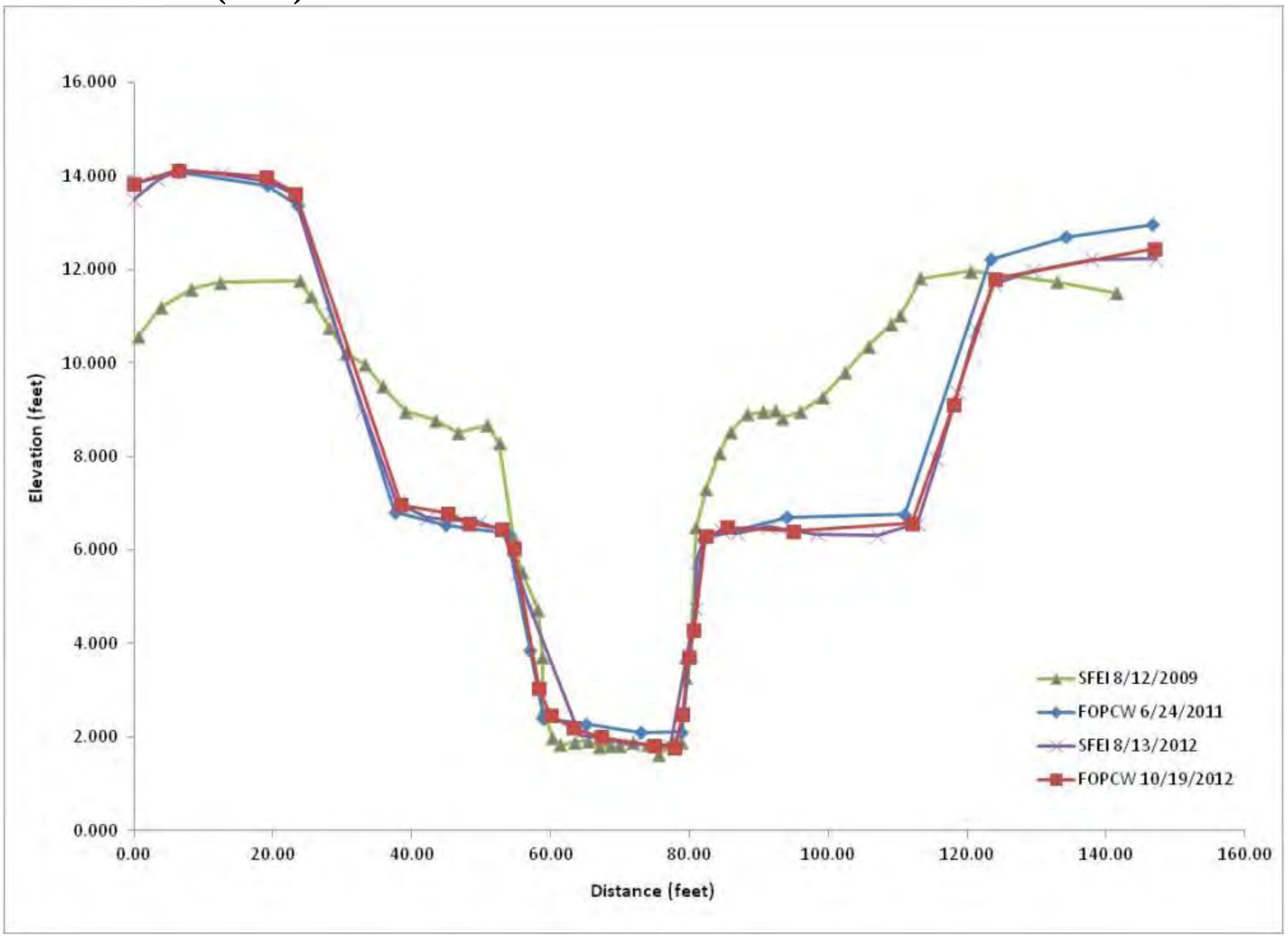
Cross Section 1 (XS-1)



Cross Section 2 (XS-2)



Cross Section 3 (XS-3)



Pinole Creek Monitoring Photopoints

12 locations, 3 photos at each location (upstream, downstream, across stream) = 36 photopoints

