Attachment 7. Technical Justification of Projects

This attachment provides the technical justification for the San Francisquito Creek Flood Protection Project's claimed physical benefits.

Project Overview

The project for which Proposition 1E funding is sought is entitled the San Francisquito Creek Flood Protection and Ecosystem Restoration Capital Improvement Project, Highway 101 to El Camino Real. The project proponent and Proposition 1E applicant is the San Francisquito Creek Joint Powers Authority.

The project consists of several project elements, collectively referred to as the Reach 2 project. The Reach 2 project builds upon Reach 1 project phases (partially funded by Round 1 Prop 1E) to provide comprehensive flood protection, ecosystem and recreational enhancements for the region.

The Reach 2 project will reduce local flood risks to homes, business and public facilities within the Cities of East Palo Alto, Menlo Park and Palo Alto. The project will provide significant benefits to the portion of the City of East Palo Alto west of Highway 101, which has been designated as a disadvantaged community (DAC) within the Bay Area IRWMP.

The project will increase the Creek's flow capacity from the Pope-Chaucer Bridge to Highway 101 by (1) creating an inlet to an expanded highway 101 bridge being built by Caltrans, (2) widening the channel in 4 locations, (3) Replacing the Newell Street Bridge, which represents a hydraulic constriction, and (4) Replacing the Pope-Chaucer Bridge, which represents a hydraulic constriction.

Benefits of the project include conveyance of creek flows up to the 50-year event, improved riparian habitat for special status species, and improved recreational opportunities for the community. Additional work needed to accommodate Reach 2 project construction includes completion of Reach 1 (construction start in 2013) and the replacement of the Highway 101 Bridge (construction start in 2014). Land acquisition needs for the project are limited to temporary and permanent easements without structures, but owned by private residents.

The Project elements are at various levels of design completion. The SFCJPA wishes to use State funding for the West Bayshore Inlet, the first constructible element within the project reach, which is at a 90% design level completion.

The total project cost for Reach 2 is $24.5M. The SFCJPA is requesting $3.5M in Prop 1E funding to accompany $21M in secured local funding to implement Reach 2.

Construction on the project is planned to begin in April or June 2014, depending on conditions set forth by the permitting agencies. Construction of the West Bayshore Inlet will be completed in one construction season. All construction activities will be completed by Fall 2016.

In November 2012, the voters of Santa Clara County approved the Safe Clean Water, which provides funding to improve flood and erosion protection for channels and creeks within the Santa Clara Valley Water District's (District) jurisdiction. As part of this program, local funding is provided for construction of the Reach 2 project.

Figure 7-1. Map of San Francisquito Creek Flood Protection Project Limits

Figure 7-2. Map of San Francisquito Creek Flood Protection Project Reaches

Summary of Benefits

The following physical benefits are expected from Project implementation.

Table 7-1. Summary of Quantifiable Physical Benefits

San Francisquito Creek Flood Protection Project Physical Benefits	
Flood Protection Benefits	• Flood protection for approximately 4,500 structures currently included in the 2 percent fluvial floodplain, including the portion of the City of East Palo Alto west of Highway 101, which has been designated as a DACwithin the Bay Area IRWMP. • .
Water Supply Benefits	• None
Water Quality Benefits	• Up to 6,630 feet of erosion control / repairs along reaches 2a through 2d. • Reduction in up to 1,700 cubic yards of sediment deposition per year.
Environmental Benefits	• Removal of approximately 234 cubic yards of concrete upstream of University Ave bridge (end of Manhattan Ave) • Reduction in average channel velocity for the 2 percent event by up to 52% (from 8.1 to 4.2 feet per second [ft/s])for improved fish passage
Recreation/Public Access Benefits	• New and / or enhanced sidewalks and bicycle lanes along nearly 400 feet of bridges.
Energy-Related Benefits	• None
Other Physical Benefits	• None

Note: Qualitative benefits are summarized in Attachment 8.

Each benefit is discussed in further detail below.

Relationship of Project to Other Projects Included in the Proposal

No other projects are included in this proposal. All benefits described are expected to accrue from the San Francisquito Creek Flood Protection Project.

Related Studies, Reports, and Projects

The benefits described in this section are based on a body of work developed to identify the potential benefits of the San Francisquito Creek Flood Protection Project, including related projects completed or under development in the watershed. The reports and studies completed that substantiate claimed project benefits include the following.

- **San Francisquito Creek General Investigation Study:** The San Francisquito Creek Feasibility Study is a congressionally authorized feasibility study conducted by the U.S. Army Corps of Engineers (Corps), with the San Francisquito Creek Joint Power Authority (JPA) as the local sponsor. This study will determine the feasibility of a federally funded project to reduce flood damages, restore ecosystems and create recreational opportunities within the San Francisquito Creek watershed. Many of the tasks being completed for the feasibility study are informing the planning of capital projects on which the JPA and its member agencies may begin construction ahead of final federal appropriations for the feasibility study. These capital projects will be considered elements of the preferred plan, and will be eligible for future federal credit against final construction costs of the preferred plan.

- **Reach 1 Project:** The San Francisquito Creek Flood Protection and Ecosystem Restoration Project, East Bayshore Road to San Francisco Bay, was initiated by the JPA to provide a limited flood damage reduction effort as an interim measure to the U.S. Army Corps of Engineers San Francisquito Creek General Investigation Study. The EIP project will complete design 2012. This project is supported by the District's Early Implementation Flood Protection Project (project number 26284002).

- **Caltrans Highway 101 Project:** The California Department of Transportation (Caltrans) is currently planning and designing a project to replace the U.S. Route 101 (and frontage roads) crossing over San Francisquito Creek to improve traffic flow. Caltrans will coordinate with the JPA so that the U.S. Route 101 bridge structure will match JPA improvements for the channel to provide flood protection, should a one-percent flow event occur at the same time as a high-tide event (JPA, 2011). Construction is scheduled to begin in 2013. The JPA will be responsible for designing and constructing the inlet from the creek at the upstream face of West Bayshore Road and the downstream face of East Bayshore Road.

- **Upstream of U.S. Highway 101 Project:** Since the fall of 2009, the JPA and the District have been analyzing capital improvements necessary to provide one-percent flood protection for the flood prone reach of San Francisquito Creek upstream of U.S. Highway 101. Creek capacity improvements being analyzed include bridge replacement, channel widening and naturalization, floodwall construction or enhancement, a bypass culvert, and an upstream detention facility. It is likely that a suite of these alternatives will be required to address the flooding problem.

- **South San Francisco Bay Shoreline Study:** The South San Francisco Bay Shoreline Study (Shoreline Study) is a congressionally-authorized study being performed by the District with the Corps and other local sponsors to identify and recommend, for Federal funding, one or more projects for flood damage reduction, ecosystem restoration and related purposes such as public access. The Shoreline Study will be funded through a partnership among the District, the Corps, and the Conservancy. The U.S. Fish and Wildlife Service, the State Department of Fish and Game and the City of San Jose are also involved in the planning process.

- **South Bay Salt Pond Restoration Project:** The South Bay Salt Pond Restoration Project (SBSP Project) is a currently active project encompassing approximately 15,100 acres of former salt ponds located around the edge of South San Francisco Bay. The SBSP Project is led by the California State Coastal Conservancy (Conservancy), the U.S. Fish and Wildlife, and the California Department of Fish and Game. The SBSP Project is the largest wetlands restoration project on the West Coast of the United States. The SBSP Project is intended to restore and enhance wetlands in South San Francisco Bay while providing for flood management and wildlife-oriented public access and recreation.

- **Bay Division Pipeline Reliability Upgrade Project:** The San Francisco Public Utilities Commission (SFPUC) is undertaking a water system improvements project to upgrade major distribution pipelines and bore a new tunnel under San Francisco Bay to carry HetchHetchy water to over 2.5 million residents in Alameda, Santa Clara, San Mateo, and San Francisco counties. The Bay Division Pipeline Reliability Upgrade Project is among the largest of the SFPUC Water System Improvement Program projects to seismically upgrade, repair, and replace the aging HetchHetchy water system. The pipeline will replace the current Bay Division Pipelines 1 and 2, between Fremont and Redwood City, and Bay Division Pipelines 3 and 4, through the South Bay and Silicon Valley. The pipeline is planned to begin at the Irvington Portal in Fremont, pass through Don Edwards San Francisco Bay National Wildlife Refuge (Refuge), and end at the Bay Peninsula, with a tunnel segment under San Francisco Bay beneath Menlo Park. The 5-mile-long portion of the proposed tunnel under San Francisco Bay and adjacent marshlands is referred to as the "Bay Tunnel" project. The project Notice of Preparation (NOP) was released in 2006 and construction is scheduled to be completed in 2015 (SFPUC, 2008).

- **Don Edwards San Francisco Bay National Wildlife Refuge Comprehensive Conservation Plan:** The U.S. Fish and Wildlife Service (USFWS) is initiating the planning process for preparation of a comprehensive conservation plan (CCP) for the Refuge. The Refuge comprises approximately 30,000 acres of tidal wetland, mudflat, salt pond, seasonal wetland, upland grassland, and subtidal habitat bordering portions of Alameda, Santa Clara, and San Mateo counties in the South Bay. It is one of the seven refuges within the San Francisco Bay National Wildlife Refuge Complex. Several Federally listed species and state species of concern use the Refuge, and it is also a significant Pacific Flyway stopover for migratory waterfowl and shorebirds.

- **East Palo Alto Bay Access Master Plan:** Created by the City of East Palo Alto Redevelopment Agency, the East Palo Alto Bay Access Master Plan (BAMP) was designed to organize a vision for San Francisco Bay access and future development of the Ravenswood Business District (RBD). Its direction is a guide for East Palo Alto policy makers and the Bay Conservation Development Commission (BCDC). BAMP includes plans for a series of San Francisco Bay pocket parks that are connected by pedestrian trails. The three main goals of BAMP are to assist BCDC by prioritizing San Francisco Bay access and RBD projects to reflect the needs of East Palo Alto residents, provide guidance to policy makers who are analyzing and shaping projects and plans along San Francisco Bay and within the RBD, and create a vision of an open space "emerald necklace" that will make RBD-planned new office space and communities more attractive and desirable. Because the BAMP is a conceptual planning document only, it is exempt from National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA), (City of East Palo Alto Redevelopment Agency, 2007).

- **Palo Alto Emergency Water Supply Project:** The California Department of Health Services designated the City of Palo Alto as not having the recommended amount of water supply for

emergency water situations. The Palo Alto Emergency Water Supply Project was led by the City of Palo Alto to address the deficiency in the city's emergency water supply. The Hetch Hetchy aqueduct system provides 100 percent of the City of Palo Alto's water supply. Specific project goals included allocatio of a stand-alone emergency water system, 8-hour supply of maximum-day water demand for all areas during an emergency shutdown of the Hetch Hetchy system, maintaining city fire system reserves, and possible water supply supplementation for drought needs. To achieve these goals, the project included the following actions: rehabilitating existing city wells, constructing new wells, constructing a new 2.5-million-gallon (MG) water storage reservoir and pump station, and altering the existing Mayfield Pump Station. The project NOP was released in 2006 and project construction was completed in 2010 (City of Palo Alto, 2010a).

- **San Francisco Bay Area Regional Rail Plan:** The San Francisco Bay Area Regional Rail Plan was a joint effort, created by the Metropolitan Transportation Commission (MTC), the Peninsula Corridor Joint Powers Board (Caltrain), the Bay Area Rapid Transit District (BART), and the California High-Speed Rail Authority (CHSRA). The plan was finalized in September 2007 and includes a long-range vision for improving and expanding the passenger rail system in the San Francisco Bay Area (Bay Area) to address travel demands and an anticipated population growth in the region of 40 percent by 2050. This population growth will place tremendous pressure on the existing transportation network. Specific plans include construction of a rail network that connects San Francisco, Oakland, and San Jose, using Caltrain and BART as the network's backbone. The plan NOI/NOP was released in 2005. Overall, the plan reviewed improvements and extensions of railroad, rapid transit, and high-speed rail services for the near term (5 to 10 years), intermediate term (10 to 25 years), and long term (25 years and beyond).

