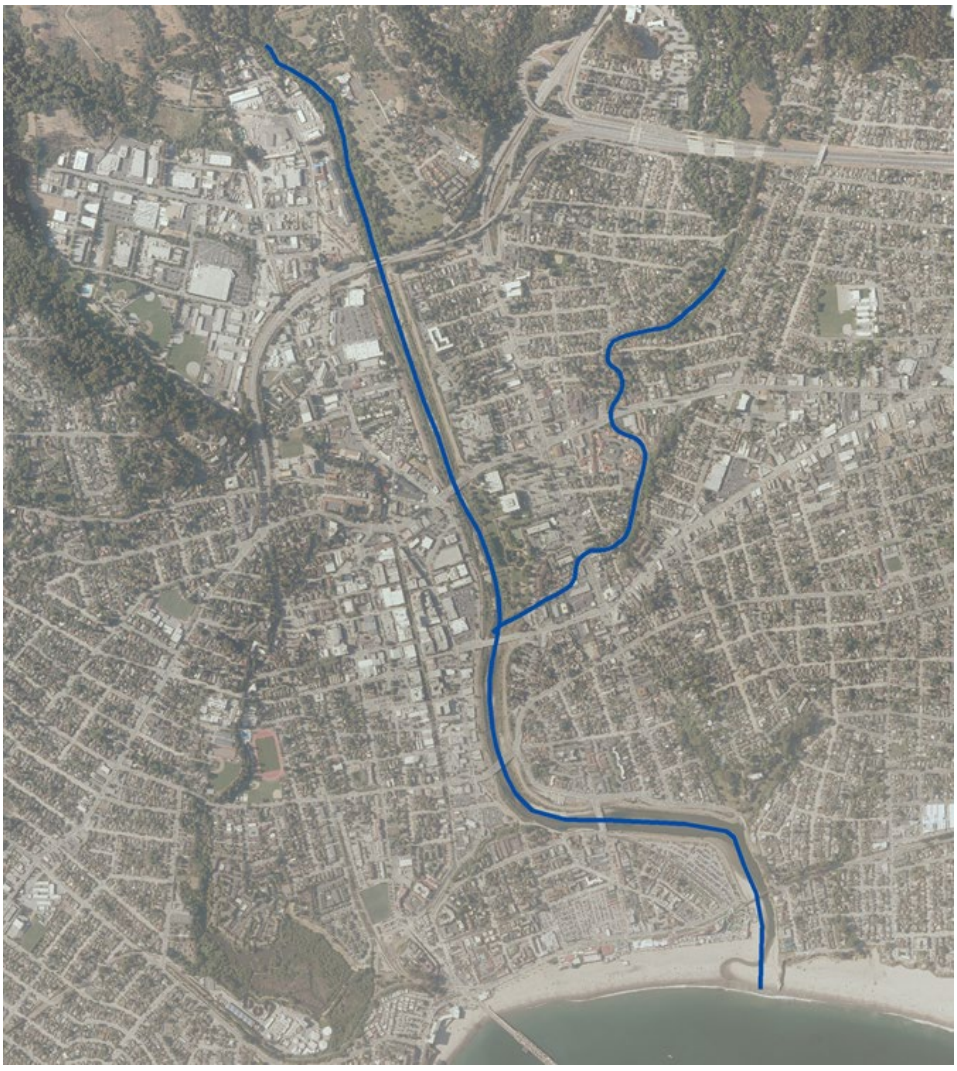
OPERATION, MAINTENANCE, REPAIR, REPLACEMENT AND REHABILITATION (OMRR&R) MANUAL

San Lorenzo River, California



3 July 2020

U.S. Army Corps Of Engineers, San Francisco District

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Acronyms and Abbreviations

AR - Army Regulation
CECW-PB – Corps of Engineers Civil Works Policy Bulletin
CEI - Continuing Eligibility Inspection
CFR - Code of Federal Regulations
CESPD – Corps of Engineers, Southern Pacific Division
EM - Engineer Manual, Emergency Manager, Emergency Management
EOC - Emergency Operations Center
EP - Engineer Pamphlet
ER - Engineer Regulation
ETL – Engineer Technical Letter
FCW - Flood Control Work
FEMA – Federal Emergency Management Agency
FR – Federal Record
HQUSACE – Headquarters, United States Army Corps of Engineers
Highway - Highway
ICW - Inspection of Completed Works
MLLW – Mean Lower Low Water
Modified Project – the portions of the San Lorenzo River Flood Risk Management Project built from 1999 to 2005
OMRR&R - Operation, Maintenance, Repair, Replacement, and Rehabilitation
O&M - Operations and Maintenance
Original Project – the San Lorenzo River Flood Risk Management Project as built in 1959
PCA - Project Cooperation Agreement.
PI – Periodic Inspection
PIR - Project Information Report
PL - Public Law
Project – the San Lorenzo River Flood Risk Management Project as it exists today
RIP - Rehabilitation and Inspection Program
SPN – San Francisco District (Southern Pacific, North)
SPRR – Southern Pacific Railroad
sta. – station (for project stationing)
UPRR – Union Pacific Railroad
USACE – United States Army Corps of Engineers
USC - United States Code
USGS – United States Geological Survey
WRDA - Water Resources Development Act

Changes to the Project or the Manual

Proposed changes to the project or this OMRR&R Manual should be discussed informally with the Inspection of Completed Works (ICW) Program Manger before officially submitting the change. Proposed changes should then be submitted to the District Commander, U.S. Army Corps of Engineers, San Francisco District for evaluation. Third-party proposed changes must be submitted to the Superintendent for the project at the City of Santa Cruz for evaluation and concurrence before officially submitting it to the U.S. Army Corps of Engineers.
Contact information is given below.

District Commander
U.S. Army Corps of Engineers, San Francisco District
450 Golden Gate Avenue
San Francisco, CA 94102
Phone: (415) 503-6700

Inspection of Completed Works Program Manager
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2100 Bridge Way – Bay Model
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Phone: (831) 420-5160

SECTION 1 GENERAL

1.1 PURPOSE, CONTENT, AND LAYOUT OF THE MANUAL

The purpose of this manual is to assist local interests in carrying out their operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) requirements and responsibilities for the San Lorenzo River Flood Risk Management Project (Project). This manual is furnished in accordance with Title 33, Code of Federal Regulations, Section 208.10(a) 10, and follows guidance given in ER 1110-2-401 in its development.

Local interests for the Project are established with the Non-Federal Sponsor – the City of Santa Cruz – who entered into a project cooperation agreement (PCA) for the Project with the Department of the Army, represented by the U. S. Army Corps of Engineers (USACE).

This manual is based on performance specification methods, meaning that the project should be operated and maintained to meet its intended design flow for flood-risk reduction. The content of the manual follows ER 1110-2-401 and includes sections on required OMRR&R activities as well as other sections with pertinent information about the Project.

The manual is divided into two volumes. The first volume (main manual) contains essential information for the Project's operations and maintenance (O&M) and other pertinent information, and should be consulted and carried into the field as needed. The second volume (appendices) contains data that are more detailed and information to be consulted for major repairs, design changes, and other uses.

1.2 PROJECT DESCRIPTION

The San Lorenzo River Project is located in the City of Santa Cruz, Santa Cruz County, on the north side of Monterey Bay in Central California (Figure 1). It provides flood-risk management and habitat restoration along 2.6 miles of the San Lorenzo River and 1.0 mile of Branciforte Creek upstream from the its confluence with San Lorenzo River. The Original Project (herein referred to as the Original Project) was constructed in 1959 to contain a Standard Project Flood (SPF), which was estimated to have a 200-year return period. The Original Project construction along the San Lorenzo River included realigning, deepening, and widening the channel; constructing a concrete floodwall; providing levees with riprap slope protection; riprapping natural banks at critical points for erosion control; placing a concrete lining, fins, and wing-walls at one existing bridge; and providing derrick stone

protection for the piers of another bridge. The construction along Branciforte Creek consisted of realigning, deepening, and widening; and a rectangular or trapezoidal concrete-lined channel, including a fish channel. Additional improvements consisted of an interior drainage system with three pumping stations and alterations to existing bridges and railroad facilities.

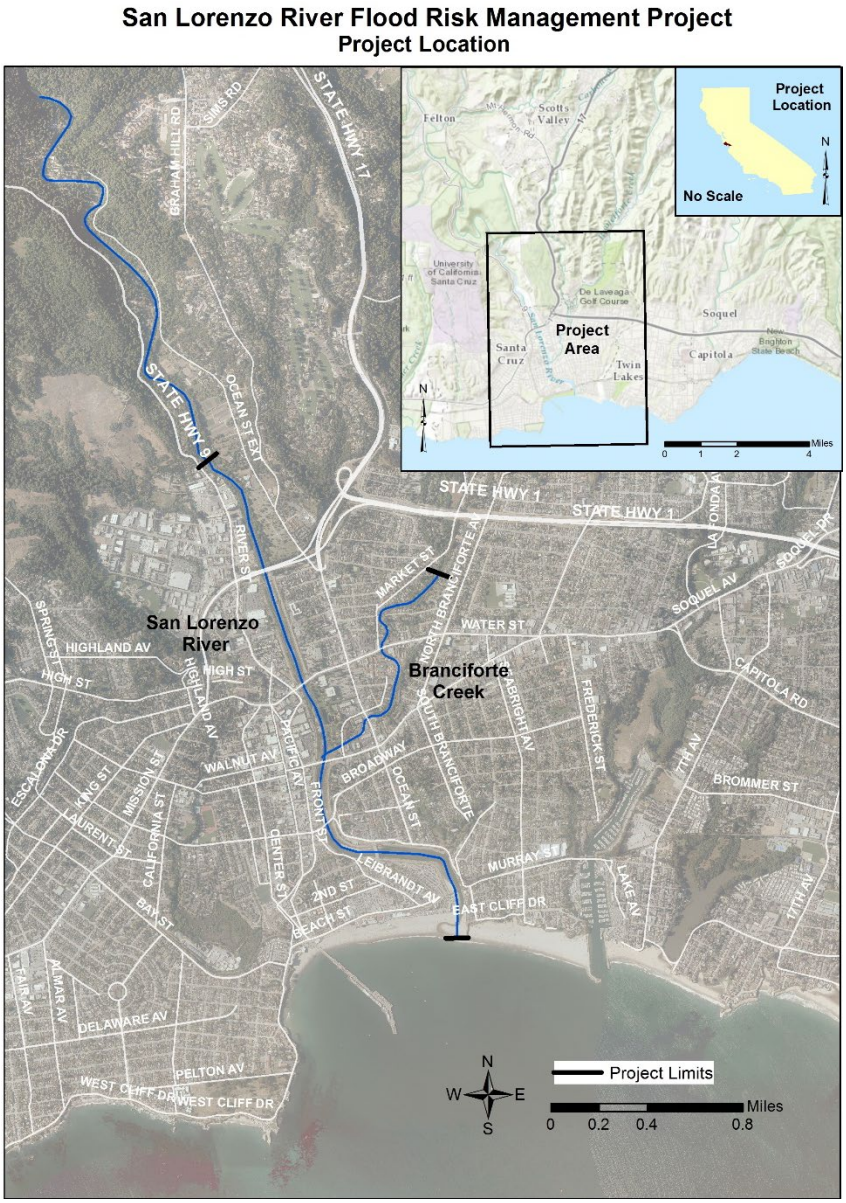


Figure 1. Location map in Santa Cruz, CA

By the early 1990s, the Original Project was estimated to contain only a 30-year return period flood because of heavy sedimentation in the San Lorenzo River channel. Branciforte Creek had also seen a reduction in its performance; it was

estimated to contain only a 25-year return period flood. Modifications to the Original Project were authorized in 1996 to include additional flood-risk management and habitat restoration features. Constructing these project features along the San Lorenzo River between Highway 1 and the Union Pacific Railroad (UPRR) Bridge took place between 1997 and 2005. The Modified Project features between Highway 1 and the UPRR Bridge are herein referred to as the Modified Project.

The Modified Project was constructed under one Section 215 agreement with the Non-Federal Sponsor and three contracts. Contracts 1 through 3 and the Section 215 agreement referred to the following reaches for the Modified Project:

- Reach 1 - Highway 1 to Water Street
- Reach 2 - Water Street to Soquel Avenue
- Reach 3 - Soquel Avenue to Riverside Avenue
- Reach 4 - Riverside Avenue to UPRR Bridge

Project features for the Modified Project included levee improvements, floodwalls, access ramps, bridges, walkways, bank stabilization, modifications to the interior drainage system, and habitat restoration along the San Lorenzo River.

No modifications have been made to the Branciforte Creek Unit since the Original Project was constructed in 1959.

Additionally, levee repairs on the right bank were completed on 17 August 2019. The repairs replaced structural backfill, repaired the bicycle path, and replaced three trees along 224 ft of the right bank immediately upstream of the Water Street Bridge.

This OMRR&R Manual addresses both the Original Project and the Modified Project, with all of their combined features being referred to as 'the Project'.

1.3 As-Built Plans and Project Stationing

Appendix A contains the available as-built plans for the Project.