PHOTOPOINT 1

Photopoint 1 (2010) upstream

Photopoint 1 (2011) right bank, upstream, downstream (toward bridge), left bank

Photopoint 1 (2012) right bank, upstream, downstream (toward bridge), left bank

PHOTOPOINT 2

Photopoint 2 (2010) upstream

Photopoint 2 (2011) upstream, downstream, across stream

Photopoint 2 (2012) upstream, downstream, across stream

PHOTOPOINT 3

Photopoint 3 (2010) downstream

Photopoint 3 (2011) upstream, downstream, across stream



Photopoint 3 (2012) upstream, downstream, across stream

PHOTOPOINT 4

Photopoint 4 (2010) upstream

Photopoint 4 (2011) upstream, downstream, across stream

Photopoint 4 (2012) upstream, downstream, across stream

PHOTOPOINT 5

Photopoint 5 (2010) upstream

Photopoint 5 (2011) upstream, downstream, across stream

Photopoint 5 (2012) upstream, downstream, across stream

PHOTOPOINT 6

Photopoint 6 (2010) downstream

Photopoint 6 (2011) upstream, downstream, across stream

Photopoint 6 (2012) upstream, downstream, across stream

PHOTOPOINT 7

Photopoint 7 (2010) upstream

Photopoint 7 (2011) upstream, downstream, across stream

Photopoint 7 (2012) upstream, downstream, across stream

PHOTOPOINT 8

Photopoint 8 (2010) downstream



Photopoint 8 (2011) upstream, downstream, across stream



Photopoint 8 (2012) upstream, downstream, across stream

PHOTOPOINT 9

Photopoint 9 (2010) upstream

Photopoint 9 (2011) upstream, downstream, across stream

Photopoint 9 (2012) upstream, downstream, across stream

PHOTOPOINT 10

Photopoint 10 (2010) upstream

Photopoint 10 (2011) upstream, downstream, across stream

Photopoint 10 (2012) upstream, downstream, across stream

PHOTOPOINT 11

Photopoint 11 (2010) across stream

Photopoint 11 (2011) upstream, downstream, across stream

Photopoint 11 (2012) upstream, downstream, across stream

PHOTOPOINT 12

Photopoint 12 (2010) upstream

Photopoint 12 (2011) upstream, downstream, across stream

Photopoint 12 (2012) upstream, downstream, across stream

Regulatory Requirements: RWQCB Mitigation and Monitoring Conditions

Monitoring will occur yearly for a minimum of 5 years and a maximum of 10 years year is defined as October 1 to September 30 of each year.

To document channel and bank conditions, RDG shall establish a minimum of 16 photo-documentation points at the Project site. These photo-documentation points shall be selected to document channel and bank conditions immediately upstream and downstream of the Project site, as well as the Project reach. RDG shall prepare site maps with the photo-documentation points clearly marked. Prior to implementing the Project, RDG shall photographically document the condition of the Project site. Following implementation of the Project, RDG shall photographically document the immediate post-construction condition of the sites and submit a report to the Water Board including the pre-construction photographs, the post-construction photographs, and the map with the locations of the photo-documentation points. This report shall be submitted to the Water Board along with the as-built report per Condition 15.

Plantings in the project site shall be monitored and maintained for a minimum period of five years, until the performance criteria in the MMRP are achieved. Percent survival must be evaluated individually for each planted species. If these success criteria are not achieved, dead plants must be replaced in kind, unless RDG demonstrates that the site is not conducive to survival of a plant species, in which case alternate native riparian plant species may be used, with the concurrence of the Executive Officer of the Water Board. Replacement plantings must be made within one year of survival rates failing to meet the specified success criteria. Replacement plants shall be monitored for five years from the date of replanting. Replacement plants are subject to the same performance criteria as the initial plantings.

Annual reports shall be submitted to the Water Board by October 31 during each year of the initial five year monitoring period, summarizing each year's monitoring results, including the need for any remedial actions (e.g., re-planting, bank stabilization, additional excavation). The annual reports shall compare data to previous years and detail progress towards meeting final success criteria. At the end of year 5, a comprehensive final report shall be prepared that includes summaries of the monitoring data, representative photos, and maps. Annual reports and the comprehensive final report shall include photographs from the photo-documentation points specified in Condition 18. The final report shall document if the site meets the final success criteria of the MMRP. If the criteria are not met, the report shall identify measures to be undertaken, including extension of the monitoring period until the criteria are met. Monitoring reports shall be submitted by uploading them to the Wetland Tracker website at http://www.wetlandtracker.org/tracker/ba/list, via email, or via mail (see the address on the letterhead). To upload the reports, go to the above link, click on your project, click on Files & Links, and follow the steps. Success of the mitigation program shall be determined by Water Board staff.