- **Stanford University Habitat Conservation Plan:** Stanford University, in partnership with USFWS and the National Marine Fisheries Service (NMFS), developed a habitat conservation plan (HCP) for Stanford University lands in April 2010. The HCP is intended to ensure the land's long-term protection of endangered species as the university grows, and includes concentrated conservation efforts in high-priority areas, long-term habitat protection, restoration and protection of riparian areas, habitat enhancement, implementation of a conservation credit system, and monitoring and adaptive management practices. The HCP NOI was released in 2006 and implementation of the HCP began in 2009.

- **Steelhead Habitat Enhancement Project:** Stanford University HCP actions for structural modifications and operational changes to the Los Trancos Creek and San Francisquito Creek Pumping Station diversions, and accompanying maintenance to restore storage capacity at Felt Reservoir, are known as the Steelhead Habitat Enhancement Project (SHEP). Design for the proposed modifications and operating protocols for SHEP were finalized by Stanford, in consultation with the California Department of Fish and Game (DFG), and NFMS. NMFS issued a Biological Opinion (BO) to the Corps for the project in April 2008, and the CEQA process was completed in August 2008. Construction of SHEP was completed in late 2009. The new protocols substantially increase flows through the fish ladder, which enhances conditions for steelhead migration and spawning. These enhancements also accommodate the upstream and downstream movement of juvenile steelhead.

- **Interim Flood Channel Improvements:** San Francisquito Creek overtopped its banks and caused severe flood damages at numerous locations in 1955. Local areas suffered flooding again in 1958 when an earthen levee failed and creek flows inundated the Palo Alto Golf Course and Airport. As a result of these flood events, the District and SMCFCD partnered to construct

"Interim Flood Channel Improvements" along San Francisquito Creek. These improvements are described below.

- *Interim Flood Channel Improvements, 1955:* After the 1955 flood, the District lined approximately 800 linear feet of the south bank in Santa Clara County with sacked concrete upstream of Highway 101; in Reach 2 between Highway 101 and Newell Road.
- *Interim Flood Channel Improvements, 1958:* Following the floods of 1958, the District constructed about 800 linear feet of low berm along the south bank which was previously lined with sacked concrete in 1955. The District also placed approximately 2,200 linear feet of sacked concrete along the south bank between this berm and the bridge at Newell Road. In the same year, the SMCFCD constructed low floodwalls along Woodland Avenue in Menlo Park in San Mateo County, upstream of Highway 101. Also in 1958, Reach 1 was excavated, graded, and widened in a cooperative effort between the District and the SMCFCD. Levees were repaired and improved to carry a design flow of 7,100 cfs with 1.5 to 2 feet of freeboard.

- *Interim Flood Channel Improvements, 1969:* In 1969, "Interim Flood Control Measures" were implemented in Reach 2 between Highway 101 and Middlefield Road, in a cooperative effort between the SMCFCD and the District. The project included the installation of low berms at Middlefield Road and Pope/Chaucer Street bridges, and intermittent sacked concrete revetment and low floodwalls along both banks from approximately 1,200 feet upstream of University Avenue to Highway 101. The improvements were designed to increase the capacity of San Francisquito Creek to 6,000 cfs. It is not known if design freeboard was provided. The project was designed as an interim measure to reduce residential flooding while a permanent solution was to be studied and implemented.

- **San Francisquito Creek Levee Project, 2003:** In 2003, members of the JPA completed a levee restoration project in Reach 1. The primary objectives of the project were to partially restore the original level of flood protection to the area downstream of Highway 101 by restoring the levees to their 1958 elevations and to provide supplemental flood protection to the area until a comprehensive multiyear planning study could be completed for the entire watershed. In addition to levee improvements in Reach 1, the project also constructed approximately 1,000 linear feet of concrete floodwall extending upstream from West Bayshore Road along the Santa Clara County side of Reach 2.

Key Technical Studies Justifying Physical Benefits

These studies formed the basis for development of the proposed Project. Specific project details and physical benefits are supported by the following documents, which have been appended to this Attachment.

- **Draft Planning Study Report for the San Francisquito Creek Flood Protection Project, Santa Clara Valley Water District, October 2012 (included as Appendix 7-1):** Documents the Project objectives, flooding and erosion problems, the development and evaluation of solutions to these problems. Provides a staff-recommended alternative to solve identified flooding problems.

- **San Francisquito Creek – Preliminary Flood Damage Analysis, United States Army Corps of Engineers, San Francisco District, 2011 (included as Appendix 7-2):** Completed detailed hydrologic modeling and analysis of without- and with-Project conditions. Developed a complete economic analysis consistent with Army Corps of Engineers standards.
- **90% Percent Design Drawingsfor the Inlet of West Bayshore(included as Appendix 7-3):**90 percent design has been completed, identifying specific improvements to be completed as part of the Project and substantiating the claimed physical benefits.

Description of Physical Project Benefits

The following physical benefits are expected from this project.

Benefit: Avoided Flood Damages

The project will provide flood protection for 4,500 structures currently included in the 2 percent fluvial floodplain, including the portion of the City of East Palo Alto west of Highway 101, which has been designated as a DACwithin the Bay Area IRWMP.

Background and Historical Conditions
As discussed on pages 2-5 of the Draft Planning Study Report for the San Francisquito Creek Flood Protection Project(included as Appendix 7-1), the watershed currently experiences severe flooding under even relatively minor hydrologic events. Excerpts from that study are provided below.

Historic Flooding
San Francisquito Creek has a history of recurring floods which have adversely impacted the safety and economic stability of the residents, businesses, and government property within the flood plain. Flooding within the watershed has been documented as far back as 1910, and historical flood events reported for the creek are summarized below.

<u>Reach 1 and 2 - December 1955</u>
The largest flood on record for San Francisquito Creek prior to 1998 occurred during December 1955. The San Francisquito Creek flow atthe USGS station (#11164500) located at the Stanford University golf course measured 5,560 cfs. During this flood, San Francisquito Creek overtopped its banks in several locations in Reaches 1 and 2, including the bridge at Middlefield Road, the bridge at Pope/Chaucer Street, the bridge at U.S. Route 101, and two locations along the low levees upstream from U.S. Hwy 101. The flood inundated about 1,200 acres of commercial and residential property, about 70 acres of agricultural property, and the Palo Alto Airport and Palo Alto Municipal Golf Course.

<u>Reach 1 - April 1958</u>
In April 1958, a flow of 4,460 cfs, measured at the USGS station (#11164500), caused a levee failure in Reach 1, with subsequent flooding of the Palo Alto Airport, Palo Alto Municipal Golf Course, and City of Palo Alto Landfill to depths of up to 4 feet. In addition, water backed up behind the U.S. Hwy 101 bridge over San Francisquito Creek, causing over-banking upstream from the highway.

<u>Reach 1 and 2 – 1878, 1980, 1982</u>
Several high-flow events caused scour and erosion problems in 1978, 1980, and 1982. During each of these events, erosion occurred along Palo Alto Avenue, especially near Waverly Street and between Fulton Street and Middlefield Road. In 1982, the creek overtopped its banks near Alpine Road, at University Avenue, and downstream from U.S. Route 101, at a flow of 5,220 cfs measured at USGS

station (#11164500). Flows were probably several hundred cfs greater at locations downstream from El Camino Real. Extensive erosion caused damage to private and public property, undermining roads and destroying fences, retaining walls, and private bridges.

Reach 2 – 1995

In 1995, a flow of 3,320 cfs, measured at USGS station (#11164500), caused water to back up in the local drainage system, resulting in localized flooding near U.S. Route 101.

Reach 1 and 2 – February 1998

The maximum instantaneous peak flow recorded at the San Francisquito Creek at USGS station (#11164500) occurred on February 3, 1998, with a peak of 7,200 cfs. After record rainfalls, San Francisquito Creek overtopped its banks and inundated over 11,000 acres of land in Palo Alto, East Palo Alto, and Menlo Park, affecting approximately 1,700 residential and commercial structures. The 1998 flood caused an estimated $28 million in damages in Palo Alto, East Palo Alto and Menlo Park; $25.5 million of this was residential damages, largely in Palo Alto where 1,155 homes were damaged. In East Palo Alto (San Mateo County), 533 homes were damaged and 325 people were evacuated. In Menlo Park seven homes were damaged. U.S. Hwy 101 was also closed, as were numerous other streets. The peak flow as measured by the USGS gaging station located near the Stanford University golf course was 7,200 cfs, which is approximately a 25-year to 50-year event. It is likely that flows in Reaches 1 and 2 occurring downstream from the USGS station (#11164500) were several hundred cfs greater during this event.

Figure 7-3. High-Flow Event at Upstream Face of Pope/Chaucer Street (2003)

Figure 7-4. High-Flow Event at Upstream Face of West Bayshore Road (2005)