Project Stationing

Original Project stationing was projected from the project centerline to each bank and levee centerline. Construction drawings and as-built plans for the Modified Project (in Contracts 1–3) contain local stationing, with some stationing

corresponding to the Original Project stations and others not corresponding. Care must be taken when using these drawings in relating one part of the project to another. Modified Project centerline stationing (in Contracts 1–3) show the

- UPRR Bridge as station (sta.) 6+00
- Riverside Avenue Bridge at approximately sta. 28+00
- Laurel Street Bridge at approximately sta. 42+50
- Soquel Avenue Bridge at approximately sta. 55+50
- confluence with Branciforte Creek at approximately sta. 57+50
- Water Street Bridge at approximately sta. 74+00
- Highway 1 Bridge at sta. 100+00.

USACE Inspection Stationing

The stationing used for previous and future USACE routine and periodic inspections uses a reference of the UPRR Bridge as sta. 0+00 with just upstream of the Highway 1 Bridge at sta. 100+00. The USACE National Levee Database Surveys are conducted along the centerline of the project levees and floodwalls, each with different stationing depending upon where the survey begins.

1.4 Project Datum and Datum Compliance

Original Project

The coordinate system used for the design and construction of the Original Project was NAD 27 California Coordinate System, Zone 3. The vertical datum used for design and construction was the National Geodetic Vertical Datum of 1929 (NGVD 29). The vertical datum was labeled on original drawings as 'Mean Sea Level'.

Modified Project

Design drawings for Contracts 1–3 project are based on the horizontal coordinate system of California Coordinate System – 1983 (CCS83-1991.35) and the vertical datum of NGVD 29.

Base-map topography for Contracts 1–3, which was provided by USACE, was based on photogrammetric methods from aerial photographs taken 25 March 1995. The vertical datum for the survey was NGVD 29, and the grid coordinates were the California State Coordinate System, Zone III, 1927 datum. The USACE converted the horizontal grid coordinates to the 1983 datum for use as base maps for the project. Some differences between the 1995 survey data and the actual ground surface elevations are likely.

Datum Compliance

The current recommended horizontal datum and vertical datum for this project are the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD 88), respectively.

A certification of vertical datum compliance has not been completed for the Project. This OMRR&R manual references the NGVD 29 datum unless otherwise stated. All as-built plans and construction drawings for completed project features reference NGVD 29.

For purposes of conducting a performance analysis in 2014 (USACE 2014), elevations were converted from NGVD 29 to NAVD 88 using the software VERTCON, which resulted in an elevation difference of +2.73 ft (i.e., NGVD 29 + 2.73 ft = NAVD 88).

SECTION 2 AUTHORIZATION

2.1 SUMMARY OF PROJECT AUTHORIZATIONS

The original San Lorenzo River flood control project was authorized by the Flood Control Act of 1954, Public Law 780, 83rd Congress, second session, approved on September 3, 1954, for the benefit of navigation and the control of destructive floodwaters. The Original Project was constructed in 1959 to provide protection from a 200-year flood to the City of Santa Cruz, California, by means of general improvement to approximately 13,500 ft of channel on the San Lorenzo River and approximately 5,500 ft of channel on Branciforte Creek.

Major project improvements to the Original Project were constructed between 2001 and 2005. Section 101 of the Water Resources Development Act (WRDA) of 1996, authorized the construction of the Modified Project These improvements were divided into three separate authorized contracts (Contracts 1–3). Contracts 1 and 2 consisted of raising the levees and environmental restoration between the Highway (Highway) 1 Bridge (upstream) and the Union Pacific Railroad (UPRR) Bridge (downstream). Contract 3 consists of the right bank of the levee system between the Laurel Street Bridge (upstream) and the Riverside Avenue Bridge (downstream). Section 306 of PL 106-53 (WRDA 1999) authorized the project modifications to include stream-bank erosion-control measures and bank stabilization, with Federal and non-Federal funding.

Authorization language for the major project phases is listed below.

2.2 ORIGINAL PROJECT (1959) | SECTION 203 OF THE FLOOD CONTROL ACT OF 1954

Flood Control Act of 1954

Sec. 203: The following works of improvement for the benefit of navigation and the control of destructive floodwaters and other purposes are hereby adopted and authorized to be prosecuted under the direction of the Secretary of the Army and the supervision of the Chief of Engineers in accordance with the plans in the respective reports hereinafter designated and subject to the conditions set forth therein: *Provided*, That the necessary plans, specifications, and preliminary work may be prosecuted on any project authorized in this title with funds from appropriations heretofore or hereafter made for flood control so as to be ready for rapid inauguration of a construction program: *Provided further*, That the projects authorized herein shall be initiated as expeditiously and prosecuted as vigorously as may be consistent with budgetary requirements: *And provided further*, That

penstocks and other similar facilities adapted to possible future use in the development of hydroelectric power shall be installed in any dam authorized in this Act for construction by the Department of the Army when approved by the Secretary of the Army on the recommendation of the Chief of Engineers and the Federal Power Commission.

San Lorenzo River Basin: The project for flood protection on San Lorenzo River, California, is hereby authorized substantially in accordance with the recommendation of the Chief of Engineers in House Document Numbered 447, Eighty-third Congress, at an estimated cost of $2,665,000.

2.3 Modified Project, Contracts 1 & 2 (1999-2003) | Section 101 of WRDA 1996

Water Resources Development Act of 1996 Sec 101

PUBLIC LAW 104-303 [S. 640]

OCTOBER 12, 1996

WATER RESOURCES DEVELOPMENT ACT OF 1996

104 P.L. 303; 110 Stat. 3658; 1996 Enacted S. 640; 104 Enacted S. 640

SEC. 101. PROJECT AUTHORIZATIONS.

(a) PROJECTS WITH CHIEF'S REPORTS – Except as provided in this subsection, the following projects for water resources development and conservation and other purposes are authorized to be carried out by the Secretary substantially in accordance with the plans, and subject to the conditions, described in the respective reports designated in this subsection:

(5) SAN LORENZO RIVER, CALIFORNIA.—The project for flood control, San Lorenzo River, California: Report of the Chief of Engineers, dated June 30, 1994, at a total cost of $21,800,000, with an estimated Federal cost of $10,900,000 and an estimated non-Federal cost of $10,900,000 and habitat restoration, at a total cost of $4,050,000, with an estimated Federal cost of $3,040,000 and an estimated non-Federal cost of $1,010,000.

2.4 Modified Project, Contract 3 (1999-2005) | Section 306 of WRDA 1999

Water Resources Development Act of 1999 Sec 306

SEC. 306. SAN LORENZO RIVER, CALIFORNIA.
The project for flood control, San Lorenzo River, California, authorized by section 101(a)(5) of the Water Resources Development Act of 1996 (110 Stat. 3663), is

modified to authorize the Secretary to include as a part of the project stream-bank erosion-control measures to be undertaken substantially in accordance with the report entitled ''Bank Stabilization Concept, Laurel Street Extension'', dated April 23, 1998, at a total cost of $4,800,000, with an estimated Federal cost of $3,100,000 and an estimated non-Federal cost of $1,700,000.

SECTION 3 PROJECT LOCATION, EXTENT, REACHES, AND ACCESS

3.1 PROJECT LOCATION

The San Lorenzo River is located along the central coast of California in the City and County of Santa Cruz, approximately 75 miles south of San Francisco, California. The City of Santa Cruz was incorporated in 1866 and serves as the seat of the County government. The 2010 census recorded a population for the City of Santa Cruz of 59,946. An estimated 94% of the lands within the City of Santa Cruz are developed. The City of Santa Cruz has established goals to develop the remaining undeveloped lands in a manner consistent with protecting natural areas, fostering a regional and citywide jobs-to-housing balance, and meeting the needs of projected increases in population.

3.2 PROJECT EXTENT

The San Lorenzo River Project for flood risk management and habitat restoration purposes extends along 2.6 miles of the San Lorenzo River from the City Weir upstream (approximately ½ mile north of the Highway 1 Bridge) to the UPRR Bridge downstream (near the Monterey Bay). The project also extends along 1.0 mile of Branciforte Creek, a major tributary to the San Lorenzo River, from its confluence with the San Lorenzo River upstream to about Grant and Market Streets.

3.3 PROJECT REACHES

The Project can be grouped into seven reaches **(Figure 2)**. Stations are approximate and based on the Original Project stationing. Reaches are listed in order from upstream to downstream.

Upstream Limit to Highway 1

Sta 128+08 to 100+53

This reach extends from the upstream limit of the Project downstream to Highway 1. The left bank consists of a natural channel bank that has been cut and filled to a 1/3 slope and protected with 18 in of riprap, except for a 10-ft section where the riprap is omitted and the side slope is carried up into the steep bank material. The right bank (looking downstream) consists of a natural channel bank that has been cut and filled to a 1/3 slope and protected with 18 in of riprap, except for an approximately 100-ft section where a concrete floodwall was built to protect the City of Santa Cruz's pump-house building. The channel has been protected from scour for a

distance of 75 ft upstream of the City Weir using a 3-ft protective layer, 12-inch filter blanket, and 15-inch layer of riprap. Construction was completed in 1959.

Highway 1 to Water Street Bridge (Reach 1)

Sta 100+53 to 74+37

This reach consists of earthen levees on both banks from Highway 1 downstream to the Water Street Bridge. This reach also contains a designed initial overtopping section, approximately 1,000 ft long, on the right bank. The downstream end of this section is approximately 500 ft upstream of the Water Street Bridge. In 1995 demolition and reconstruction of the northern two lanes of the Water Street Bridge was conducted to remove the mid pier obstruction. This reach was modified from the Original Project, with construction being completed in 2003.

Water Street Bridge to Soquel Avenue Bridge (Reach 2)

Sta 74+37 to 55+93

This reach consists of natural high ground on the left bank and a concrete floodwall on the right bank from the Water Street Bridge to the Soquel Avenue Bridge. Improvements to this reach included reconstruction and raising of the Soquel Avenue Bridge in 1999-2000. This reach was modified from the Original Project, with construction being completed in 2003.

Branciforte Creek

Sta 0+00 to 59+63

This reach consists of a 5,500-ft long, rectangular or trapezoidal, concrete-lined channel, with a one-ft deep trapezoidal low-flow fish channel notched down its centerline. The channel extends 5,500 ft upstream from the confluence of the San Lorenzo River. Wing walls perpendicular to the centerline tie into the riprap protected levees of the San Lorenzo River. Branciforte Creek has not been modified since the Original Project was constructed in 1959.

Soquel Avenue Bridge to Riverside Avenue Bridge (Reach 3)

Sta 55+93 to 28+20

This reach consists of earthen levees on the left and right banks, and bank stabilization for the downstream 900 ft on the right bank. The Riverside Avenue Bridge was reconstructed and raised in 1991. This reach was modified from the Original Project, with construction being completed in 2005.

Riverside Avenue Bridge to the Union Pacific Railroad Bridge (Reach 4)

Sta 28+20 to 6+20

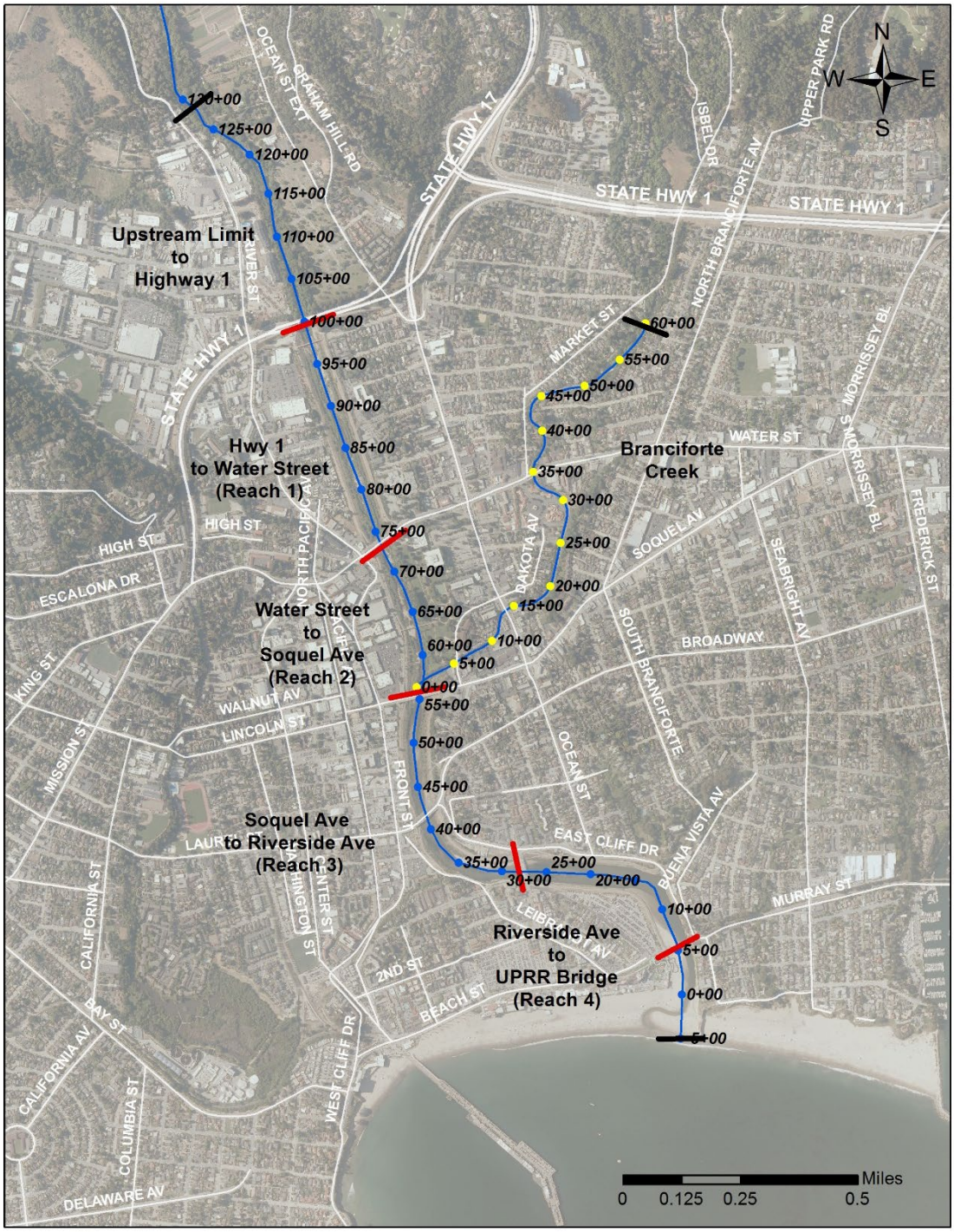
This reach consists of earthen levees on both the right and left banks, with the left bank terminating into high ground at Ocean View Avenue, and the right bank terminating at the UPRR Bridge (also known as the Santa Cruz Riverwalk). This reach was modified from the Original Project, with construction being completed in 2003.