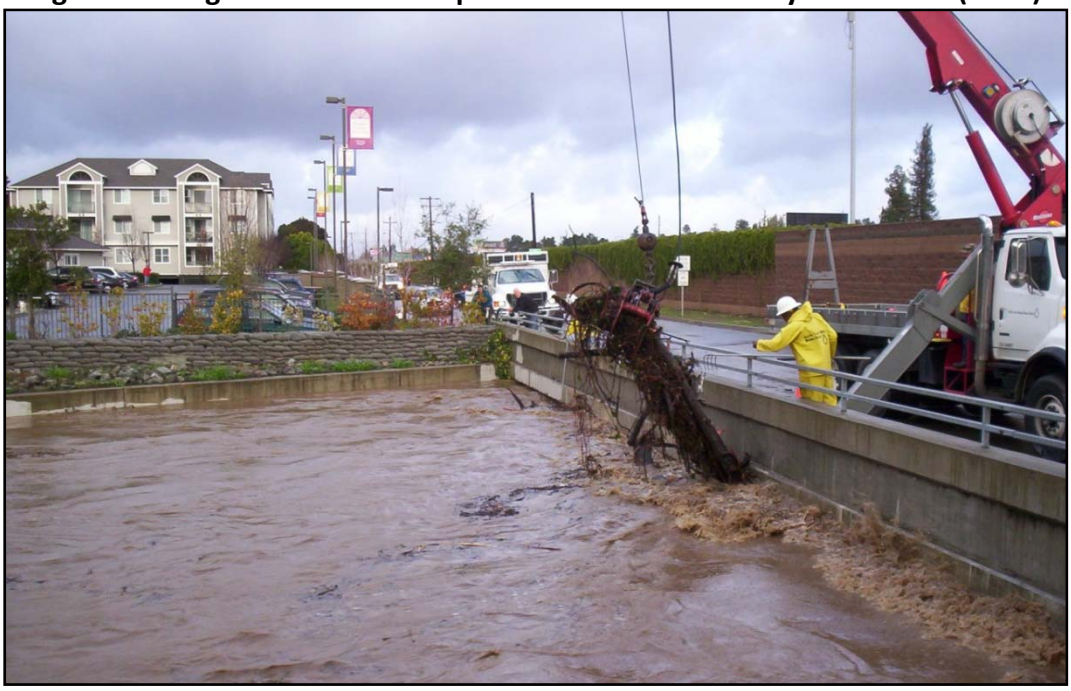
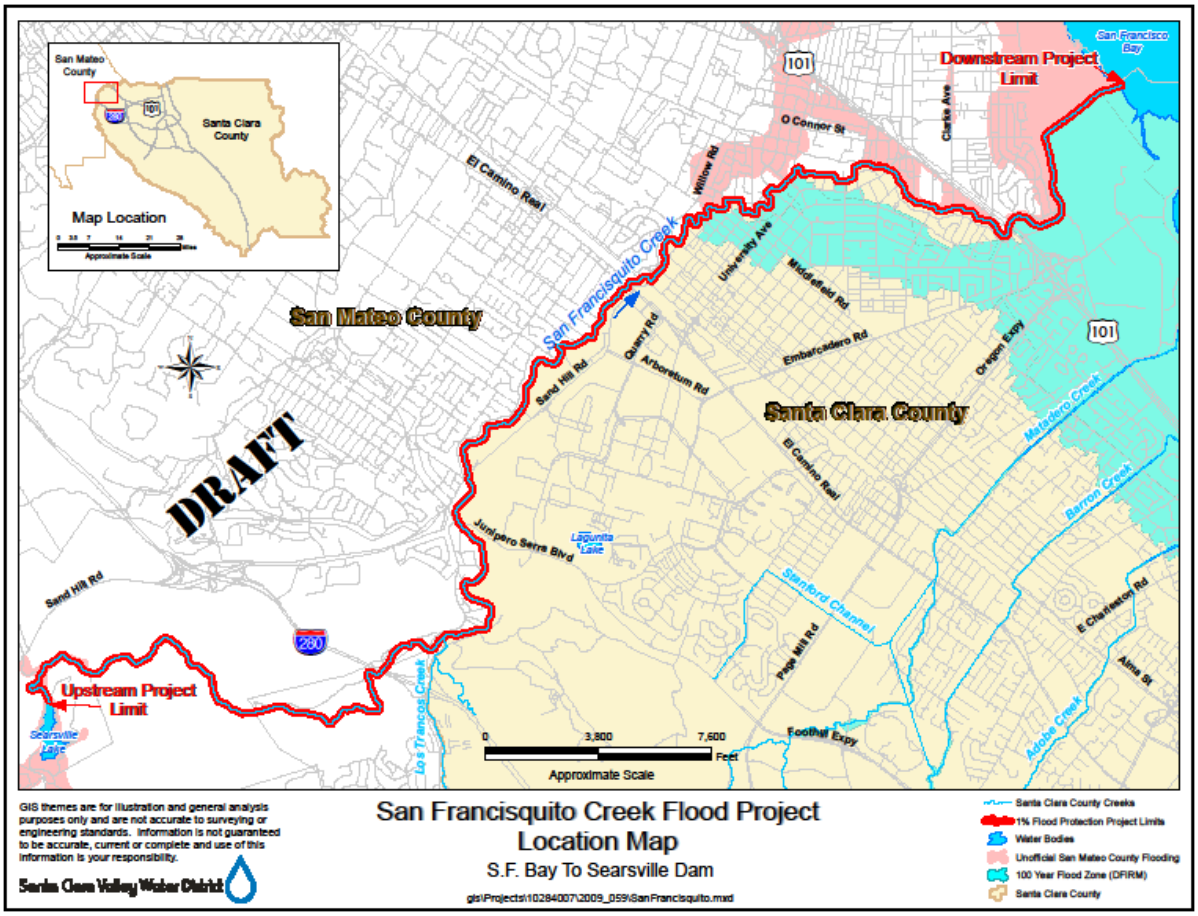


Figure 7-5: High-Flow Event at Upstream Face of West Bayshore Road (2010)

District Floodplain Map

Figure 7-6 shows the 100-year (or one-percent) FEMA floodplain area for San Francisquito Creek. The one-percent FEMA flood map includes areas that have a one-percent chance of experiencing flooding at a one foot or greater depth for any given year. Residents and businesses within the FEMA one-percent flood zone are required to purchase costly flood insurance.

Figure 7-6. District One-Percent Flood Risk Areas



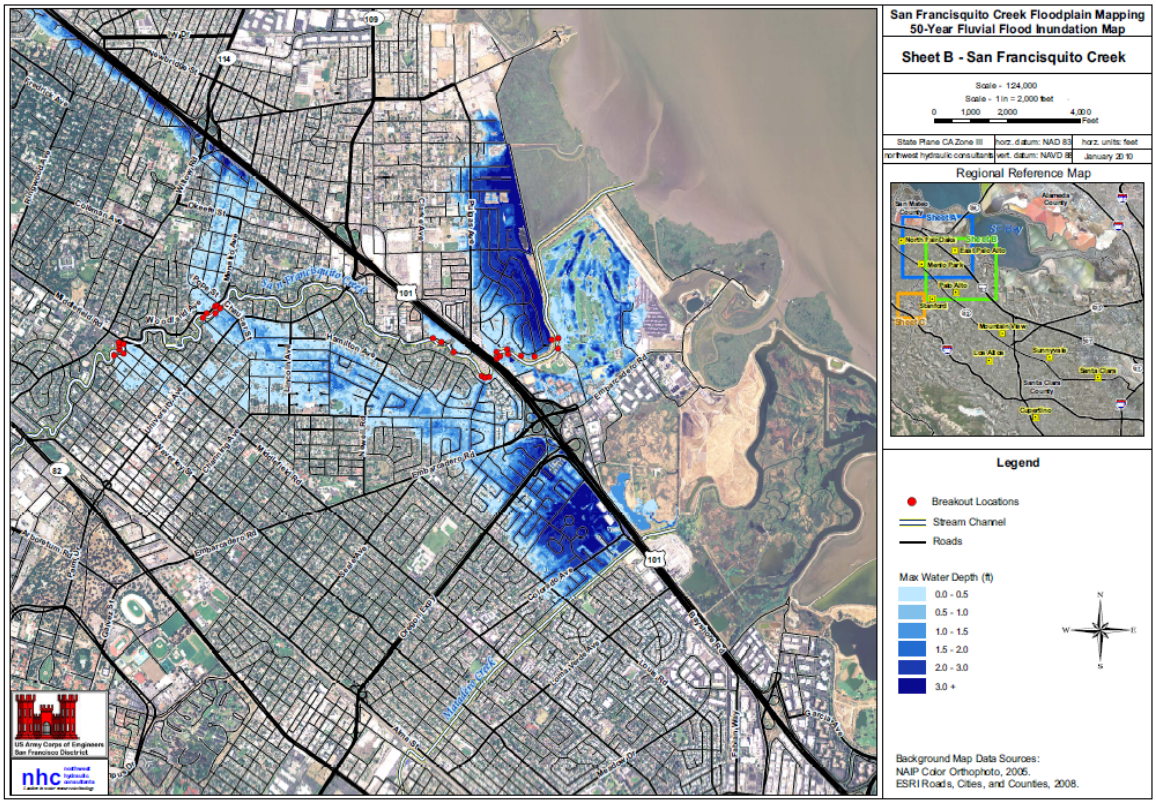
Based on hydraulic modeling of San Francisquito Creek using HEC-RAS, 25-year or greater flood events are expected to result in levee overtopping at multiple locations along the creek. Flows would break out of the channel at six locations for the 100-year (one percent) flood event, five locations for the 50-year flood event, and four locations for the 25-year flood event; all breakout locations are located in Reaches 1 and 2, and are shown in Figure 7-7.

<u>Channel Overtopping</u>

The six breakout locations for the one-percent flood event (Figure 7-7) are located on the left and right banks (looking downstream)of San Francisquito Creek upstream from the Middlefield Road bridge, on the left and right banks upstream from the Pope/Chaucer Street bridge, and on the left and right banks downstream from U.S. Route 101.

Figure 7-7. Flood Breakout Locations in Reaches 1 and 2

Figure 7-8. Extent of Two-Percent Flooding



As illustrated in Figure 7-8, Reach 1 has inadequate flow capacity for the 50-year (two-percent) flow event. In fact, the maximum flow capacity is approximately 4,400 cfs, which is between the 5-year and 10-year flood events.

In Reach 2, the floodwalls upstream from U.S. Hwy 101 to about 1,000 feet downstream from the University Avenue crossing are high enough to prevent water overtopping up to the 50-year flood event. However, earthen levees downstream from U.S. Hwy 101 are not high enough to prevent water overtopping during 25-year or greater flood events. Breakout flow characteristics are shown in Table 7-2. Bridges in Reach 2 at Middlefield Road, Pope/Chaucer Street, and U.S. Hwy 101 each present flow constriction and break out points for the two-percent event.

Riverine floodplain inundation modeling was conducted using the FLO-2D numerical model. Breakout hydrographs from the hydraulic modeling described above were input to the FLO-2D model to predict areas of inundation and flood-wave attenuation.

As mentioned, based on hydraulic modeling results, levee overtopping would occur in several locations in Reach 4, and in multiple locations along Reaches 1 and 2. No levee overtopping would occur in Reach 3. In Reach 4, the creek is confined by high ground; in-channel flows and overland flows are hydraulically interconnected.

Table 7-2. Breakout Flow Summary for One-Percent Event

Breakout Location	Volume (acre-feet)	Duration (hours)	Peak Flow Rate (cfs)
Upstream from Middlefield Road, Right	287	6.0	1,107
Upstream from Middlefield Road, Left	45	5.0	208
Upstream from Pope/Chaucer Street, Right	668	9.0	1,178
Upstream from Pope/Chaucer Street, Left	230	9.0	415
Downstream from U.S. Hwy 101, Right	221	12.5	293
Downstream from U.S. Hwy 101, Left	674	13.0	830

Source: USACE (2010)
Notes:
Left and right with respect to facing downstream

In the northern floodplain area connected to breakout flows upstream from U.S. Route 101, overland flows would travel northeast as sheet flow in a broad band toward U.S. Route 101. At U.S. Route 101, floodwaters would pond in front of the highway noise walls and median barrier, and travel northwest along the highway, before spilling over the highway at the railroad crossing. Flows spilling over the highway would spread into commercial and industrial areas between U.S. Hwy 101 and State Route (SR)

84. Some flows would spill over U.S. Hwy 101 in the vicinity of Willow Road and cause minor flooding in residential and commercial areas on the north side of the highway. Maximum water depths would generally be less than 1 foot in areas of sheet flow; about 2 to 5 feet in ponded areas upstream from highways; and as deep as 7 to 16 feet in the topographic depression at U.S. Hwy 101 near the railroad crossing in Menlo Park. Maximum flow velocities would generally be less than 1 to 2 feet per second. In the northern floodplain area connected to breakout flows downstream from U.S. Route 101, over-bank outflows would inundate residential areas located north of the highway and east of Clarke Avenue. Maximum inundation depths here would generally be 1 to 5 feet in the residential areas and 5 to 11 feet in topographic depressions along the outboard levee. Maximum flow velocities would generally be from 1 to 3 feet per second.

On the southern floodplain, the inundated area would include extensive residential areas between San Francisquito Creek and Matadero Creek south of U.S. Route 101, undeveloped lands on the north side of U.S. Route 101, and the Palo Alto Airport and Municipal Golf Course area. No water would spill over the outboard levee into Matadero Creek or the South Bay. Maximum flow depths would be up to about 1 to 3 feet in the inundated residential areas between San Francisquito Creek and Embarcadero Road; 1 to 4 feet near the Palo Alto Airport and Municipal Golf Course; and up to 3 to 6 feet in the ponded areas along the Matadero Creek levee. Maximum flow velocities would be about 0.5 to 2 feet per second in areas of shallow flooding and up to 2 to 5 feet per second in areas of deep flooding.

Freeboard Deficiency

Potential locations of flooding and/or freeboard deficiency along San Francisquito Creek have been identified using hydraulic engineering numerical analysis software (HEC-RAS). Table 7-3 summarizes locations where the channel does not meet FEMA freeboard standards (3.5 feet of freeboard in sections of channels with levees or floodwalls, 4 feet of freeboard within 100-feet of structures in sections of channels with levees or floodwalls), lack one-percent flow capacity, or both.

Freeboard deficiency in each reach was determined by first adding the required freeboard to the one-percent water surface elevation and then subtracting the lowest top of bank elevation at each hydraulic cross section. Freeboard deficit calculations reported in Table 7-3exclude the existing sacked-concrete floodwall and gravity wall in Reaches 2a and 2b because these structures are considered to be structurally insufficient for FEMA certification. Instead, calculations reference the existing ground at the outside base of either structure. For brevity of reporting, only the maximum freeboard deficiency for each reach is reported. The required freeboard heights used were: 4 feet within 100 feet of a bridge face of a leveed section, 3.5 feet in the main channel of a leveed section, and 1 foot along non-leveed sections of channel. These criteria are the same as the design criteria listed in Section 6.1 of the San Francisquito Creek – Preliminary Flood Damage Analysis included as Appendix 7-2. It should be noted that in some sections, it is possible for the channel to have one-percent flow capacity but to lack the required freeboard; for example the water surface could be a half-foot below the bank in a non-leveed section but would still require a half foot of freeboard.

The HEC-RAS model was originally developed by Noble Consultants under contract to Corps (2009). Geometric data was developed based on a channel topographic survey (Bestor Engineers) which was performed in 2008 and LIDAR data for the project area, both provided by Corps. The model extends from the creek mouth at San Francisco Bay to approximately one mile upstream of Interstate Hwy 280, with a total length of approximately 55,000 feet. To ensure accuracy, the model was calibrated and validated to three and four historic flooding events, respectively.

Table 7-3: San Francisquito Creek Capacity and Freeboard Deficiency by Reach

Reach	Location		Levees or Floodwalls	100-year Capacity	Maximum Freeboard Deficiency (ft)	Cause of Overtopping or Freeboard Deficiency
	From (downstream)	To (upstream)				
1	SF Bay	U.S. Hwy 101	Levee	No	N/A	100-year flow
2a	U.S. Hwy 101	Newell Rd	Floodwall	No	6.9	100-year flow
2b	Newell Rd	University Ave	Floodwall	No	4.4	backwater effects behind Newell Rd. and 100-year flow
2c	University Ave	Pope/Chaucer St	No	No	4.6	backwater effects behind Univ. Ave. and 100-year flow
2d	Pope/Chaucer St	Middlefield Ave	No	No	6.5	backwater effects behind Pope/Chaucer St. and 100-year flow
2e	Middlefield Ave	El Camino Real	No	Yes	6.6	backwater effects behind Middlefield Rd.
3	El Camino Real	Sand Hill Road	No	Yes	0.0	none
4	Sand Hill Road	Upstream from Sand Hill Road	No	Yes	0.0	none

Source: District (2012)

Without-Project Conditions

Without the Project, severe flooding will continue in the study area under the ten year storm and greater.

Methods Used to Estimate Benefits

The proposed Project will:

- Provide two-percent riverine flood protection to approximately 4,500 homes and businesses.
- Restore ecosystem quality, habitat, and function where possible.
- Minimize project impacts on the environment – both long range and during construction.
- Identify opportunities to provide recreation and access to San Francisquito Creek.
- Provide flood protection to the portion of the City of East Palo Alto west of Highway 101, which has been designated as a DACwithin the Bay Area IRWMP.

As delineated in Figure 7-1, the Project area includes approximately 14 miles of San Francisquito Creek as it extends from the base of the Searsville Dam (built in 1892) within Stanford University's Jasper Ridge Preserve to its terminus in South San Francisco Bay approximately 2.5 miles south of the Dumbarton Bridge. Figure 7-2 identifies specific Project reaches.

Methods to estimate damages are described in detail on pages 2-18of the San Francisquito Creek – Preliminary Flood Damage Analysis Report (Appendix 7-2). The following sections are taken from that report. For additional information, please refer to Appendix 7-2.
Based on the San Francisquito Creek – Preliminary Flood Damage Analysis Report (Appendix 7-2), flood damages were estimated in the following benefits categories with- and without-Project:

- Cost to temporarily displaced residents
- Automobile damages
- Traffic delay and detour costs
- Emergency and cleanup costs

The damage to structures, contents, automobiles, and the cost of residential displacement were all estimated within the computer program HEC-FDA v.1.2.5a, while damages related to the other categories will be estimated outside of the HEC-FDA program. Traffic delay costs were estimated via a simple spreadsheet model that is based on the methodology and value of time recommended by IWR Report 91-R-12 "*Value of Time Saved for Use in Corps Planning Studies*." For those damage categories calculated in HEC-FDA, the value of these assets was estimated outside of the program, and then imported into the program along with probability-stage data for each particular structure. The base structure elevation data (not including a first floor adjustment) was provided to the USACE San Francisco Economics Section by the Geographic Information System (GIS) Section.

The HEC-FDA models were built with data for each structure for each exceedance probability – 4%, 2%, 1%, .4% and .2% events. The San Francisquito Creek – Preliminary Flood Damage Analysis Report (Appendix 7-2) uses exceedance probabilities to describe flood events. The exceedance probability is the reciprocal of what is often referred to as the "return period." The return period (or recurrence interval) of an annual maximum flood event has a return period of X years if its magnitude is equaled or exceeded once, on the average, every X years. As an example, a 1% return period (1/100) means that there is a 1% probability of an occurrence in any one year. HEC-FDA uses Monte Carlo simulation to calculate a stage-damage relationship with uncertainty, and the program then annualizes the probability-weighted damages to calculate an equivalent annual damage value for each scenario considered.

The Report addresses the fluvial and coastal flood risk in the study area, though this analysis focuses on the fluvial risk.

The analysis used the procedures of directly inputting the set of water depths for each of the economic impact areas (EIAs) into HEC-FDA as a water surface profile, then calculated the exceedance-probability stage data within HEC-FDA, and including the ground elevations of the structures (with first floor elevation (FFE) adjustments) in the inventory import file. As such, HEC-FDA calculates the depth of flooding at each structure for each event and develops an aggregated stage-damage curve. Finally, the program calculates an Expected Annual Damage figure by linking the exceedance probabilities to stage-damages, incorporating risk and uncertainty based upon the Period of Record assigned to the probability-stage curve and the standard deviations resulting from the aggregated stage-damage curves.

Flood Modeling Overview

The flood damage analysis considers damages from San Francisquito Creek fluvial flooding. The extent to which the flooding from these two sources is coincidental is not known at this point. It is expected, however, that flooding from these two sources will be somewhat correlated, and proper procedures to avoid double-counting will need to be incorporated during the next phase of this study. In order to accurately understand the benefits of a project, and in order to understand the residual risk associated with a fluvial project, it is important to understand the relationship between the flooding sources. It is likely that adjustments to the analysis will need to be made as more is learned about the likelihood of coincidental flooding in some areas.

With respect to fluvial flooding, according to the Without-Project H&H analysis, flooding in the EIAs is primarily caused by a lack of capacity for conveying water volumes under several bridges that cross San Francisquito within the study area. Moreover, there are existing levees at the downstream end of the study area that would be overtopped during the 4% event and greater. Geotechnical investigations completed for this study indicates that the levees have fragility curves (i.e., there is a probability of some type of engineering failure before being overtopped), but due to the volume of water escaping into the upstream floodplains because of the too-small bridge underpasses, the geotechnical fragility curves were not used for the Without Project damages calculation. These levee fragility curves will be incorporated in the subsequent Alternatives Analysis phase of this feasibility study.

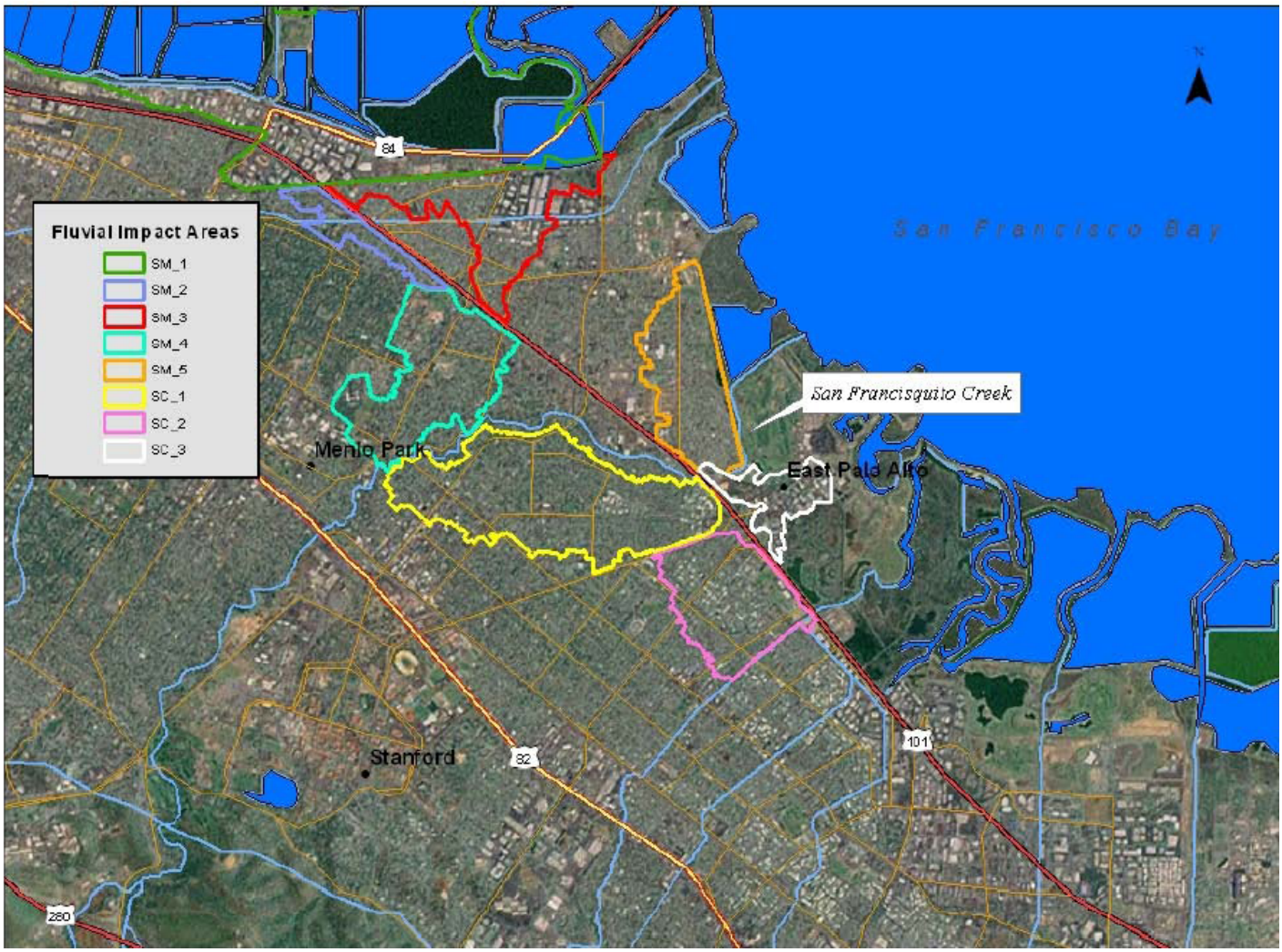
Fluvial Economic Impact Areas

Figure 7-9below shows the fluvial economic impact areas (EIAs) in the study area. In the figure, EIAs San Mateo County are called SM_1 through SM_5, while those in Santa Clara County are called SC_1 through SC_3. Table 7-4 and the sections that follow further describe the location of each of the impact areas and the land use within each area. The proposed Project would benefits all EIAs except Santa Clara 3 (SC_3) and San Mateo 5 (SM_5).