Union Pacific Railroad Bridge to the River Mouth

Sta 6+20 to -5+00

This reach consists of a channel that must be periodically opened prior to the start of the flood season to provide flood conveyance capacity for the Project.

San Lorenzo River Flood Risk Management Project
Reach Boundaries and Project Stationing



Project Limits — Reach Boundaries — Branciforte Creek Stationing — San Lorenzo River Stationing

Figure 2. Reach boundaries and project stationing

3.4 PROJECT ACCESS POINTS: VEHICLE, BICYCLE, AND PEDESTRIAN

Primary vehicle observation and access points for viewing and flood fighting on the San Lorenzo River are located at the project access point locations listed below (Figure 3). Even numbering represents access points on the left bank. Odd numbering represents access points on the right bank.

- 3rd & Beach Streets (1)
- Riverside Avenue Bridge (3)
- Laurel Street Bridge (5)
- Soquel Avenue Bridge (7)
- Water Street Bridge (9)
- Josephine Street (11)
- East Cliff Street (2)
- Riverside Avenue Bridge (4)
- Laurel Street Bridge (6)
- Soquel and Dakota Avenues (8)
- Dakota Avenue at Branciforte Creek (10)
- Water Street Bridge (12)
- From Ocean Street on Felker Street (14)

Figure 3. San Lorenzo River access points

SECTION 4 PERTINENT INFORMATION

4.1 SAN LORENZO RIVER DRAINAGE BASIN

The San Lorenzo River Basin, which lies in the Santa Cruz Mountains north of Monterey Bay, flows into the Monterey Bay at Santa Cruz (

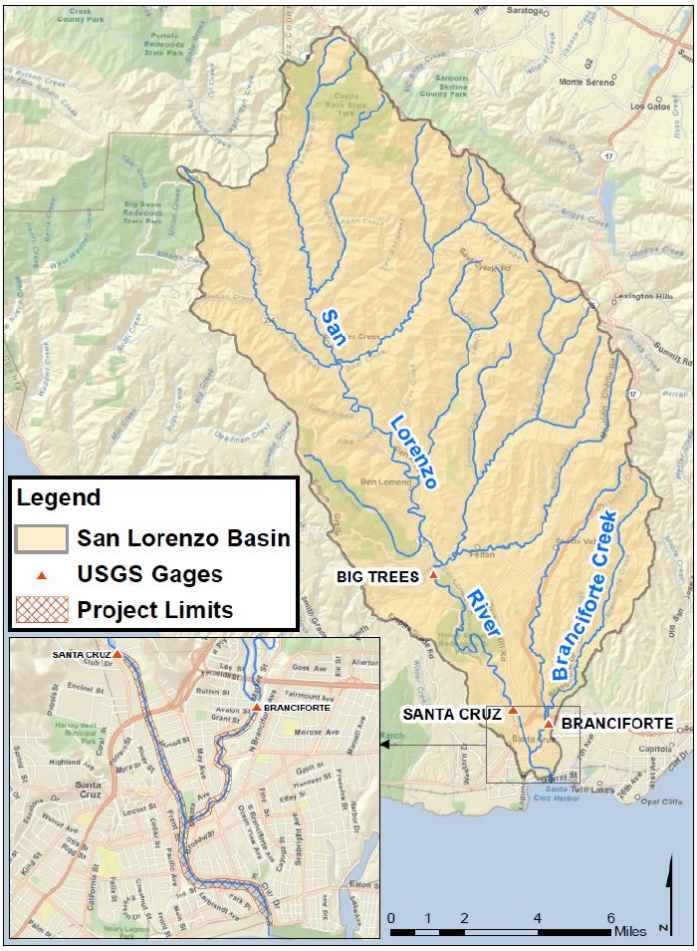


Figure 4**)**. The basin's headwaters are near Castle Rock, about five miles west of Saratoga, California. At the mouth, the San Lorenzo River and its tributaries drain a total area of approximately 135 square miles. Cities and communities within the drainage basin are Santa Cruz, Scotts Valley, Boulder Creek, Ben Lomond, and Felton. The population in the drainage basin is generally concentrated in the narrow valleys along the river and its tributaries.

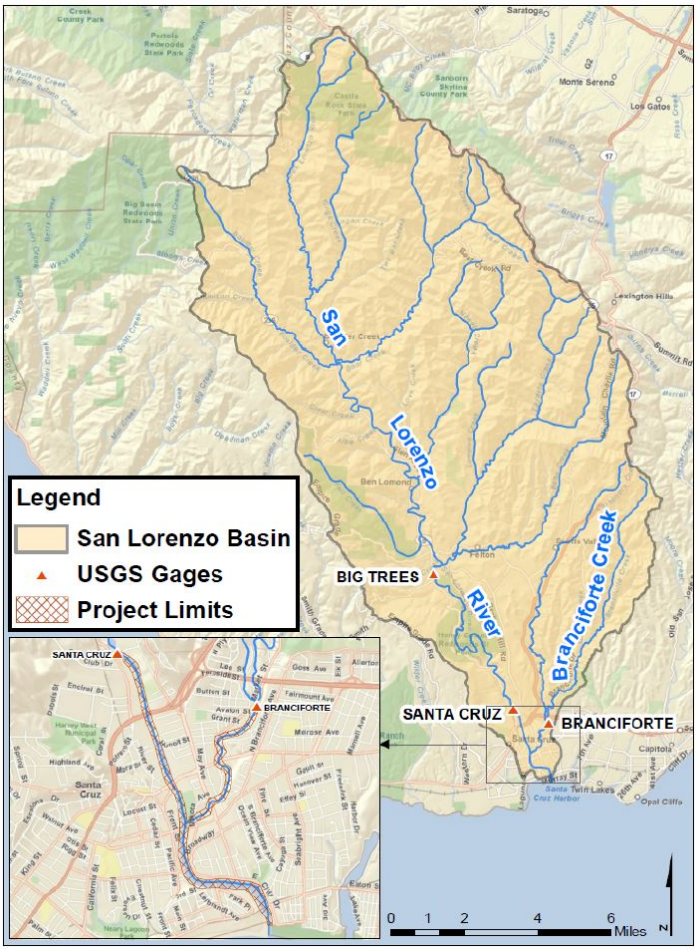


Figure 4. San Lorenzo River watershed and USGS stream gage locations (Branciforte gage in service from 1940 – 1968)

The San Lorenzo River experiences high peak winter flows and low summer flows. Major storms in the basin may last for a period from 24 hours to several days. Because of the short time of concentration, however, rainfall materially affecting the magnitude of peak discharges is confined to less than a duration of 24 hours. Floods in the San Lorenzo River basin are of the "flash" type because the time of concentration at the mouth is only about six hours and on Branciforte Creek at Santa Cruz about three hours.

Table 1 lists basin characteristics for San Lorenzo River at Big Trees (approximately 8 mi upstream of the Project) and Branciforte Creek. The basin characteristics for San Lorenzo River at Big Trees were calculated for a 1973 hydrology study; those for Branciforte Creek were calculated for a 1990 hydrology study.

Table 1 Basin Characteristics

	San Lorenzo River at Big Trees	Branciforte Creek
Drainage area (square miles)	106	17.3
Length of primary watercourse (miles)	20.3	9.7
Average slope of primary watercourse (ft/mile)	109	90
Lag time[1] (hours)	8/7.5	5/4.5
Normal annual precipitation (in)	49.7	40.0
Year calculated	1973	1990

[1] Time from start of runoff to the point where 50% of the ultimate discharge reaches the downstream end of the basin. Values shown reflect the 1990 assumption for existing/future basin development.

4.2 Climate

The drainage basin, which is situated on the windward side of the coast mountain range, has a Mediterranean climate moderated by its proximity to the Pacific Ocean. The warm, dry summers are cooled at times by morning fog at lower elevations. The winters are cool and wet. The City of Santa Cruz has an average annual temperature of about 57 degrees in January to 65 degrees in August. The normal annual precipitation (NAP) at Santa Cruz is above 25 in, with some 80 percent of the total occurring in the five-month period from November to March. Farther inland, where the elevations are higher, the seasonal variation in temperature and annual rainfall is greater because of the influence of topography. In some of the mountainous areas in the basin, the NAP is about 60 in, while over the basin, the NAP is about 47 in. Snow occasionally falls on mountain summits but not in sufficient amounts to affect the magnitude of flood runoff.

4.3 Seismicity

The Project is located in an area of high seismic activity with maximum credible earthquake (MCE) capable of producing a peak ground acceleration (PGA) in excess of 0.5 g (USGS 2011). Liquefaction analyses suggest that the lower portion of the San Lorenzo levee systems is vulnerable to foundation liquefaction induced by earthquake magnitudes greater than 6.0 (USACE 1994).

4.4 USGS Stream Gages

There are two locations in the San Lorenzo River Basin where data is available from active United States Geological Survey (USGS) stream gages (Big Trees and Santa Cruz) and one additional location within the project area where historical gage data is available (Branciforte Creek at Market Street (Table 2; Figure 4). The Big Trees

gage, located in Felton, CA has been in operation since 1936 and has the most comprehensive data record. The gage is located approximately 9.1 miles upstream of Monterey Bay and is not influenced by tidal motion. The Santa Cruz gage is located just downstream of the upstream end of the Original Project.

Table 2 USGS Stream Gage Locations

Location	Drainage Area (square mi)	Stream Gage ID	Period of Record[1]
San Lorenzo River at Big Trees	106	11160500	1937-present
San Lorenzo River at Santa Cruz	115	11161000	1953-present (excluding 1961-1987)
Branciforte Creek at Santa Cruz (located at Market Street)	17.3	11161500	1941-1968

[1]Period of record refers to peak stream flow in each Water Year (annual maximum flow).

4.5 Historical Peak Discharges

Flows in the San Lorenzo River have varied drastically over the past century. Floods of record occurred in 1869, 1890, 1895, 1909, 1911, 1931, 1940, 1941, and 1945. The last led to the authorization of the original San Lorenzo River flood control project by the Flood Control Act of 1954. In 1955, before the project was constructed, the San Lorenzo River reached its highest flow of 30,400 cubic ft per second (cfs) above Branciforte Creek.

Since construction, the most recent flooding of the San Lorenzo River occurred in 1982 when peak discharge was estimated to be 37,000 cfs at the mouth and 31,500 cfs above Branciforte Creek. This flood, which was significantly larger than any other flood that had occurred since construction of the project, was estimated to be approximately a 25-year flood. The two largest historical peak discharges at both USGS gage locations occurred in 1955 and 1982 (Table 3**)**. Although the Santa Cruz gage had a data gap from 1961 through 1987, observers estimated the 1982 peak discharge to be 31,500 cfs (USACE 1994).

Table 3 Peak Discharges Recorded on the San Lorenzo River

Year	San Lorenzo River at Big Trees	San Lorenzo River at Santa Cruz[1]
1955	30,400 cfs	30,400 cfs
1982	29,700 cfs	31,500 cfs

[1] 1982 discharge is estimated

Hydrologic Studies and Design Discharges

Four hydrologic studies – USACE 1957; USACE 1990; USACE 2010 – were conducted for the Project (Table 4).

Table 4 Completed Hydrologic Studies for the San Lorenzo River Project

Report or Study	Year	Results	Purpose
Original hydrology	1957	Determined discharge-frequency curves for the lower reaches of the San Lorenzo River	1957 General Design Memorandum and Reconnaissance Phase of the GI
Report on Standard Project Flood and Intermediate Regional Flood Determination	1973	Determined discharge-frequency curves for the upper reaches of the San Lorenzo River	1973 Flood Plain Information report
Hydrologic Engineering Office Report	1990	Determined Standard Project Flood (SPF) and discharge-frequency curves for the San Lorenzo River Basin for existing and future conditions	1994 feasibility study for the General Investigation (GI)
Hydrology Update San Lorenzo River Basin	2010	Revised the 1990 discharge-frequency curves using 20 years of new data available at the Big Trees gage. Statistical peak discharge decreased, particularly for less frequent events.	Performance assessment of the project improvements constructed in 1999-2005

Hydrology Update (2010)

In 2010, USACE updated the 1990 hydrologic study to include 20 additional years of streamflow data from the San Lorenzo River at the Big Trees stream gage. The 2010 analysis computed an existing condition and a future condition to account for future climate change. The results are generally within 5% of each other, with future conditions being slightly larger than existing conditions. For planning purposes, the future peak discharges should be used (Table 5).