Table 7-4. Description of Fluvial Economic Impact Areas

EIA	Description
San Mateo 1	BAYFRONT EXPRESSWAY (mostly industrial/commercial area north of Bohannon Dr/RR tracks between Marsh and Willow Rds.)
San Mateo 2	FLOOD PARK TRIANGLE (mostly residential generally bound by Bohannon, Van Buren, and Bay Rd. -- west of US 101)
San Mateo 3	BELLE HAVEN (mostly residential with some industrial located south of Bohannon/RR tracks, east of US 101 and west of Ralmar Ave)
San Mateo 4	WILLOWS/VINTAGE OAKS (mostly residential west of US 101, east of Middlefield Rd, between the north bank of San Francisquito Creek and Willow Rd)
San Mateo 5	PULGAS AVENUE (mostly residential straddling Pulgas Ave east and west by several blocks, bounded between Bay Rd to the north and US 101 to the south)
Santa Clara 1	CRESCENT PARK/DUVENECK-ST FRANCIS (mostly residential with commercial; south of San FrancisquitoCrk. across University, north of Embarcadero Rd between Waverly St and US 101)
Santa Clara 2	OREGON EXPRESSWAY (residential south of Embarcadero Rd. and north of Clara Dr. between Ross Rd. and US 101)
Santa Clara 3	EMBARCADERO/EAST BAYSHORE (mostly commercial with industrial located west of US 101 straddling Embarcadero Rd eastward to Embarcadero Way

Figure 7-9. Fluvial Economic Impacts Areas[1]



This section describes the types of structures and flooding characteristics in each of the eight EIAs. The land use maps were created based on the structure inventory work performed by the Corps between during February and March 2011. The source of the raw data (particularly square footage) was county assessor parcel data obtained directly from San Mateo and Santa Clara counties, with field investigations done by Corps economists. The construction characteristics of the homes and businesses in the study area are consistent with other regions of California.

Structure Types and Flooding Characteristics by EIA

This section describes the types of structures and flooding characteristics in each of the eight EIAs. The land use maps were created based on the structure inventory work performed by the Corps between during February and March 2011. The source of the raw data (particularly square footage) was county assessor parcel data obtained directly from San Mateo and Santa Clara counties, with field investigations done by Corps economists. The construction characteristics of the homes and businesses in the study area are consistent with other regions of California.

The structure inventory database and the flood damage analysis contain 16 structure types. A description of these structure types is contained in Section 3. The extent of the inventory was based on

a. [1] The proposed Project would benefits all EIAs except Santa Clara 3 and San Mateo 5.

an estimate of the .2% floodplain extent of the Curve III sea-level rise scenario. Due to FFE adjustments, in reality the number of structures susceptible to flood damage is somewhat fewer than is reflected in the inventory maps. USACE, San Francisco District San Francisquito Creek – Preliminary Flood Damage Analysis 7.

For the Base Year 2017, each EIA was assigned a water surface elevation profile which was created by overlaying floodplain depths generated by FLO2D and overlaid onto GIS maps of the study area. All of the EIAs floodplains were then attached to an H&H (hydrology and hydraulics) index point at the upper end of the creek. This adjustment was necessary due to the relatively "flat" probability-stage relationship within the overbank floodplains. Since HEC-FDA is largely dependent upon change-in-depth flooding (as opposed to sheet-flow flooding where subsequent larger events tend to have similar depths but larger geographical extents), the FLO2D floodplains depths were attached to an in-channel HEC-RAS probability-stage curve. This methodology has been used in other San Francisco and Sacramento District studies as an appropriate way to accurately model damages while using the USACE-approved HEC-FDA model. Flood maps are displayed showing the depths of flooding for the 5 modeled events previously noted. The actual depths in and around the structures generally averages no more than a few feet, due to the sheet-flow nature of the overbank flooding.

San Mateo EIAs

Bayfront Expressway (San Mateo 1) is primarily a commercial and industrial area located between the San Francisco Bay and US 101. There is one small pocket of residential structures at the most eastern extent of this EIA called Harbor Village Mobile Home Park. This EIA contains the Carlsen Porsche dealership as well as several industrial and commercial park areas with a wide variety of companies: mailing & shipping, medical technology, banking, and machining to name a few.
San Mateo 2 – 5 contain the neighborhoods of Belle Haven and the Pulgas Avenue area on the east side of US 101 (generally, East Palo Alto). West of US 101 the neighborhoods of Flood Park Triangle and Vintage Oaks (Menlo Park) lie within the study area. All are almost completely residential, with only a few commercial structures susceptible to flood damage. In addition to residences, these neighborhood EIAs have several schools, parks, libraries, hospitals, and churches. In Base Year 2017, the first significant floodplain damage occurs at approximately the 4% event.

Santa Clara EIAs

Santa Clara 1 (Crescent Park/Duveneck-St Francis) is the largest geographic EIA within the study area (Palo Alto). It covers several older and more established neighborhoods and the accompanying shops, restaurants, and grocery stores typical near residential areas. The Edgewood Plaza Shopping Center is located within this EIA. It also has several schools and medical facilities, as well as a community center and library branches. This EIA is directly adjacent to San Francisquito Creek. The Oregon Expressway EIA (Santa Clara 2) shares Embarcadero Road as a border; EIA 2 is similar in structure type and land use to Santa Clara 1.

Santa Clara 3 is also within the city limits of Palo Alto, although it is located across US 101 from both Santa Clara 1 & 2. This EIA contains mostly commercial structures (restaurants, office parks, and car dealerships) as well as several public buildings including the Palo Alto Post Office. Nearby, there is the Palo Alto commercial airport and the Palo Alto Municipal Golf course; neither of these land parcels were shown to incur flooding at the .2% event however and do not factor into this economic damage analysis.

Structure, Content & Vehicle Valuation

In order to estimate the value of damages to property as a result of flood events within the study's floodplains, it is first necessary to inventory the structures and other assets within the floodplain. This section describes how the inventory and valuation of structures were accomplished. The next section will describe how this data was used to develop an estimate of the value of the damages expected to occur from flooding.

Structure Inventory

An initial inventory of the parcels in each 0.2% floodplain was compiled in ArcGIS (ArcMap) software by linking the raster flooding depth file with a point shapefile containing the parcel information, and then exporting those parcels in the modeled floodplains to a spreadsheet. For each parcel, the data was linked to the geographic center of mass of the particular parcel by creating a data centroid within the ArcMap program. Because only those parcels whose centroid overlaps the floodplain are considered as impacted, only those parcels that are at least bisected by the floodplain are included in the inventory. This is done in an attempt to improve the accuracy of the structure inventory – eliminating the inclusion (and ultimate valuation) of those parcels that are least likely to have structures that are actually impacted by the flooding, even while a portion of the parcels receive some non-zero level of flooding. However, there are cases where the centroid of the parcel shape does not accurately enough reflect the location of the structure – for instance, some commercial, industrial, or public parcels contain more than one structure. In order to manage this eventuality, and to make sure the damage model includes all of the structures at risk of flooding, spot checking of the parcels and structures along the outer edge of each floodplain was conducted during the economic fieldwork. When it was the case that aerial photography showed a structure to be located in the floodplain when the ArcMap centroid method did not, this structure was added to the database with the appropriate depth of flooding referenced.

Structure Inventory and Valuation Results – Fluvial Floodplain

Table 7-5 shows the numbers of structures by type that was inventoried for the 0.2% floodplain. Not all of these buildings ultimately end up contributing to damage estimates. Based upon the depth of water for the 0.2% flood event and the data gathered during the economic fieldwork—specifically the building foundation height--, many of these structures' first floor were in fact elevated well above the floodplain.

Table 7-5: Structures in 0.2% Floodplain EIA

EIA	Residential	Commercial	Industrial	Public
SM 1	5	31	89	0
SM 2	356	3	0	1
SM 3	791	6	56	16
SM 4	1,123	25	1	6
SM 5	1,263	8	4	10
SC 1	2,646	61	0	9
SC 2	1,266	1	0	4
SC 3	0	26	4	2
Total	7,450	161	154	48
Total without SM5 and SC3	6,187	127	146	36

Of these structures, approximately 5,500 are present in the 50-year floodplain, with approximately 1,000 structures located in SC3 and SM5. As such, the proposed Project, which provides protection

against the 2% event, would provide flood protection for approximately 4,500 structures, including the portion of the City of East Palo Alto west of Highway 101, which has been designated as a DACwithin the Bay Area IRWMP.

New Facilities Required to Achieve Benefit

All proposed project facilities would be required to be constructed to achieve the flood protection benefits described above, including:

- West Bayshore Inlet
- Channel Widening at 4 locations
- Newell bridge replacement
- Pope-Chaucer Bridge replacement

Benefit: Reduced Erosion

Up to 6,630 feet of erosion control / repairs along reaches 2a through 2d.

Background and Historical Conditions

As discussed on pages 15-18 and 26-27 of the Draft Planning Study Report for the San Francisquito Creek Flood Protection Project(included as Appendix 7-1), the project team has identified the locations and general sources of erosion problems within the project area. Significant bank erosion was not identified in Reach 1 and Reaches 2a through 2d where high flows access floodplains (Reach 1) and the channel is hardened by concrete protection (Reaches 2a through 2d). Serious bank erosion was identified for reaches located upstream from the bridge at Pope/Chaucer Street (Reaches 2d-2f) where bank protection is less frequent.

The level of erosion per reach is summarized in Table 7-6. Identified erosion sites are generally either slumping failures, toe erosion, or scour near structures or roads. These erosion problems have been determined based on review of the Bank Stabilization and Revegetation Master Plan (2000), the Geomorphic and Sediment Yield Analysis (2009), annual maintenance investigations performed by the JPA, and field visits by the project team.

As the extent of erosions along the creek is continually changing due to channel flows, the information in this section is considered preliminary and the exact locations and dimensions of the erosion will be finalized during the design phase of the project. While erosion is evident in reaches upstream from Middlefield Road, it is beyond the scope of this project to analyze all of the erosion sites in San Francisquito Creek. As such, the project team has focused on erosion occurring downstream from Middlefield Road (Reaches 1 through 2d) where flood improvements are anticipated and on critical bank failures identified by the JPA in Reach 2f (Table 7-7).

Table 7-6. Level of Erosion along San Francisquito Creek

Reach	Level of Erosion			
	Insignificant	Mild	Significant	Serioius
R1	0%	0%	0%	0%
R2a	94%	6%	0%	0%
R2b	73%	5%	14%	9%
R2c	50%	22%	13%	15%
R2d	18%	18%	25%	39%
R2e	15%	17%	24%	44%
R2f	12%	15%	28%	45%
3	75%	25%	0%	0%

Source: Bank Stabilization Master Plan (2000)

Table 7-7: Erosion Sites along San Francisquito Creek Channel

Reach	Station (ft)		Description	Side of Creek	Erosion Repair Dimensions	
	Begin	End			Length (ft)	Ave. Ht. (ft)
R1	NO SIGNIFICANT EROSION					
R2a	NO SIGNIFICANT EROSION					
R2b	119+80	123+50	Toe erosion and slump failure	North	370	20
R2b	126+00	130+50	Toe erosion and slump failure undermining Woodland Avenue in East Palo Alto	North	450	20
R2c	134+50	135+50	Toe erosion and slump failure	North	100	20
R2c	141+00	142+80	Toe erosion and slump failure undermining Woodland Avenue in East Palo Alto	North	180	20
R2c	159+00	161+60	Toe erosion and slump failure undermining Woodland Avenue in East Palo Alto	North	260	20
R2c	164+50	166+50	Toe erosion and slump failure	North	200	20
R2c	164+50	166+50	Toe erosion and slump failure	South	200	20
R2c	169+50	171+00	Toe erosion and slump failure	South	200	20
R2c	174+00	176+50	Toe erosion and slump failure	North	250	20
R2c	178+00	180+00	Toe erosion and slump failure	North	200	20
R2c	178+00	180+00	Toe erosion and slump failure	South	200	20
R2c	186+00	208+00	Toe erosion and slump failure	North	2,200	20
R2c	188+00	194+00	Toe erosion and slump failure	South	600	20
R2d	198+00	202+20	Toe erosion and slump failure	North	420	20
R2d	204+00	206+00	Toe erosion and slump failure	South	200	20
R2d	206+00	208+00	Toe erosion and slump failure	North	200	20
R2d	208+00	210+00	Toe erosion and slump failure	South	200	20
R2d	218+00	220+00	Toe erosion and slump failure	South	200	20
R2d	222+00	224+00	Toe erosion and slump failure	South	200	20
Source: Bank Stabilization and Revegetation Master Plan Appendix 3.8 (2000), JPA (2010)						

Erosion problems along San Francisquito Creek Channels are pervasive and include historic invert erosion, localized scour, slumping failures, toe erosion, and undermining of hardscape features. They present a significant maintenance issue for the District because the erosion problems frequently threaten structures located adjacent to the top of the channel banks; i.e., the channel lacks sufficient floodplain.