Table 5. Peak Discharges for Future Conditions (used for 2014 Performance Analysis)

Exceedance Probability	Discharge on San Lorenzo River at Big Trees (cfs)	Discharge on San Lorenzo River Upstream of Branciforte Creek (cfs)	Discharge on San Lorenzo River Downstream of Branciforte Creek (cfs)
50%	5,722	6,437	7,663
20%	12,760	14,120	16,540
10%	18,420	20,550	24,210
5%	24,300	26,980	31,410
2%	32,400	36,080	41,590
1%	38,640	42,980	48,930
0.5%	44,930	49,340	55,360
0.2%	53,270	58,820	64,870

4.6 Diversions

The San Lorenzo River watershed has been fully appropriated for water supply between the months of June and October by the California Department of Water Resources. The watershed has dozens of appropriative users, as well as dozens of riparian rights on record. All of the appropriative rights are junior to the City of Santa Cruz's water rights. The largest potential impact to flow in the Lower River is from water diversions, most notably from the City of Santa Cruz diversion at Tait Street, which is located near the upstream end of the Original Project (above Highway 1). The City of Santa Cruz's water right allows diversion of up to 12.2 cfs with no requirement for bypass flows at the Tait Street diversion. The Tait Street diversion provides as much as 75% of the daily summer water demand in the City of Santa Cruz. The City of Santa Cruz Water Department is required to provide bypass flows at Loch Lomond and the Felton Diversion but not at Tait Street.

4.7 Environmental Considerations: Habitat

The San Lorenzo River is divided into three distinct reaches with respect to habitat and ecological communities. Certain habitat areas and species may require special management considerations or protection when conducting O&M on the Project.

Reach 1 - Riverine

Reach 1 of the project is a defined riverine area that stretches from the city weir (upstream of Highway 1) down to the Water Street Bridge. The vegetation in Reach 1 is typified by grassland, mixed riparian forest, and a mosaic of willows and

freshwater marsh species, which occur along the channel. The riparian forest in this area consists mainly of alder, willow, and cottonwood thickets and provides habitat for wildlife movement as the San Lorenzo River changes from a heavily forested area upstream to a heavily managed ecosystem in the project area. This reach provides a variety of fish habitats with morphologic complexity –e.g., fast riffles, channel edge, and small pools – all with annual riparian cover provided by well-developed emergent vegetation. Importantly, the riparian habitat along this reach varies in both height and density and provides cover for avian and terrestrial species. The western pond turtle is also found in this reach.

Reach 2 and the upper half of Reach 3 - Transitional

Reach 2 and the upper half of Reach 3 (from Laurel St. upstream to Soquel Ave.) is known as the transitional area, where the riparian ecosystem transitions into an estuarine ecosystem. The transitional reach vegetation is typified by grassland and riparian forest in the upstream part changing into estuarine wetland with willow, bulrush, and cattail further downstream along the levee toe and into the channel. Adjacent to San Lorenzo Park is a well-developed riffle-pool complex with large cottonwoods and alders providing undercut bank and cover habitat for fish and piscivorous birds. Downstream of the Soquel Avenue Bridge the velocities decrease because of a lower channel slope and tidal effects. The vegetation along the banks enhances rearing habitat for fish and reptiles (e.g., tidewater goby, salmonids, and the western pond turtle) and provides a resting and foraging area for avian species.

The lower half of Reach 3 and Reach 4 - Estuarine

The lower half of Reach 3 and Reach 4 (from Laurel St. downstream to Riverside Avenue) is the estuarine stretch of the river. That stretch consists of mixed scrub, brackish marsh plants, grassland, and small areas of willow thickets. This estuarine reach transitions from a deltaic river mouth in winter to a backwater lagoon in summer following the formation of the summer sandbar at the mouth, isolating the river from daily tidal influxes. The freshwater lagoon that occurs in the summer is a naturally highly productive system, critical habitat for rearing the native salmonid species, critical avian habitat, and potential habitat for the tidewater goby.

4.8 Environmental Considerations: Ecological Communities

Each type of habitat is individually important to the species in the area and provides the unique benefits required to carry the species through each life stage.

Aquatic Communities

The San Lorenzo River has historically supported large populations of the federally threatened steelhead trout (*Oncorynchus mykiss irideus*) and federally endangered coho salmon (*Oncorhynchus kisutch*). Species identified as "threatened" are likely to become endangered within the near future throughout all or a significant portion of its range (Busby et al, 1996; National Marine Fisheries Service, 1997). Both steelhead and coho are anadromous fish, meaning they are born in freshwater streams, migrate to the ocean to mature and return to spawn in their natal stream. The riparian vegetation provides the necessary organic matter to the stream to support salmonid food sources while also serving as a place for avian species to breed and forage. The natural features in the San Lorenzo River are greatly influenced by the vegetation along the banks.

The National Marine Fisheries Service (NMFS) adopted a Final Rule designating steelhead trout in the Central California Coast Evolutionary Significant Unit (ESU) as a federally threatened species effective October 17, 1997 (Busby et al, 1996; National Marine Fisheries Service, 1997). The designation applies only to naturally spawned populations of anadromous forms of *O. mykiss* residing below long-term naturally occurring or man-made impassable barriers. The San Lorenzo River is included in critical habitat designated under the federal listing for all accessible reaches excluding reaches above Loch Lomond Reservoir. Steelhead south of San Francisco Bay are listed as a threatened species by the State of California under the California Endangered Species Act.

Coho salmon historically inhabited most coastal streams in Santa Cruz counties. Coho salmon in the Central California Coast ESU were protected under the Endangered Species Act as a threatened species on December 2, 1996, and changed to an endangered species on June 28, 2005. The tidewater goby (*Eucyclogobius newberryi*), listed as endangered, has also been found in the River. The lamprey eel, a species of concern, is present in the San Lorenzo River. It may eventually be added to the federal endangered species list if populations decline.

Prior to 2000, the City of Santa Cruz created a low-flow channel from Highway 1 downstream to improve fish passage and provide juvenile steelhead rearing habitat. This practice has stopped because of regulatory concerns, but the City of Santa Cruz would consider creating a low-flow channel if it could be permitted.

A deep, properly functioning, freshwater lagoon is important to steelhead as it provides an area where the steelhead can make the transition from freshwater to

saltwater, provide adequate food resources to grow quickly, and allow fish to escape from predators by maintaining refuge habitat. Factors such as suspended sediment, pH, dissolved oxygen (DO), salinity, and water temperature also affect the viability of the lagoon for juvenile survival and optimal rearing. The size and water quality of the lagoon is influenced by the amount of freshwater inflows and the condition of the sandbar at the mouth of the river. During winter months, the sandbar is open and the river is subject to tidal exchange. In the summer months, the combined effect of declining river flow and the creation of a sandbar by summer wave action can result in closure of the river mouth, thus eliminating tidal effects on the lagoon. The Superintendent should ensure proper flood conveyance prior to the start of each flood season (Section 6.1).

Avian Communities

Riparian trees and shrubs are used for nesting, foraging, roosting, protective cover, and migration habitat by many bird species. The complex structure of riparian habitat provides a large diversity of protected nesting substrates (e.g. cavities, tree branches, dense understory), and supports an abundance for food sources including invertebrates, seeds, and vegetation. Seven avian Riparian Focal Species have been identified along the San Lorenzo River. These species have all experienced a reduction in their historic breeding ranges and represent birds that utilize the full range of successional stages in riparian ecosystems. The warbling vireo (*Vireo gilvus*) prefers large deciduous trees associated with a water source, such as the black cottonwoods and box elders on the San Lorenzo River. The yellow warbler (*Dendroica petechia*) (a CA Species of Special Concern), inhabits early successional riparian communities consisting of willows (Salix spp.) and California rose. The black-headed grosbeak (*Pheuticus melanocephalus*) utilizes vertically stratified riparian habitat and needs an area that support shrubs, moderate woody vegetation, and tree species like the red alder. The Swainson's thrush (*Catharus ustulatus*) requires dense to moderate cover, such as the willow thickets along the edge of the levee toe found in Reach 1. In addition to the riparian species listed here the San Lorenzo River is an extremely important resting area and feeding area for marine bird species like the brown pelican (*Pelecanus occidentalis*) (a CA Species of Special Concern) and the Forster's tern (*Sterna forsteri*). The transitional area of the river along Reach 3 provides habitat for birds that live in both fresh and saltwater ecosystems like the great blue heron (*Ardea herodias*), the hooded merganser (*Mergus merganser*), and the western snowy plover (*Charadrius alexandrines*).

Terrestrial Communities

The San Lorenzo River's riparian vegetation plays host to a number of different terrestrial faunal species. Larger mammals along the river's edge include the mule deer (*Odocoileus hemionus*), raccoon (*Procyonlotor*), opossum (*Didelphis virginiana*), striped skunk (*Mephitis mephitis*) and coyote (*Canis latrans*). Small mammals found along the San Lorenzo River include the California ground squirrel (*Otospermophilus beecheyi*), California vole (*Microtus californicus*), Botta's pocket gopher (*Thomomys bottae*) and more. Currently bat species along the riparian corridor are unknown but is likely to include the Yuma myotis (*Myotisyumanensis*), big brown bat (*Eptesicus fuscus*), and Mexican free-tailed bat (*Tadarida brasiliensis*), because of the occurrence of suitable nesting sites and ample foraging habitat. Herptiles found along the San Lorenzo River include the aquatic garter snake (*Thamnophis atratus*, Sierran tree frog (*Pseudacris sierra*), the Western pond turtle (*Actinemys marmorata*) and more. Based on an extensive survey in 1997 and no further sightings, it is unlikely, but possible, that the California red legged frog (*Ranaaurora draytonii*), a federally endangered species, has inhabited the lower San Lorenzo River. The western pond turtle is a CA Species of Special Concern and is targeted for management to increase populations by the City of Santa Cruz. The turtle would be found in the slow water and pools along reaches 2 and 3, usually in warmer months. Western pond turtles hibernate underground in the winter. In the San Lorenzo River there is little protected space for the turtles to hibernate downstream of Highway 1, but sufficient space upstream of the highway.

SECTION 5 CONSTRUCTION HISTORY

There have been multiple episodes of construction since the Original Project was completed in 1959. Repairs to structural features damaged by the Loma Prieta earthquake were completed in 1989. The Modified Project was constructed using one Section 215 agreement and three contracts between 1997 and 2005. The separate construction episodes are described in more detail below.

5.1 ORIGINAL PROJECT (1959)

The construction of the original San Lorenzo River levee systems project started in November 1957 and ended on July 30, 1959. The Original Project constructed general improvement to approximately 13,500 ft of channel on the San Lorenzo River (from the mouth of the river upstream to the city weir) and approximately 5,500 ft of channel on Branciforte Creek. The improvement for the original San Lorenzo River levee systems project consisted of realigning, deepening, and widening the channel; construction of a concrete floodwall; providing levees with riprap slope protection, and riprap protection of natural banks for erosion control at critical points; placing a concrete lining, fins, and wing-walls at one existing bridge; and providing derrick stone protection for the piers of another bridge. The improvement for Branciforte Creek consisted of realignment, deepening and widening, and the provision of a rectangular (trapezoidal in some areas), concrete-lined channel. Protection from local flooding behind the levees was provided by an extensive interior drainage system of open ditches, pipe culverts, gravity drains through the levee, and three pumping stations to be utilized during coincident high river flows and heavy rains. Additional improvements included alterations to existing bridges and railroad facilities

5.2 EMERGENCY REPAIRS (1989-1990)

In 1989, the magnitude 7.1 Loma Prieta earthquake on the Southern Santa Cruz Mountain segment of the San Andreas Fault caused major damage to the San Lorenzo levee system because of earthquake-induced liquefaction of foundation materials. Emergency repairs were completed within three months of the earthquake. Repair work consisted of levee restoration at seven sites, pump station repair at three sites, and gravity-drain repair work at two sites. Most of the repair work consisted of excavating approximately 5,900 ft of levee to the landside ground surface, and reconstructing the levees to their original design cross section using imported and onsite fill, and riprap for riverside bank protection (USACE 1989, USACE 1991). Damages included:

- Open cracks in the levee crests, slopes, and along the toe of the embankment slope
- Slope and crest deformation
- Structural damage within reaches
- Tilting of gravity outlets and broken RCP connections
- Separated discharge pipes, raised or tilted structures, and/or broken electrical service at pump stations

5.3 Section 215 Work (1997)

The Non-Federal Sponsor performed grading and development work along a 900 lineal-ft section of the project between Highway 1 and Josephine Street (on the right bank of Improved Project Reach 1). This work consisted of a floodwall, levee sub-grade drainage system, levee patrol road, levee armoring, and habitat restoration planting and irrigation system.