Bank erosion occurs throughout the San Francisquito Watershed, primarily during extreme floods. On San Francisquito Creek significant bank damage occurred in February 1940, December 1955, April 1958, January 1982 and again during the 1997-98 El Nino storms (Corps 1972; San Francisquito Creek Coordinated Resource Management and Planning 1998; Cushing 2000). Erosion also occurred during earlier floods but was likely not documented because of the lack of damage to structures or property.

The project team has identified several main causes of erosion problems along San Francisquito Creek, as detailed below. Each of the erosion sites identified by the project team may be due to one or more of these causes.

- Lack of an upstream sediment supply. Previous studies indicate that San Francisquito Creek is lowering its slope by incising from Sand Hill Road to Pope-Chaucer Road and by depositing sand and fine gravel on the bed downstream from Pope-Chaucer Bridge to the delta. The incision is assumed to result from slope adjustments that are a response to the capture of coarse sediment from Corte Madera and other creeks in Searsville Lake and also from increased peak flows from development. San Francisquito Creek is now incising into coarse, partly indurated gravels in the bed between El Camino Real and University Avenue and rates of incision have been quite slow, averaging about 0.012 feet/year from 1964 to 1998 (1.2 feet per century), and seem nearly negligible since 1998. Incision rates were likely greater earlier in the twentieth century.

- Insufficient floodplain or right-of-way corridor. This prevents the constructed channels from naturally evolving to a stable, geomorphic geometry.

- Intermittent hardscape and natural reaches of channel. Largely due to the existing narrow right-of-way corridor, the District has repaired bank erosion at many locations by lining the channels with sacked concrete, rip-rap, or concrete in areas where structures or property are threatened by erosion. This has led to reaches of channel with intermittent sections of hardscape and natural channel, leaving natural channel reaches particularly subject to further erosion problems.

- Multiple road crossings. San Francisquito Creek has 23 road, pedestrian, and golf cart bridges combined, three of which are concrete culverts. A number of these bridges (Piers Lane, El Camino Real, University Avenue, and Newell Road) include abutments located within the channel that effectively constrict and accelerate flow velocities and increase the potential for scour and deposition upstream and downstream from the bridges. Each of the culverts (Middlefield Road, Pope/Chaucer Street, and U.S. Hwy-101) provide similar scour and deposition hydraulics.

- Hydromodification of the watershed area due to urbanization and land development. For storms of the same recurrence interval, urbanization and land development decrease the watershed's time of concentration and increase the peak flow rates.

- The project team relied on bank erosion information presented in the JPA's Bank Stabilization and Revegetation Master Plan (2000) which was based on site evaluations conducted during 1998 and 1999. The project team recognizes that creek conditions may have worsened or improved since the Master Plan was completed.

- Chinese Mitten crab (Eriocheirsinensis) infestation may have a significant impact on bank stability within the project area.

San Francisquito Creek bank erosion mainly occurs upstream from the bridge at Pope/Chaucer Street which is about 1,500 feet upstream from where floodwalls would be implemented by the Project. This pattern is supported by the Bank Stabilization and Revegetation Master Plan (2000) which included a detailed investigation of the creek in 1998 and 1999 and suggests that areas of high erosion potential in Reach 2a, 2b, and 2c which have already received sacked-concrete treatment are generally considered to be stable. Annual maintenance walks conducted by the JPA (including participation from JPA member agencies and interested members of the public) support this pattern and report only occasional small scale erosion at the toe of some sacked concrete bank protection. The JPA has identified erosion sites upstream from El Camino Real as candidates for bank stabilization projects.

Figure 7-10. Member of the JPA Maintenance Walk Inspect the Creek

The Bank Stabilization and Revegetation Master Plan suggests that the "No Action" Alternative or an alternative emphasizing revegetation or non-native species removal be applied to Reaches 2a, 2b, and 2c. However, the project team recommends continued inspection of these reaches, with specific attention to locations where continued bank erosion may pose a threat to safety or property.

Field inspections performed by the project team in 2009, 2010 and 2011 have identified one such area of concern near the downstream face of the bridge at University Avenue where the creek bank is nearly vertical and in close proximity to Woodland Avenue (Figure 7-11).

Figure 7-11. Bank Erosion Along Woodland Avenue Near University Avenue

With the Project, this section of creek bank would be treated as part of modifications or replacement of the bridge at University Avenue. The project team recommends that potentially significant erosion areas identified by the Bank Stabilization and Revegetation Master Plan (2000) in Reach 2b, and 2c be inspected for further consideration during the design phase. For planning purposes, the rock toe bank protection method is recommended for all such erosion repairs. This method is appropriate for the identified erosion sites, which have steep side slopes (1.5:1, H:V, or steeper) and velocities lower than 7 ft/sec. It consists of protecting the toe and lower banks with rock up to the 10-year flow level and repairing the slope above this level with a combination of earth fill, erosion protection fabric, native vegetation, and hydroseed.

Figure 7-12. Example of rock toe and earth fill slope protection

Without-Project Conditions
Without the Project, erosion – and associated impacts to environmental resources and water quality - will continue at historical rates.

Methods Used to Estimate Benefits
Erosion repairs needed and associated improvements resulting from the Project were estimated as discussed din the Bank Stabilization Master Plan. Actual length of erosion repairs is based on the estimated need identified in Appendix 3.8 of the Bank Stabilization Master Plan for Reaches 2b through 2d (reproduced herein as Table 7-7). Precise erosion repairs to be implemented as part of the Project are currently uncertain; as such, these benefits have not been monetized in Attachment 8.

Benefit: Reduced Sedimentation
Reduction in sediment deposition by up to 1,700 cubic yards per year.

Background and Historical Conditions
As discussed on pages 19-20 of the Draft Planning Study Report for the San Francisquito Creek Flood Protection Project(included as Appendix 7-1), sedimentation problems exist along San Francisquito Creek at Searsville Dam, between Pope/Chaucer Street bridge and U.S. Hwy 101 (Reach 2a through Reach 2c), and in Reach 1. Sedimentation in these areas is generally due to either the deposition of coarse gravels from incising beds and bank erosion occurring between El Camino Real and Sand Hill Road (Reach 2f and Reach 2g) or the sedimentation of silts and clays which form bay mud in tidally influenced reaches (Reach 1 and Reach 2a).

U.S. Hwy 101
Sediment deposition and the resulting loss of channel conveyance in the vicinity of U.S. Hwy 101 has been a long term problem for the District. On average, the District removed 1,700 cubic yards of sediment per year near U.S. Hwy 101 between 1997 and 2007.

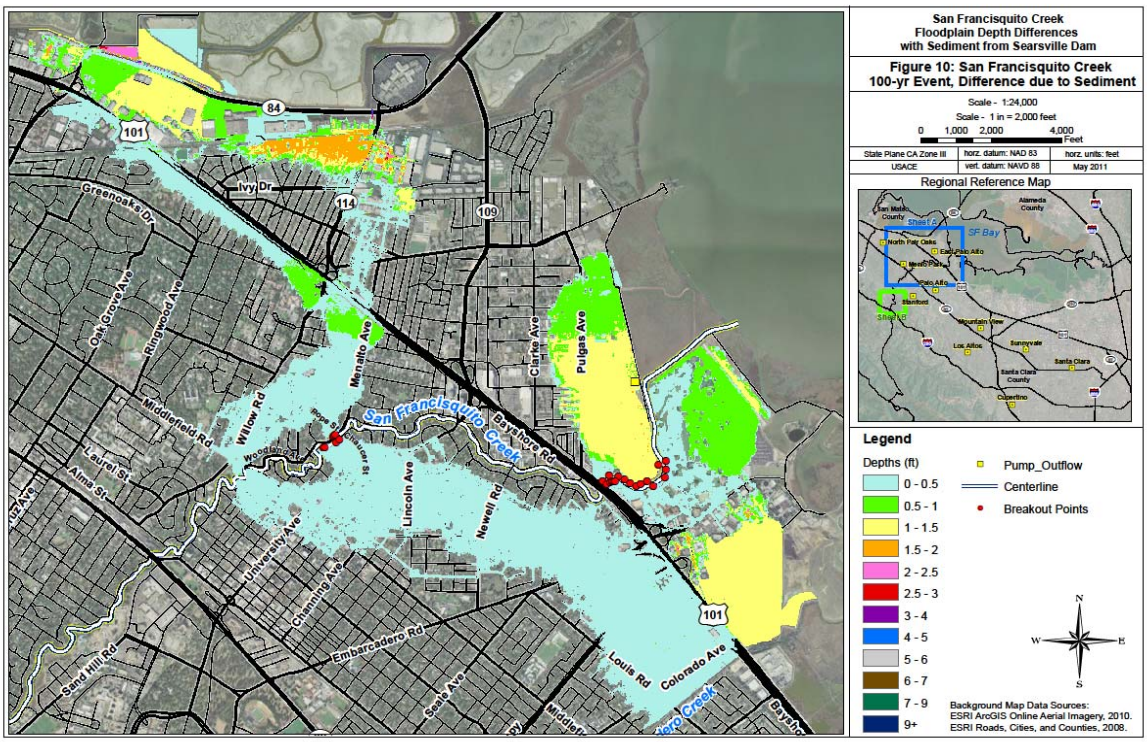
Reach 1

Deposition has also occurred from Highway 101 to the mouth of San Francisquito Creek, a distance of some 7,500 feet. In 1958, this reach was lowered to an elevation of -3 to -4 feet and widened (San Francisquito Creek CRMP 1998). The excavated channel has since re-filled and has bars or berms of silty clay along the channel margins.

Searsville Lake

Searsville Lake is expected to fill with sediment in the next 15 to 40 years (NHC 2010). This will increase the volume and caliber of sediment contributed to San Francisquito Creek from the Searsville Lake subwatershed. The immediate geomorphic responses expected to result from Searsville filling (i.e. change to existing creek bed incision and bank erosion rates) are undetermined at this time, however, fifty-year sediment transport simulations (HEC-6T) indicate continued incision and lower flood levels upstream from Pope/Chaucer Street and continued aggradation and raised flood levels downstream of Pope/Chaucer Street (Figure 7-13).

Figure 7-13. Change in One-Percent Water Flooding Due To Sedimentation (50 years in future)



Without-Project Conditions

Without the Project, sedimentation is expected to continue at historical rates.

Methods Used to Estimate Benefits

Reduced sedimentation was estimated based on documented historical sedimentation removal requirements, as discussed in the San Francisquito Creek – Preliminary Flood Damage Analysis (Appendix 7.2)and described above. Modifications to the outlet will eliminate the need for future sediment removal with- or without-Project. As such, sediment removal costs have not been estimated in Attachment 8. However, historical removal rates provide an indication of the degree of sediment deposition.

Benefit: Environmental Enhancements

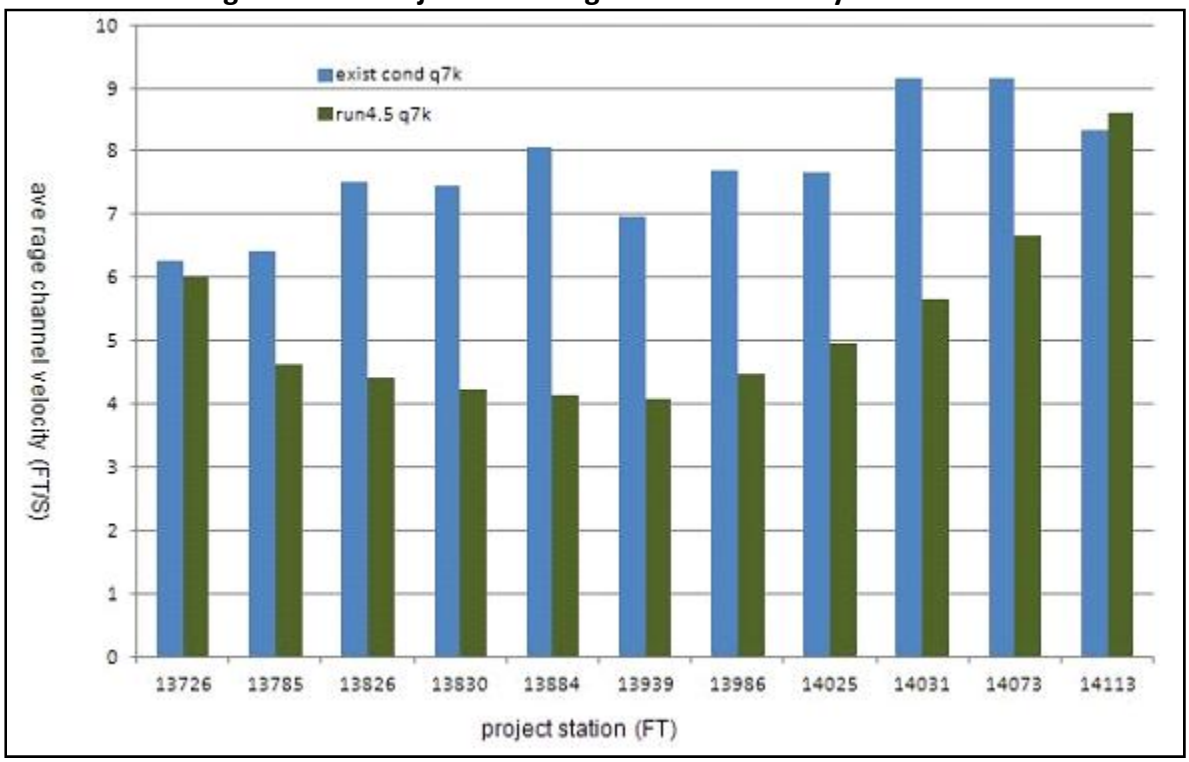
With the project, approximately 234 cubic yards of concrete will be removed upstream of University Ave bridge, enabling establishment of native vegetation and habitat. In addition, average channel velocity will be reduced by up to 52% (from 8.1 to 4.2 ft/s) during the 2 percent storm, improving fish passage.

Background and Historical Conditions

Currently, the bottle-neck located upstream from University Ave bridge (end of Manhattan Ave) on San Mateo County side of creek includes about 6,326 square feet of concrete, which averages about 1 foot deep, for a total volume 6,326 cubic feet or 234 cubic yards. This will be removed as part of Project implementation, enabling establishment of native vegetation and habitat.

In addition, under the 2 percent event, channel velocities currently average about 8.1 cfs, impairing fish passage. The proposed Project will reduce channel velocities to approximately 4.2 cfs (a 52% reduction). Figure 7-14 presents the average channel velocity reduction projected.

Figure 7-14. Projected Average Channel Velocity Reduction



Methods Used to Estimate Benefits

Environmental benefits were estimated based on the lengths of bridges proposed to be repaired or enhanced with project implementation.

Benefit: Enhanced Recreation

New and / or enhanced sidewalks and bicycle lanes along nearly 400 feet of bridges.

Background and Historical Conditions

As discussed on page 30 of the Draft Planning Study Report for the San Francisquito Creek Flood Protection Project(included as Appendix 7-1), the Project includes opportunities to create new or

improved bicycle lanes, pedestrian walk ways, and viewing stations where bridges would be modified or replaced. These betterments have been included in the project cost estimate.
In total, four vehicular bridges and two private pedestrian bridges would be modified or replaced to provide two-percent flood conveyance, and associated recreation improvements would be made as follows:

- Newell Road Vehicular Bridge – the 40-foot long bridge would be modified to include two 16 foot wide traffic lanes (for shared vehicular/bicycle traffic) and 5 foot wide sidewalks on each side of the road (proposed bridge length of approximately 100 feet)

- Pope/Chaucer Street Vehicular Bridge – the 35 foot long bridge, which includes sidewalks along both edges of the roadway and no bicycle lanes, will be replaced with a three-span bridge structure including sidewalks and bicycle lanes (proposed bridge length:: approximately 100 feet)

- Two pedestrian bridges on private properties between University Avenue and Pope/Chaucer Street – these 60- foot and 80-foot long pedestrian bridges may be modified or replaced to pass the two-percent flow

A brief description of each bridge follows.

<u>Newell Road Bridge Replacement Project (Station 112+20)</u>
The single span bridge at Newell Road is approximately 40 feet long by 22 feet wide and accommodates one lane of traffic (Figures 7-15 and 7-16). The bridge, which was originally constructed in 1911, is owned by the City of Palo Alto and considered by Caltrans to be functionally obsolete. The traffic lanes are substandard, and the bridge has no provision for bicycle or pedestrian traffic. In addition, the sight distances from the bridge are poor, and the bridge alignment creates an undesirable offset in the horizontal alignment of Newell Road.

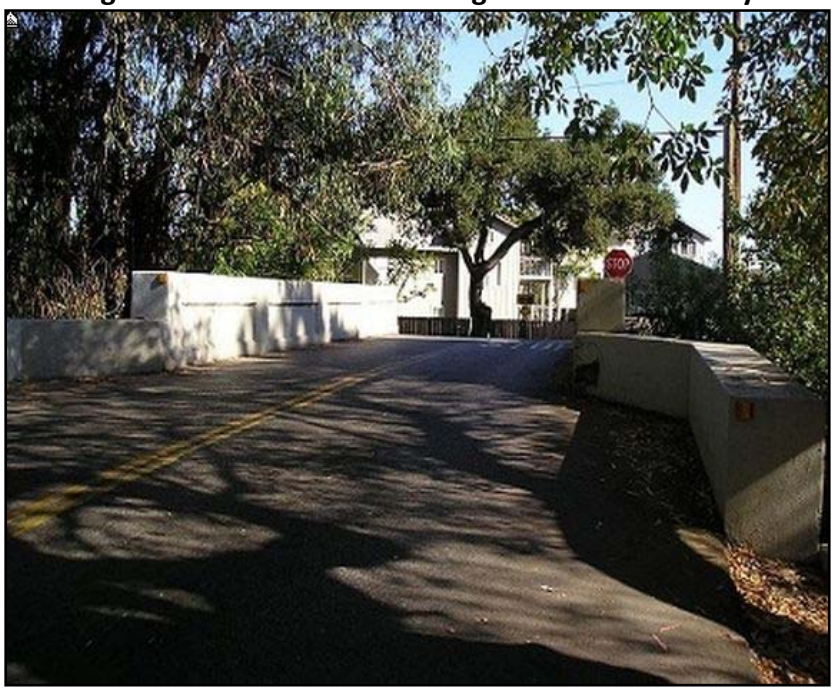
In 2010, at the request of the JPA, the City of Palo Alto applied for a Caltrans Highway Bridge Program grant for preliminary engineering, including engineering design and environmental assessment, for the replacement of the Newell Road Bridge over San Francisquito Creek. As part of the program, Caltrans required that 11.5% of the cost of the work be paid by the agency receiving the grant. In consideration of the City of Palo Alto applying for the grant, the JPA offered to pay the local match.

The replacement bridge is tentatively proposed to include two 16 foot wide traffic lanes (for shared vehicular/bicycle traffic) and 5 foot wide sidewalks on each side of the road. The proposed bridge length is approximately 100 feet, which is the approximate distance between the top of the creek banks, allowing the new abutments to be constructed outside the creek channel. The new bridge will be designed to pass the two-percent flow event and accommodate future channel improvements both upstream and downstream from the bridge which may include floodwalls.

With the Project, approximately 6 foot tall floodwalls on either bank would tie into the bridge at Newell Road at both the upstream and downstream bridge faces.

Figure 7-15. Newell Road Bridge Plan View

Figure 7-16. Newell Road Bridge Elevated Roadway



Pope/Chaucer Street Bridges Replacement (Station 177+70)

The single span bridge at Pope/Chaucer Street is approximately 35 feet long by 60 feet wide and accommodates two lanes of vehicular traffic (Figure 7-17). The bridge was originally constructed in 1907 as a single span reinforced concrete arch structure (Figure 7-18), and was modified in 1948 to include a narrower opening (Figure 7-19). The bridge is owned by the City of Palo Alto and appears to be in good

condition. The bridge includes sidewalks along both edges of the roadway; however there are no bicycle lanes.

The bridge at Pope/Chaucer Street is a known break out point for flooding during peak flow events and was identified early on in the planning phase as a necessary component to provide two-percent flood protection for each of the feasible alternatives. As such, the project team has retained consultant services to begin preparing engineering plans and specifications to replace the bridge.

In order to increase the hydraulic capacity of the bridge, the existing arch structure, fill, and adjacent plantings will be removed. The new bridge will likely include a three span bridge structure rather than a single span. The three span bridge may be chosen over a single clear span bridge to minimize the bridge thickness and thus maintain the lowest possible roadway elevation which will reduce grading impacts to local residents.

With the Project, approximately 6 foot tall floodwalls on either bank would tie into the bridge at Newell Road at both the upstream and downstream bridge faces.