5.4 Modified Project, Contracts 1, 2, and 3 (1999-2005)

The construction of structural features between the UPRR Bridge and Highway 1 Bridge was accomplished under Contracts 1 and 2. The contracts also included non-structural flood control features and habitat restoration features. The "river bend" portion of the San Lorenzo River (right bank of Stations 25+00 through 37+00 – near Riverside Avenue Bridge) was excluded from Contracts 1 and 2, but was protected with erosion control measures and bank stabilization under Contract 3, which also included habitat restoration features. Constructed features under Contracts 1, 2, and 3 were divided into four reaches (Table 6 [USACE 1999, USACE 2000, USACE 2003]).

Table 6. Constructed Features under Contracts 1, 2, and 3

	Reach Extent	Major Constructed Features
1	Highway 1 to Water Street	Landside toe drains Levee raising A one-ft lower levee initial overtopping section with landside stone erosion protection Habitat restoration
2	Water Street to Soquel Avenue	Flood wall (west bank) Asphalt at County buildings (east bank) Habitat restoration
3	Soquel Avenue to Riverside Avenue	Landside toe drains Levee raising Floodwall Gabion blankets Landside stone erosion protection Crib walls Bank stabilization In-channel habitat restoration Roadway replacement along bank Maintenance path
4	Riverside Avenue to UPRR Bridge	Landside toe drains Levee raising Floodwall Raised gabion walls New pump station (#1B) New outfall and discharge lines at Pump Station 1A Work on Pump Station 2

5.5 Right Bank Levee Repair (2019)

During the August 2012 routine inspection, longitudinal cracking and landside settlement with a vertical offset of up to 4 in, 6-ft wide, 100-ft long, was observed on the right-bank levee crest upstream of the Water Street Bridge. Repair of this section was delayed until funding became available. Construction site work began May 24, 2019 and ended on August 17, 2019 (Table 7). The prime contractor was ROD Construction, of West Sacramento, California. Unsuitable backfill material along the right bank, immediately upstream of the Water Street Bridge was replaced with new structural backfill material from Station 67+68.38 to Station 69+92.79. The paved bicycle path, trees disturbed by the work, and irrigation lines to support the trees were also replaced.

Table 7. Right Bank Levee Repair Construction History Summary

Item	Description
Contract Title:	San Lorenzo River Right Bank Levee Repair Project
Contract Number	W912P719C0005
Contractor	ROD Construction 3960 Industrial Boulevard, Suite 500 West Sacramento, CA 95691-2112
Construction Period	24 May 2019 to 17 August 2019
Contract Performance Period	1 April 2019 to 1 January 2020
Final Contract Amount	$499,271.97
Project Engineer	Gerado Prado
Resident Engineer	David Franzen
Contracting Officer	Theodore Turney

5.6 BRIDGES

When the Original Project was constructed, several bridges constructed in the early 1900's were incorporated into the project. All of the bridges (except for Highway 1 and the UPRR Bridge) have been replaced since 1980 and have new geometric configurations (Table 8). The new bridges allow for greater capacity of flows during floods, primarily because of reducing debris loading on bridge piers.

Table 8. Bridge Improvement Dates

BRIDGE	IMPROVEMENT DATES
Laurel/Broadway Street Bridge	1980
Soquel Avenue Bridge	1984
Water Street Bridge	1985
Water Street, Soquel Avenue, Riverside Avenue, and Laurel Street Bridges (bridges reconstructed or replaced)	1990-1997

Two pedestrian bridges have been constructed along the San Lorenzo River in the project area. The first bridge (sta. 57+50) was constructed in 1960 and the second bridge (sta. 92+00) in 2008.

SECTION 6 PROJECT PERFORMANCE

6.1 OVERVIEW

Existing Project Performance

The Original Project was constructed to contain the Standard Project Flood (SPF) for the City of Santa Cruz, which was estimated to be a 200-year return period flood. The project performance declined because of heavy sedimentation in the San Lorenzo River channel; in the early 1990s, USACE estimated that the return period was less than 30 years. Similarly, the return period was estimated to be 25 years in Branciforte Creek. The Modified Project restored flood conveyance capacity along the San Lorenzo River between Highway 1 and the Union Pacific Railroad (UPRR) Bridge, has a 100-year return period. Based on the updated hydrology (see Section 4), the 100-year return period flood discharge is within ten percent of the original SPF. The noted differences in project performance (i.e. Original Project and Modified Project) are not anticipated to materially affect the operation or maintenance of the Project.

The project performance of the channel above Highway 1 on San Lorenzo River, all of the Branciforte Creek channel, and the San Lorenzo River channel below the UPRR Bridge has not been verified and may not contain the original SPF, because of changes in channel conditions since its original construction in 1959. It should be noted that channel flood flow capacity upstream of Highway 1 is regulated by the channel width, which now matches the width of the arched waterways below the Highway-1 Bridge. However, to ensure project performance, the Superintendent should verify prior to the start of each flood season that the river flows with sufficient hydraulic capacity all the way into Monterey Bay. A limited amount of ponding may be allowed within the system as long as there is sufficient hydraulic capacity to meet the required project performance. Verifying sufficient hydraulic capacity can be accomplished by opening the river mouth to Monterey Bay, performing an analysis showing that at higher flows the river will scour out the channel to obtain the hydraulic capacity needed, installing a culvert to carry sufficient flow into Monterey Bay, or possibly other methods. Any method other than opening the river mouth will require prior approval by the Inspection of Completed Works Program Manager.

. The estimated project performance for the Project (based on a compilation of multiple FEMA data sets (FEMA 2012, FEMA 2017) and information from the 2014 performance report (USACE 2014) is shown in Figure 5. The map shows four different areas:

- The dark blue-striped area is maintained to project standards and will contain the design discharge.
- The light blue areas show locations that will flood from the design discharge for areas that are currently not maintained, or areas that potentially could flood if they do not continue to be maintained to project standards.
- The orange area shows locations that will flood from 100-year return period coastal storm waves, regardless of how well the Project is maintained.
- The yellow areas show locations that will flood for flows greater than the design discharge.

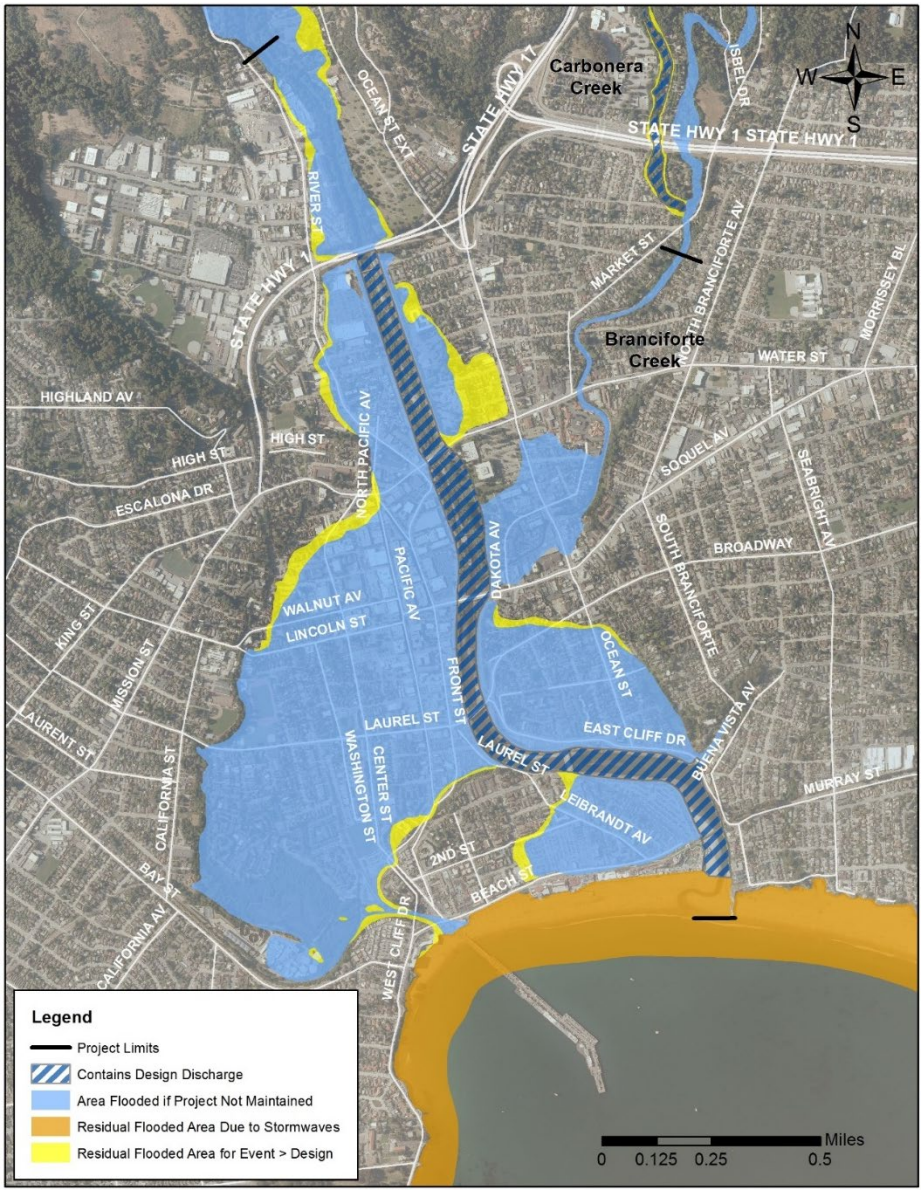


Figure 5 Estimated Project Performance Based On FEMA Data (September 2017)

A study was performed in 2014 (USACE 2014) to evaluate the existing and future safety of the levee systems using probabilistic (risk-based) methodology as required in EC 1110-2-6067 with guidance found in EM 1110-2-1619. The analysis determined that the Modified Project could safely pass the 100-year return period flood (dark blue-striped area).

By following the guidance given in this manual, the Project should be maintained, and restored as needed, such that the entire project will contain the design discharge (i.e. a continuous dark blue-striped area between the project limits). In addition, residences and businesses located within the light blue, orange, and yellow areas should be notified of their flood risk and evacuation plans developed for these areas.

Design Discharges

Table 9 gives design discharges for the Project at specific locations.

Table 9 Design Discharges for the San Lorenzo River FRM Project

Location	Discharge (cfs)
San Lorenzo River Upstream of Highway 1[1]	46,800
San Lorenzo River Below Highway 1 and Upstream of Branciforte Creek Confluence[2]	42,980
San Lorenzo River Downstream of Branciforte Creek Confluence[2]	48,930
Branciforte Creek[1]	8,400

[1] Discharge values from the 1957 Design Memorandum.
[2] Discharge values from the 2010 updated hydrology analysis

6.2 Benefits of Project Functions

Flood Risk Reduction Benefits

The Project is designed and built to contain an approximate 100-year return period flood, and thereby reduce the risk of loss of life and property damage from inundation by floodwaters to the City of Santa Cruz.

Habitat Restoration Benefits

The Project has restored approximately 189 acres of native habitat along the San Lorenzo River, including seasonal and emergent wetlands, and riparian woodland. Habitat has been established or improved for several aquatic, terrestrial, and avian species. This riparian habitat will continue to flourish provided the Project is operated and maintained per the environmental guidance given in this manual

6.3 Initial Overtopping Location

USACE FRM projects must consider measures to assure the least hazardous (damaging) initial overtopping location, superiority to prevent chain reaction failure of leveed cells, or to assure initial overtopping of levee on least hazardous (damaging) side (ER 1110-2-1405). An "initial overtopping section" was designed and constructed as a structural section on the right bank (west bank) between Highway 1 and the Water Street Bridge. This location was chosen based on this area being expected to overtop first (based on the 1994 USACE feasibility study analysis). Because some portions of the Project do not meet their performance discharges, the location for initial overtopping may have moved. Corrective actions should be taken on these portions to meet their performance criteria, or further analyses should be performed on the existing conditions to determine where the initial overtopping of the Project will occur.

6.4 Consequences of Floods Exceeding Present Capacity

Bridges

Water Street, Soquel Avenue, Laurel Street, and Riverside Avenue Bridges will not likely be accessible during floods, and alternative routes will be needed for evacuation. These bridges should be closed to public access prior to flooding, when the river water-surface elevation approaches within two ft of the bridge low chord.

Initial Overtopping Section

Planned overtopping occurring at the initial overtopping section during a flood peak is expected to be of short duration. It will begin as sheet flow into the mobile home park next to the levee. The floodwaters are expected to pond in the mobile home park area up to a depth of three- to three and one-half ft. Interior drainage and flow from upstream of Highway 1 will add to the flooding. If flooding continues, it will run off to Monterey Bay along creek beds. The ponded water will be removed gradually through City storm drains by pumping to the San Lorenzo River after the flood recedes.

Residual Flooding and Coastal Flooding

No project can protect against all floods; there will always be a residual risk of flooding for the City of Santa Cruz. When the performance criteria for the Project are exceeded, inundation of floodwaters will occur in the light blue and yellow areas shown in Figure 5. The extent and depth of flooding will depend on the nature and size of the flood. People living or working in the blue, yellow, and orange shaded

areas should be made aware of the flood-risk hazard and of evacuation plans should a flood occur.

The Project is designed to contain riverine flooding. It is not designed to protect against flooding from coastal storms. The orange area shown in Figure 5 will flood from 100-year return period storm waves, regardless of how well the Project is maintained.

SECTION 7 PROJECT COOPERATION AGREEMENTS

Two resolutions were issued by the City of Santa Cruz describing their assurance for local cooperation on the Original Project. Also, two project cooperation agreements (PCAs), and one amendment to the 1998 PCA have been signed between the Department of the Army and the City of Santa Cruz on the Modified Project. These five documents describe the cooperation requirements of both the local sponsor and the federal government for the entire (Original and Modified) Project.

The City of Santa Cruz issued Resolution No. NS-2123 on March 13, 1956 describing their assurance of cooperation for the Original Project. The City of Santa Cruz then issued a second resolution, Resolution No. NS-2742 on 27 August 1957 further expanding its assurance of cooperation for the Original Project.

The Department of the Army, represented by and through the District Engineer, U.S. Army Engineer District, Sacramento, and the City of Santa Cruz, represented by the City Manager of the City of Santa Cruz, California, entered into a PCA on July 1, 1997 for construction of 900 lineal ft of the west bank levee raising (a portion of the authorized Modified Project). Further, the Department of the Army, represented by and the District Engineer, U.S. Army Engineer District, Sacramento, and the City of Santa Cruz, represented by the City Manager of the City of Santa Cruz, California, entered into a PCA on 15 October 1998 for construction on the remaining work for the Modified Project. The PCA states the Non-Federal Sponsor shall contribute a minimum of 25 percent, but not to exceed 50 percent, of total project structural flood-control costs.

Finally, the October 15, 1998 PCA was amended between the Department of the Army, represented by and the District Engineer, U.S. Army Engineer District, Sacramento, and the City of Santa Cruz, represented by the City Manager of the City of Santa Cruz, California, on 19 March 2004 to add bank protection features to the Modified Project. This PCA states the Non-Federal Sponsor shall contribute a minimum of 35 percent, but not to exceed 50 percent, of total bank-protection costs.

As stipulated by the PCAs, USACE was responsible for project design, construction and prescribing operation-and-maintenance requirements, as well as providing construction-period maintenance of plants to ensure plant survival prior to turnover to the City of Santa Cruz.

The City of Santa Cruz is responsible for ongoing routine operation and maintenance of the project components, as well as repair, replacement and rehabilitation of

associated project features required to meet the performance standards specified in this manual.

Copies of these five documents are included in Appendix B of this manual.

SECTION 8 GENERAL PROVISIONS

8.1 REGULATIONS

General provisions for the operation and maintenance of local flood-protection works are presented in the Code of Federal Regulations, Title 33 – Navigation and Navigable Waters, Chapter II – Corps of Engineers, Department of the Army, Part 208 – Flood Control Regulations, as amended and supplemented. A copy of the regulations is provided in Appendix C. Compliance with these regulations is one of the requirements of local cooperation.

8.2 GENERAL PROVISIONS

Maintenance and operation of structures and facilities shall be in accordance with the general regulations contained in paragraph 208.10 (a):

General.

1) The structures and facilities constructed by the United States for local flood protection shall be continuously maintained in such a manner and operated at such times and for such periods as may be necessary to obtain the maximum benefits.

2) The State, political subdivision thereof, or other responsible local agency, which furnished assurance that it will maintain and operate flood control works in accordance with regulations prescribed by the Secretary of the Army, as required by Law, shall appoint a permanent committee consisting of or headed by an official hereinafter called the "Superintendent," who shall be responsible for the development and maintenance of, and directly in charge of, an organization responsible for the efficient operation and maintenance of all of the structures and facilities during flood periods and for continuous inspection and maintenance of the project works during periods of low water, all without cost to the United States.

3) A reserve supply of materials needed during a flood emergency shall be kept on hand at all times.

4) No encroachment or trespass that will adversely affect the efficient operation or maintenance of the project works shall be permitted on the rights-of-way for the protective facilities.

5) No improvement shall be passed over, under, or through the walls, levees, improved channels, or flood way, nor shall any excavation or construction

be permitted within the limits of the project right-of-way, nor shall any change be made in any feature of the works without prior determination by the District Engineer of the Department of the Army or an authorized representative that such improvement, excavation, construction, or alteration will not adversely affect the functioning of the protective facilities. Such improvements or alterations as maybe found to be desirable and permissible under the above determination shall be constructed in accordance with standard engineering practice. Advice regarding the effect of proposed improvements or alterations on the functioning of the project and information concerning methods of construction acceptable under standard engineering practice shall be obtained from the District Engineer or, if otherwise obtained, shall be submitted for the District Engineer's approval. Drawings or prints showing such improvements or alterations as finally constructed shall be furnished to the District Engineer after completion of the work.

6) It shall be the duty of the Superintendent to submit a semiannual report to the District Engineer covering inspection, maintenance, and operation of the protective works.

7) The District Engineer or an authorized representative shall have access at all times to all portions of the protective works.

8) Maintenance measures or repairs that the District Engineer deems necessary shall be promptly taken or made.

9) Appropriate measures shall be taken by local authorities to insure that the activities of all local organizations operating public or private facilities connected with the protective works are coordinated with those of the Superintendent's organization during flood periods.

10) The Department of the Army will furnish local interests with an Operation and Maintenance Manual for each completed project, or separate useful part thereof, to assist them in carrying out their obligations under this part.

8.3 DEFINITIONS

Definitions of selected terms used in this manual are:

- District Engineer. The term "District Engineer" shall be defined to mean the USACE San Francisco District, District Engineer, or authorized representative;
- Superintendent. The term "Superintendent" shall be defined to mean the person, persons, or agency appointed by the City of Santa Cruz to be directly

in charge of an organization which will be fully responsible for the continuous operation, maintenance, and inspection of the project works;

- Regulations. The term "Regulations" is defined as the regulations presented in the Code of Federal Regulations described above in paragraphs 8-1;
- City. The term "City" shall be defined to mean the City of Santa Cruz (the Non-Federal Sponsor).

8.4 RESPONSIBILITIES

City of Santa Cruz

The City shall operate, maintain, repair, replace, and rehabilitate the functional portions of the Project, at no cost to the Government, in a manner compatible with the Project's authorized purposes and in accordance with applicable Federal and State laws as provided in the PCAs, and specific directions prescribed by the Government in the OMRR&R Manual and by subsequent amendments thereto. In this case, "functional portions" are portions covered in this manual.

Federal Government

The City hereby gives the Government a right to enter, at reasonable times and in a reasonable manner, upon property that the Non-Federal Sponsor owns or controls for access to the Project for the purpose of inspection and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the Project. If an inspection shows that the Non-Federal Sponsor for any reason is failing to perform its obligations under this Agreement, the Government shall send a written notice describing the non-performance to the Non-Federal Sponsor. If, after 30 calendar days from receipt of notice, the Non-Federal Sponsor continues to fail to perform, then the Government shall have the right to enter, at reasonable times and in a reasonable manner, upon property that the Non-Federal Sponsor owns or control for access to the Project for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the Project. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Government shall relieve the Non-Federal Sponsor of responsibility to meet the Non-Federal Sponsor's obligations as set forth in the PCA, or to preclude the Government from pursuing any other remedy at law or equity to ensure faithful performance pursuant to this Agreement.

District Engineer

The District Commander of the San Francisco District, USACE is the authorized engineer, or authorized representative for the federal government. The following assistance shall be furnished by the District Engineer to the local interest:

- Furnish "As Constructed" or best available drawings of the project works;
- Make periodic inspections of the project works and notify the local interests of any repairs or maintenance measures which the District Engineer deems necessary in addition to measures taken by the Superintendent;
- Submit a request to the Office of the Chief of Engineers regarding all cases of noncompliance, with full details thereof, for determination of corrective measures to be taken;
- Make prior determination that any proposed encroachment, improvement, excavation, construction within the rights-of-way, or alteration of the project works will not adversely affect the functioning of the protective facilities;
- Assist the local interests as may be practicable in their duties of ascertaining storm developments having flood-producing potential and assembling flood-fighting operations to the extent permitted by existing laws and regulations; and
- Assist, advise, or otherwise suggest the course of action to be taken if the project works has sustained serious damage which is beyond the capability of the local interest to repair.

Superintendent

In accordance with the provisions of the Regulations, the general duties of the Superintendent include the following:

Key Personnel

Key personnel shall be trained so regular maintenance work is performed efficiently and to insure that unexpected problems related to flood control may be handled in an expeditious and orderly manner. The Superintendent should have available the names, addresses and telephone numbers of all key personnel and a reasonable number of substitutes. These persons shall, in turn have similar data on all of the personnel that will be necessary for assistance in the discharge of their duties. The organization of key personnel shall include the following:

- in case of the Superintendent's absence or indisposition an assistant authorized to act;
- Work supervisors in sufficient number to lead maintenance patrol work of the levee, inspect the channel, and operate the structures properly during flood

periods. High qualities of leadership and responsibility are necessary for these positions;

Filing

The Superintendent shall maintain a file of reports, records and drawings concerning the Project works and have readily available at all times to the District Engineer.

Preventing Encroachment & Trespassing

In accordance with the provisions of Regulations 208.10(a)(4) above, no encroachment or trespass that will adversely affect the efficiency of the operation and maintenance of the project works shall be permitted on the rights-of way for the protective facilities. The Superintendent, therefore, shall cause notices to be posted at places along the project rights-of-way directing public attention to this regulation. The Superintendent shall take whatever authorized actions necessary to remove any unauthorized encroachment or to prosecute the trespassers.

Permits for Right-of-Entry or Construction

Permits for temporary Right-of-Entry shall be issued by the City of Santa Cruz. The Superintendent shall review such permits and ensure they are cleared in a timely manner so there is no interference with necessary project access or operation.

Coordination

In accordance with the provisions of Regulations 208.10(a) (9) above, the Superintendent, during floods, shall coordinate the functions of all agencies, both public and private, that are connected with the protective works. Arrangements shall be made with the local law enforcement agencies, street departments, railroads, utilities and any other concerned local interests for developing a coordinated flood-fighting program. An outline of this program shall be filed with the District Engineer.

Improvements, changes, and alterations

In accordance with the provisions of Regulations 208.10(a) (5) and (8) above, the Superintendent shall be fully responsible for maintenance, repairs, and the methods used to accomplish them. All changes are subject to the provisions in Section 9. All repairs shall be made in accordance with standard engineering practice, to line, to grade, and in accordance with details shown on the "As-Built" or best available drawings for the project works. No change or alteration shall be made in any feature of the project works without prior determination by the City and the District Engineer that such alteration will not adversely affect the stability and functioning of

the protective facilities. Plans and specifications of all changes or alterations that may be proposed by the Superintendent shall be submitted to the City for forwarding to the District Engineer for investigation and approval before commencement of the work.

Field Inspections

The Superintendent is responsible for insuring periodic monitoring and required inspections of the Project are conducted. These efforts shall determine the condition of the various components of the Project and disclose any areas that require repair or replacement. The Project should be walked and visually inspected before the beginning of the flood season and immediately after each high-water period.

Inspections shall be made at the following times:

- Immediately prior to the beginning of the flood season
- Immediately after each major high water period
- Following major flood events, earthquakes, and other emergencies based upon the criteria described in Section 12
- Otherwise, at intervals not exceeding 90 days

8.5 Permits for Channel Maintenance

Maintenance of the improved channel will be required to ensure it maintains its required hydraulic capacity and structural stability (i.e. no excessive down-cutting or side-slope sloughing of the channel). Certain maintenance activities may or may not be needed to maintain the channel – such as removal of sediment and debris, bank repair, and control of vegetative growth. Pump-station outfalls along the San Lorenzo River also must be maintained. The City, or the approved designee, shall continue to monitor shoaling in the channel to determine the need for long-term usage permits to address shoaling. Whenever required, the Superintendent shall obtain all necessary permits for such activities.

8.6 Permits for Sediment Disposal

The Superintendent is responsible for maintaining the flood-control capacity of the channel. This responsibility includes all aspects of maintenance such as obtaining any additional rights-of-way and necessary permits for all activities, including disposal areas for sediment removal, with sediment removal being conducted on an as-needed basis to maintain the design grade of the channel.

8.7 Environmental Permits

The City is required to perform all OMRR&R under this manual. The Superintendent must obtain all necessary environmental permits needed for the work prior to performing the work.

8.8 Permits for Encroachment

Permits for temporary Right-of-Entry and temporary minor encroachments on local flood-protection features and the associated rights-of-way are controlled by the City in accordance with the Regulations. No encroachment or trespass that will adversely affect the efficient operation or maintenance of the project works shall be permitted on the rights-of-way for the protective facilities.

If the use proposed by an applicant could result in damage to the rights-of-way or associated flood-control structures, it is suggested that the applicant be required to post a bond to protect the local interests from any costs for removal, repair, or restoration. This bond will guarantee that the permittee faithfully meets conditions imposed by the approved permit. In such cases, the permit would state the amount and conditions of the bond.

Structures may have to be moved and relocated for maintenance or flood-control operations. Permits for right of entry should stipulate a condition of addressing any relocations.