Figure 7-17. Pope/Chaucer Street Bridges Plan View

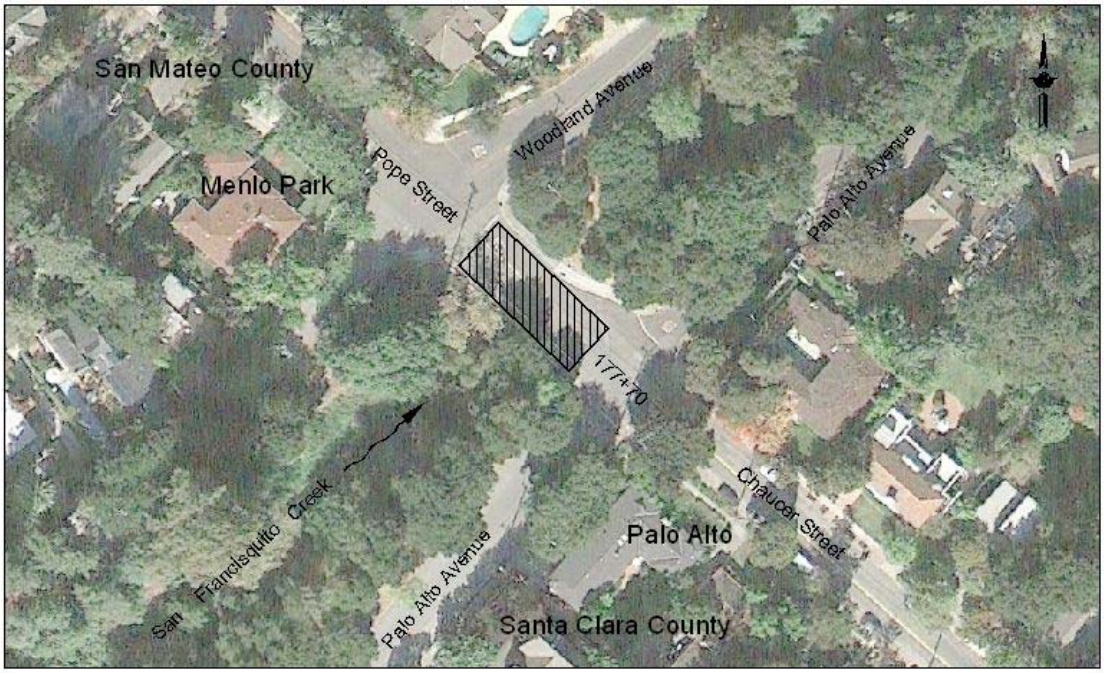
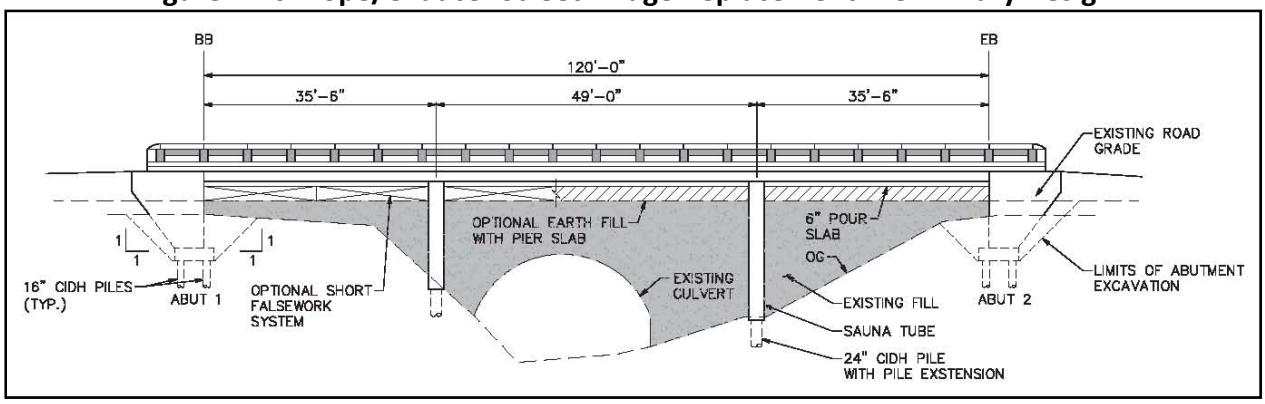


Figure 7-18. Pope/Chaucer Street Bridges Elevation View (circa 1907)

Figure 7-19. Pope/Chaucer Street Bridge Elevation View (current condition)

Figure 7-20. Pope/Chaucer Street Bridge Replacement Preliminary Design



Two Private Pedestrian Bridges Replacement/Modification (Station 149+00, Station 151+80)

Two privately owned single span pedestrian bridges are located in the reach between University Avenue and Pope/Chaucer Street (Figures 7-21, 7-22 and 7-23). The downstream and upstream bridges; both appear to be in good condition; are approximately 5 feet wide; and are 60 feet by 80 feet long, respectively. The date of construction of each bridge is unknown.

With the Project, both bridges may be modified or replaced to pass the two-percent flow event and accommodate approximately 6 foot tall floodwalls on either bank which would tie into the bridges at both the upstream and downstream bridge faces.

Figure 7-21. Private Pedestrian Bridges Plan View

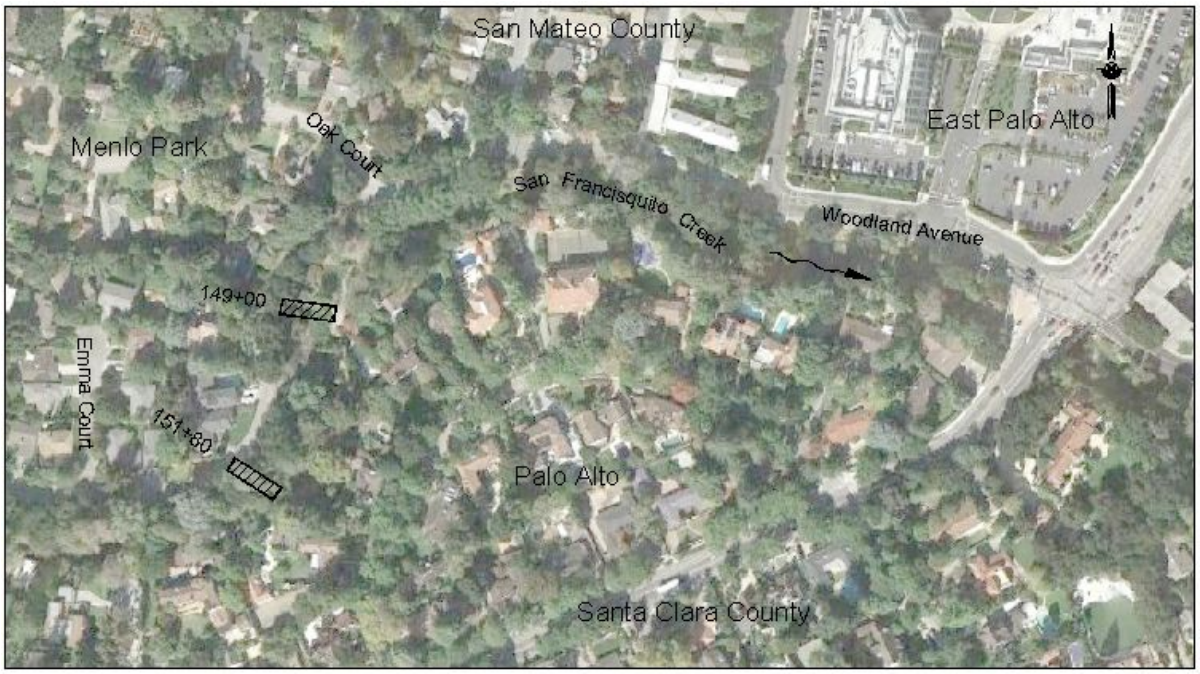


Figure 7-22.Private Pedestrian Bridge Elevation View Looking Upstream

Figure 7-23. Private Pedestrian View Bridge Footing

Without-Project Conditions

Without the Project, the new and enhanced recreation opportunities described above would not be realized.

Methods Used to Estimate Benefits

Enhanced recreation opportunities were estimated based on the lengths of bridges proposed to be repaired or enhanced with project implementation.

Potential Adverse Physical Effects

Potential adverse effects of the Project are expected to be limited to temporary construction impacts. While some trees will be removed for the Project, however they would be replaced appropriately. All impacts will be fully mitigated.

Uncertainty of Benefits

Projected benefits are based on hydrologic and economic modeling and analysis. The following Table summarizes areas of uncertainty and the potential impacts on estimated benefits.

Table 7-8. Uncertainty of Benefits

Uncertainty	Description	Potential Impact on Benefits
Modeling assumptions	Inundation areas and depths are based on hydrologic modeling.	Modeling inaccuracies could result in under- or over-estimates of potential flood damages / benefits.
Structural Inventory	Structural inventory is based on parcel data.	Inaccuracies in assessor parcel data could result in over- or under-estimates of structural damage.
Erosion reduction	Potential erosion reduction benefit is presented as a range.	Actual reductions in erosion depend upon maintenance effectiveness.
Sediment removal requirements	Reduction in sediment removal is based on historic removal requirements near U.S. Hwy 101 alone. Sedimentation reduction benefits to Searsville Lake and Reach 1 have not been estimated.	If the Project does not completely eliminate sedimentation problems near HW 101, reduction could be less than 1,700 cy per year. However, unquantified sedimentation reductions to Searsville Lake and Reach 1 are expected to outweigh overestimates along HW 101.
Recreation benefits	Recreation benefits are estimated based on the planned feet of new and / or enhanced sidewalks and bicycle paths	The actual increase in recreation user days associated with new and enhanced sidewalks and bicycle paths is unknown, and is estimated based on approximate percentages of nearby residents taking advantage of enhanced facilities.
Greenhouse gas reduction benefits	No greenhouse gas reduction benefits are claimed.	Motor vehicle usage would be expected to be reduced due to enhanced bicycle facilities and reduced sediment removal requirements; however, the uncertainty associated with GHG reductions was too great to merit quantification.

Annual Project Physical Benefits

Tables 7-9 through 7-13 (PSP Table 7from Exhibit C of the SWFM PSP) present the physically quantifiable benefits for the San Francisquito Creek Flood Protection Project.

Table 7-9. Annual Project Physical Benefits (Parcels Removed from Floodplain)

Table 7a – Annual Project Physical Benefits Project Name: San Francisquito Creek Flood Protection Project			
Type of Benefit Claimed: Flood protection for 4,500 parcels			
Measure of Benefit Claimed (Name of Units): Number of Parcels Removed from 2% Floodplain			
Additional Information About this Measure:			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2017-2066	4,500	0	4,500
Comments:			

Table 7-10. Annual Project Physical Benefits (Erosion Control)

Table 7b – Annual Project Physical Benefits Project Name: San Francisquito Creek Flood Protection Project			
Type of Benefit Claimed: Erosion Control Repairs			
Measure of Benefit Claimed (Name of Units): Feet			
Additional Information About this Measure:			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2017-2066	0	Up to 6,630	Up to 6,630
Comments:			

Table 7-11. Annual Project Physical Benefits (Sediment Deposition)

Table 7c – Annual Project Physical Benefits Project Name: San Francisquito Creek Flood Protection Project
Type of Benefit Claimed: Reduced Sediment Deposition
Measure of Benefit Claimed (Name of Units): Cubic Yards of Sediment Deposited / Year

Additional Information About this Measure:			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2017-2066	1,700	0	1700
Comments:			

Table 7-12. Annual Project Physical Benefits (Concrete Removal to Enable Establishment of Native Vegetation)

Table 7d – Annual Project Physical Benefits Project Name: San Francisquito Creek Flood Protection Project			
Type of Benefit Claimed: Concrete Removed to Enable Establishment of Native Vegetation			
Measure of Benefit Claimed (Name of Units): Cubic yards			
Additional Information About this Measure:			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2017-2066	0	234	234
Comments:			

Table 7-13. Annual Project Physical Benefits (Enhanced Fish Passage)

Table 7e – Annual Project Physical Benefits Project Name: San Francisquito Creek Flood Protection Project			
Type of Benefit Claimed: Reduced Channel Velocity during the 2 Percent Event			
Measure of Benefit Claimed (Name of Units): ft/s			
Additional Information About this Measure:			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)

2017-2066	8.1	4.2	3.9
Comments:			

Table 7-14. Annual Project Physical Benefits (New and / or Restored Sidewalks and Bicycle Paths)

Table 7f– Annual Project Physical Benefits Project Name: San Francisquito Creek Flood Protection Project			
Type of Benefit Claimed: New or Enhanced Sidewalks and Bicycle Paths			
Measure of Benefit Claimed (Name of Units): Feet			
Additional Information About this Measure:			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2017-2066	0	400	400
Comments:			

APPENDIX 7-1: Draft Planning Study Report for the San Francisquito Creek Flood Protection Project

APPENDIX 7-2: San Francisquito Creek – Preliminary Flood Damage Analysis

APPENDIX 7-3: West Bayshore Inlet 90% Percent Design Drawings