8.9 Modification and Alteration of Projects (Section 408 Permits)

Any significant alteration or modification to either a locally or federally maintained USACE project must be approved by the Chief of Engineers under 33 USC 408 as described in Engineer Circular (EC) 1165-2-216 (2016): Policy and Procedures Guidance for Processing Requests to Alter USACE Civil Works Projects pursuant to 33 USC 408 and related interim guidance. Modifications to a USACE project beyond those necessary to properly operate the project or to minimize maintenance costs as well as any significant alteration or modification requested by an non-federal interest for their own benefit also requires the Chief's approval under 33 USC 408.

SECTION 9 OPERATION, MAINTENANCE, AND INSPECTION

9.1 GENERAL

In accordance with the Project Cooperation Agreement, it is the responsibility of the Superintendent, appointed by the City of Santa Cruz, to maintain and operate the project in accordance with federal regulations and this OMRR&R manual. Project operation and maintenance shall include all necessary measures to prevent impairment of the hydraulic capacity of the channel of floodway. Recommendations below are based on federal regulations and the judgment of professional engineers familiar with the Project.

9.2 LEVEES

Operation of Levees

Operation of levees shall be in accordance with the regulations contained in paragraph 208.10 (b) (2) which states:

Operation. During flood periods, the levee shall be patrolled continuously to locate possible sand boils or unusual wetness of the landward slope and to be certain that:

- There are no indications of slides or sloughs developing
- Wave wash or scouring action is not occurring
- No low reaches of leave exist that may be overtopped
- No other conditions exist that might endanger the structure

Appropriate advance measures will be taken to insure the availability of adequate labor and materials to meet all contingencies. Immediate steps will be taken to control any condition that endangers the levee and to repair the damaged section.

Note that item (iii) does not apply to the intentional initial overtopping section of this project, which is located along the right bank between Highway 1 and Water Street.

Maintenance of Levees

Maintenance and inspection of levees shall be in accordance with the regulations contained in paragraph 208.10 (b) (1), which states:

Maintenance. The Superintendent shall provide at all times such maintenance as may be required to insure serviceability of the structures in time of flood. Measures shall be taken to promote the growth of vegetative cover, exterminate burrowing

animals, and to provide for routine mowing of the grass and weeds, removal of wild growth and drift deposits, and repair of damage caused by erosion or other forces. Where practicable without reducing flood capacity, measures shall be taken to retard bank erosion by planting willows or other suitable growth on areas riverward of the levees. Periodic inspections shall be made by the Superintendent to insure that the above maintenance measures are being effectively carried out and, further, to be certain that:

- No unusual settlement, sloughing, or material loss of grade or levee cross sections has taken place;
- No caving has occurred on either the land side or the river side of the levee which might affect the stability of the levee section;
- No seepage, saturated areas, or sand boils are occurring;
- Toe drainage systems and pressure relief wells are in good working condition, and that such facilities are not becoming clogged;
- Drains through the levees and gates on said drains are in good working condition;
- No revetment work or riprap has been displaced, washed out or removed;
- No action is being taken, such as burning grass and weeds during inappropriate seasons which will retard or destroy the growth of sod;
- Access roads to and on the levee are being properly maintained;
- Gates are in good condition;
- Crown of levee is shaped so as to drain readily and roadway thereon, if any , is well shaped and maintained;
- There is no unauthorized grazing, camping, or vehicular traffic on the levees;
- Encroachments are not being made on the levee right-of-way that might endanger the structure or hinder its proper and efficient functioning during times of emergency.

Such inspections shall be made prior to the beginning of the flood season; following each major high-water period, and otherwise at intervals not exceeding 90 days, and such times as may be necessary to insure the best possible care of the levee. Immediate steps will be taken to correct dangerous conditions disclosed by such inspections. Regular maintenance repair measures shall be accomplished during the appropriate season as scheduled by the Superintendent.

9.3 Flood Walls

Operation of Flood Walls

Operating flood walls shall be in accordance with the regulations contained in paragraph 208.10 (c) (2), which states:

Operation. Continuous patrol of the wall shall be maintained during flood periods to locate possible leakage at monolith joints or seepage underneath the wall. Floating plants or boats will not be allowed to lie against or tie up to the wall. Should it become necessary during a flood emergency to pass anchor cables over the wall, adequate measures shall be taken to protect the concrete and construction joints. Immediate steps shall be taken to correct any condition that endangers the stability of the wall.

Maintenance of Flood Walls

Maintenance and inspection of flood walls shall be in accordance with the regulations contained in paragraph 208.10 (c) (1) which states:

Maintenance. Periodic inspections shall be made by the Superintendent to be certain that:

- No seepage, saturated areas, or sand boils are occurring;
- No undue settlement has occurred which affects the stability of the wall or its water tightness;
- No trees exist, the roots of which might extend under the wall and offer accelerated seepage paths;
- The concrete has not undergone cracking, chipping, or breaking to an extent which might affect the stability of the wall or its water tightness;
- There are no encroachments upon the right-of-way which might endanger the structure or hinder its functioning in time of flood;
- Care is being exercised to prevent accumulation of trash and debris adjacent to walls, and to insure that no fires are being built near them;
- No bank-caving conditions exist riverward of the wall which might endanger its stability;
- Toe drainage systems and pressure relief wells are in good working condition, and that such facilities are not becoming clogged.
- Such inspections shall be made immediately prior to the beginning of the flood season, immediately following each major high water period, and otherwise at intervals not exceeding 90 days. Measures to eliminate

encroachments and effect repairs found necessary by such inspections shall be undertaken immediately. All repairs shall be accomplished by methods acceptable in standard engineering practice.

9.4 CHANNELS AND FLOODWAYS

Operation of Channels and Floodways

Operation of channels and floodways shall be in accordance with the regulations contained in paragraph 208.10 (g) (2) which states:

Operation. Both banks of the channel shall be patrolled during periods of high water, and measures shall be taken to protect those reaches being attacked by the current or by wave wash. Appropriate measures shall be taken to prevent the formation of jams of debris. Large objects that become lodged against the bank shall be removed. The improved channel or floodway shall be thoroughly inspected immediately following each major high-water period. As soon as practicable thereafter, all snags and other debris shall be removed and all damage to banks, riprap, deflection dikes and walls, drainage outlets, or other flood control structures repaired.

Additional operational measures to be taken are as follows:

Continuous observation will be made of the Highway 1, Water Street, Soquel Avenue, Laurel Street, Riverside Avenue, and UPRR Bridges to be certain that all floating debris passes under the bridge and does not cause a jam. Debris that lodges at a bridge will be removed by truck crane or similar equipment.

Maintenance of Channels and Floodways

Maintenance and inspection of channels and floodways shall be in accordance with the regulations contained in paragraph 208.10 (g) (1) which states:

Maintenance. Periodic inspections of improved channels and floodways shall be made by the Superintendent to be certain that:

- The channel or floodway is clear of debris, weeds, and wild growth;
- The channel or floodway is not being restricted by the depositing of waste materials, building of unauthorized structures or other encroachments;
- The capacity of the channel or floodway is not being reduced by the formation of shoals
- Banks are not being damaged by rain or wave wash, and that no sloughing of banks has occurred;

- Riprap sections and deflection dikes and walls are in good condition;
- Approach and egress channels adjacent to the improved channel or floodway are sufficiently clear of obstructions and debris to permit proper functioning of the project works. Such inspections shall be made prior to the beginning of the flood season and otherwise at intervals not to exceed 90 days. Immediate steps will be taken to remedy any adverse conditions disclosed by such inspections. Measures will be taken by the Superintendent to promote the growth of grass on bank slopes and earth deflection dikes. The Superintendent shall provide for periodic repair and cleaning of debris basins, check dams, and related structures as may be necessary.

Channel Conveyance Capacity - Removal of Excess Sediment and Vegetation

If sedimentation, vegetation, and/or debris in the channel affects the conveyance capacity and impairs the ability of the Project to function as designed, the Superintendent is responsible for removing this excessive shoaling in accordance with best management practices, environmental regulations, and other permitting considerations.

Whenever visual observations suggest possible reduced conveyance capacity in the channel, then sediment survey stations can be used to verify and quantify the excessive shoaling. Sediment survey stations are fixed cross-section locations in the channel used to evaluate the changes in the cross-sectional areas because of sediment deposition, vegetation growth, debris, and erosion in the river channel. These stations are used to estimate the impact of sediment, vegetation, debris, and erosion on channel flood-flow capacity and to identify maintenance needs.

The City of Santa Cruz has been collecting cross-section data at the listed sediment survey stations periodically since 2001 (Figure 6; Table 10). Use of these fixed stations will aid in understanding long-term shoaling issues and can be supplemented with additional survey stations as needed to provide more detail of an observed excessive sediment area. It is recommended that an additional survey station be added upstream of Highway 1 as needed for observed excessive shoaling. Additionally, a hydraulic model has been provided to the City of Santa Cruz that can be used to check channel capacity for the design event against each new survey. It is highly recommend that this hydraulic model be used after each periodic survey to confirm channel capacity or delineate areas requiring removal of excess shoaling. At a minimum, data at six cross-sections (shown in **bold** in Table 10) should be taken for every survey conducted.

An assessment of sediment survey station data collection needs should be made annually, after the flood season, to determine if any sediment removal or vegetation and debris clearing may be required. The survey data and estimates of channel capacity shall be documented and included in the semiannual report.

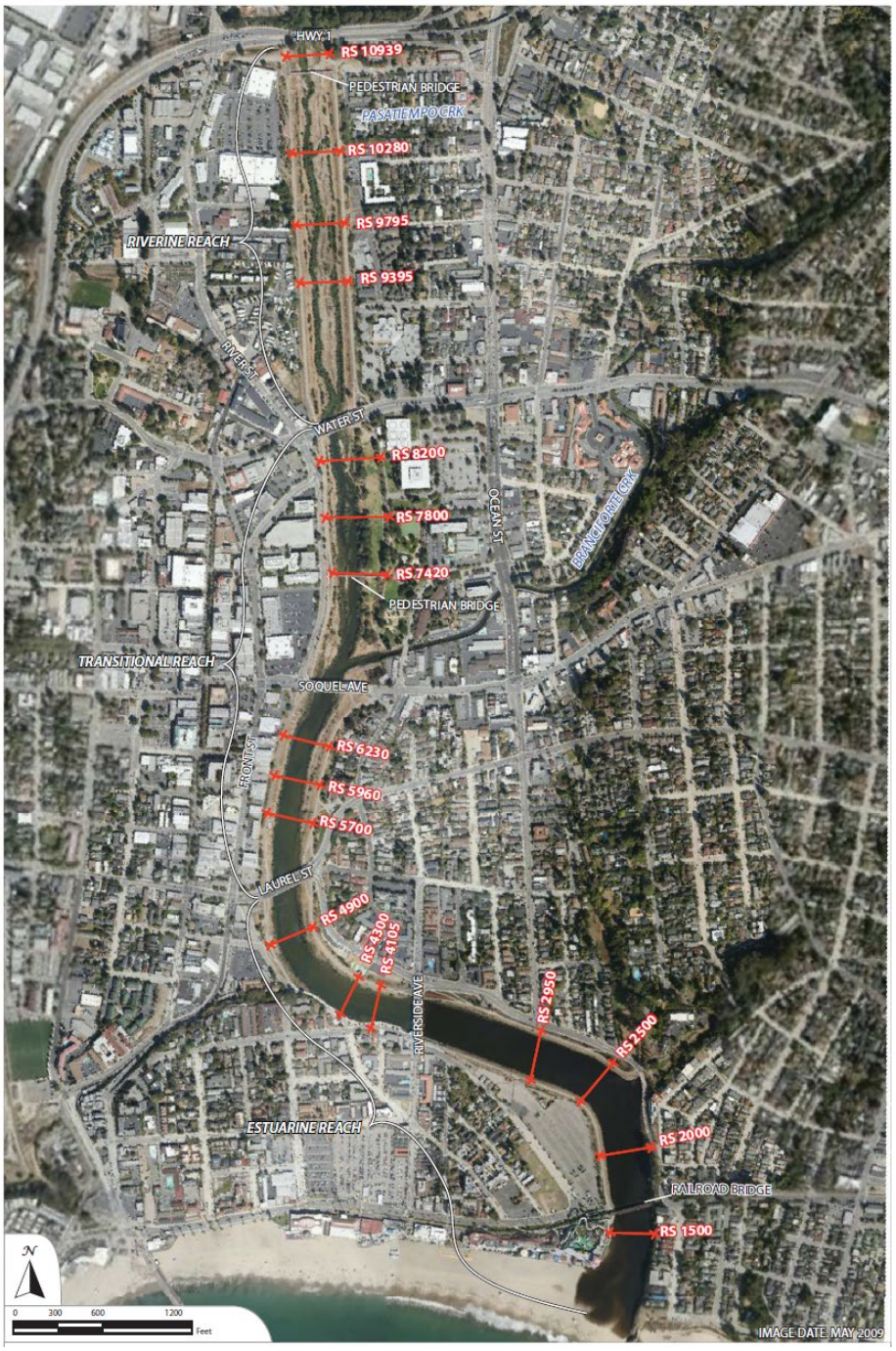


Figure 6. Locations of cross-sections used for the city's monitoring program (Waterways Consulting 2017)

Table 10 Locations of Cross-Sections for Monitoring of Excessive Shoaling

Station #	River Station[1]	Hydraulic Model Station	Bridge (for spatial reference)
16	5+00	1,500	
	6+05		UPRR
15	10+00	2,000	
14	15+00	2,500	
13	19+50	2,950	
	28+49		Riverside Avenue
12	31+05	4,105	
11	33+00	4,300	
10	39+00	4,900	
	41+50		Laurel Street
9	47+00	5,700	
8	49+60	5,960	
7	52+30	6,230	
	56+00		Soquel Avenue
6	64+20	7,420	
5	68+00	7,800	
4	72+00	8,200	
	74+84		Water Street
3	83+95	9,395	
2	87+95	9,795	
1	92+80	10,280	
0	99+39	10,939[2]	
	101+19		Highway 1
	116+00	12,600	

[1] River stationing is based (approximately) on Original Project centerline stationing. Monitoring stationing was adjusted for running HEC hydraulic models (which did not allow negative cross-section numbering).

[2] Location added in 2004

In the summer, the low-flow channel expands across no more than about 10 ft of the 200-ft-wide channel. Sediment and vegetation can be removed "in the dry", which is

relatively inexpensive and more easily permitted by regulatory agencies, as there is no impact to aquatic environments and the riparian impacts can be minimized.

Recommended Sediment and Vegetation Management Prescriptions

Regardless of the option chosen for sediment, vegetation, and debris removal, the base bed profile is the 2011 bed-elevation profile used in the project-performance evaluation (USACE 2014). The volume excavated from the channel should be close in value to the volume needed to restore the bed-elevation profile to the 2011 bed-elevation profile.

- Option 1: Sediment, vegetation, and debris removal should be conducted during the next maintenance cycle whenever the hydraulic model indicates the design event's water surface elevation is less than 0.5 ft below the levee crest, at any of the surveyed locations given in Table 10
- Option 2: Table 11 may be used to guide the frequency of sediment and vegetation removal within the channel to maintain flood channel performance:

Table 11. Recommended Sediment Management Prescriptions

Reach	Sediment and Vegetation Management Prescription	Frequency
Riverine Reach	Instream bars should be disked annually to loosen root materials and promote scour. Existing cross-channel scour areas should be encouraged through disking and manipulation of discarded root wads/vegetation material. Sediment removal areas should be defined by cross section and modeling analysis and should avoid important salmonid habitat areas including riffles, pools, and runs.	Annually
Transitional Reach	Disking on the west bank should occur east of levee toe up until outside edge of a 5-ft vegetation buffer. Existing cross-channel scour areas should be encouraged through disking and manipulation of discarded root wads/vegetation material.	As determined by cross-section monitoring
Estuarine Reach	Sediment management or removal is not necessary in this reach, unless the river mouth has closed. The river mouth should be opened prior to the start of flood season each year.	Annually

Channel Excavation Design Options

Two options may be considered for the design of channel excavation when channel conveyance capacity has been reduced to where it is required. Other designs for channel excavation can be considered on a case-by-case basis by contacting the Inspection of Completed Works Program Manager at the San Francisco District.

- Option 1: **Conventional Channel Excavation Design.** The excess sediment is excavated across the width of the channel to the 2011 bed-profile elevation.
- Option 2: **Geomorphic Bankfull Channel Excavation Design.** A narrower, deeper, geomorphic bankfull channel is excavated within a portion of the channel that restores the required channel conveyance capacity and potentially reduces the amount of future excavation required for the Project (Figure 7).

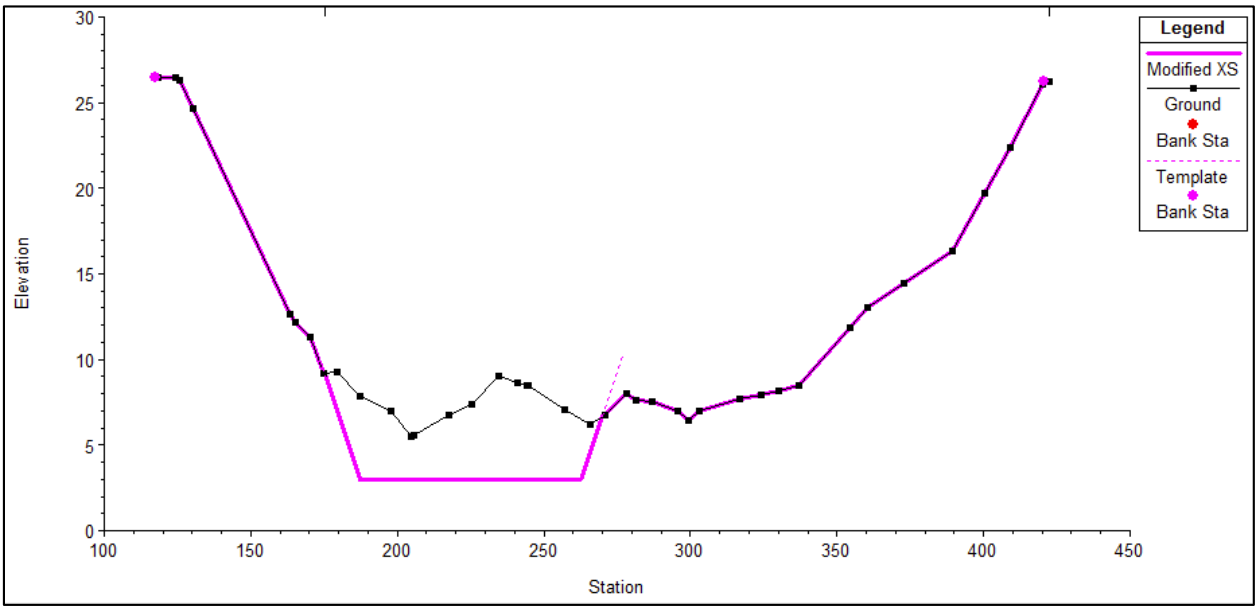


Figure 7 Geomorphic Bankfull Channel Excavation Concept (not for design or construction purposes)

Upstream Termination of Channels

The upstream termination of the channels on the San Lorenzo River and Branciforte Creek should smoothly join with the natural high ground at those locations. The transition from flood channel to existing natural channel should be inspected for irregularities and discontinuities that may lead to outflanking of the flood channel. Repairs of the upstream terminations should be initiated where large gaps or scour exist.

Channel Termination at the River Mouth/Pacific Ocean

The flood capacity of the channel is based on maintaining an open flow to the Pacific Ocean. Natural littoral processes sometimes close the mouth of the San Lorenzo River during the summer months. It is imperative that the river mouth be opened before the start of each flood season to ensure proper flood conveyance.

9.5 Interior Drainage System

The interior drainage system is intended to function for the most part under gravity flow through the gravity outlets, and pumping stations are not to become operative until it is no longer possible to drain the system by means of gravity flow. This condition exists when the water surface elevation in the San Lorenzo River and Branciforte Creek becomes high enough to close all flap gates. A location map and summary of pump stations are provided in Figure 8 and Table 12.

Figure 8. Approximate locations of pump stations and gravity outfalls

Table 12. Characteristics of the Pumps

Pump Station	Location	Pump No.	Capacity (gpm)	Minimum Horsepower
1	Laurel St. (right bank)	1	5,000	25
1	Laurel St. (right bank)	2	13,500	75
1	Laurel St. (right bank)	3	13,500	75
1A	UPRR (right bank)	1	1,200	7.5
1A	UPRR (right bank)	2	1,200	7.5
1B	3rd Street (right bank)	1	1,200	7.5
1B	3rd Street (right bank)	2	1,200	7.5
1B	3rd Street (right bank)	Godwin	6,000	
2	Bixby St. (left bank)	2	7,750	40
2	Bixby St. (left bank)	3	7,750	40
3	Water St. (left bank)	1	2,025	10
3	Water St. (left bank)	2	2,025	10

Three pump stations were listed in the 1962 O&M Manual (USACE 1962):

- Pump Station #1 (Sta 41+00) is located along the project right bank off of Laurel Street near the intersection with Front Street.
- Pump Station #2 (Sta 24+00) also known as the Bixby or Bixby Street Pump Station) is located on the left bank off of San Lorenzo Blvd. between Bixby Street and Canfield Avenue
- Pump Station #3 (Sta 76+00) is on the left bank immediately upstream from Water Street.

Two additional pump stations were constructed on the right bank after the Original Project was constructed:

- Pump Station #1A (Sta 7+70) was constructed as part of USACE repairs following the 1989 Loma Prieta Earthquake. It is located at the downstream end of the right levee. Its discharge lines were re-routed approximately 40-ft upstream and the outfall rebuilt as part of Contract 2.
- Pump Station #1B (Sta 21+50) was added upstream of Pump Station #1A on the right bank under Contract 2 to assist Pump Station #1A.

The two new pumps stations (1A and 1B) and pump station 1 are outdoor facilities, designed and constructed for direct weather exposure.

Operation of Pump Stations

Operation of pump stations shall be in accordance with the regulations contained in paragraph 208.10 (f) (2), which states:

Operation. Competent operators shall be on duty at pumping plants whenever it appears that the necessity for pump operation is imminent. The operator shall thoroughly inspect, trial operate, and place in readiness all plant equipment. The operator shall be familiar with the equipment manufacturers' instructions and drawings and with the "Operating Instructions" for each station. The equipment shall be operated in accordance with those instructions, and care shall be exercised that proper lubrication is being used for all equipment so that no overheating, undue vibration, or noise occurs. Immediately on final recession of flood waters, the pumping station shall be thoroughly cleaned; pump- house sumps flushed; and equipment thoroughly inspected, oiled, and greased. A record or log of pumping-plant operation shall be kept for each station, and a copy furnished to the District Engineer following each flood.

Maintenance and Inspection of Pump Stations

Maintenance and inspection of pump stations shall be in accordance with the regulations contained in paragraph 208.10 (f) (1) which states:

Maintenance. Pumping plants shall be inspected by the Superintendent at intervals not to exceed 30 days during flood seasons and 90 days during off-flood seasons to insure that all equipment is in order for instant use. At regular intervals, proper measures shall be taken to provide for cleaning the plant, buildings, and equipment; repainting as necessary, and lubricating all machinery. Adequate supplies of lubricants for all machines, fuel for gasoline- or diesel-powered equipment, and functional flashlights or lanterns for emergency lighting shall be kept on hand at all times. Telephone service shall be maintained at pumping plants. All equipment, including switch gear, transformers, motors, pumps, valves, and gates shall be trial operated and checked at least once every 90 days. Megger tests of all insulations shall be made whenever wiring has been subjected to undue dampness and otherwise at intervals not to exceed one year. A record shall be kept showing the results of such tests. Wiring disclosed to be in an unsatisfactory condition by such tests shall be brought to a satisfactory condition or shall be promptly replaced. Diesel and gasoline engines shall be started at such intervals and allowed to run for such length of time as may be necessary to insure their serviceability in times of emergency. Only skilled electricians and mechanics shall be employed on tests and repairs. Operating personnel for the plant shall be present during tests. Any equipment removed from the station for repair or replacement shall be returned or replaced as soon as practicable and shall be trial operated after reinstallation. Repairs requiring equipment removal from the plant shall be made during off-flood seasons insofar as practicable. Additional information is given in Appendix E.

Pump Station Records

Logs of inspections, testing, maintenance, and repair activities shall be recorded and centrally stored to be made available to staff and inspection personnel. O&M manuals, safety inspection records, and training records shall be made available for Government inspection on prior notice.

Hard copy binders, which include O&M manuals, safety-compliance reports, Megger tests, training and inspection records and reports and emergency operations directories, shall be stored at the Wastewater Treatment Plant Offices at 110 California Street, Santa Cruz. O&M manuals are not stored at the pump stations because some of the pumps are outdoor facilities that are not equipped with file storage cabinets. Changes, updates, and upgrades to all pump stations, and safety inspection and training records shall be kept by the Superintendent with the O&M manuals, and USACE should be notified of any changes as part of the semiannual report.

Gravity Outlet Locations

Figure 8 shows the approximate locations of Original Project drainage structures. The flap gates have been replaced with duckbill valves in many cases.

Operation of Gravity Outlets and other Interior Drainage Structures

The gravity outlets and attendant drainage system shall be operated in accordance with regulations contained in paragraph 208.10 (d) (2), which states:

Operation. Whenever high-water conditions impend, all gates will be inspected a short time before water reaches the invert of the pipe, and any object that might prevent closure of the gate shall be removed. Automatic gates shall be closely observed until it has been ascertained that they are securely closed. Manually operated gates and valves shall be closed as necessary to prevent inflow of floodwater. All drainage structures in levees shall be inspected frequently during floods to determine if seepage is taking place along the lines of their contact with the embankment. Immediate steps shall be taken to correct any adverse condition.

Maintenance and Inspection of Gravity Outlets and other Interior Drainage Structures

Inspection and maintenance of the gravity outlets and attendant drainage system shall be in accordance with regulations contained in paragraph 208.10 (d) (1), which states:

Adequate measures shall be taken to insure that inlet and outlet channels are kept open and that trash, drift, and debris are not allowed to accumulate near drainage structures. Flap gates and manually operated gates and valves on drainage structures shall be examined, oiled, and trial operated at least once every six months. Where drainage structures are provided with stop log or other emergency closures, the condition of the equipment and its housing shall be inspected regularly and a trial installation of the emergency closure shall be made at least once each year. Periodic inspections shall be made by the Superintendent to be certain that:

- Pipes, gates, operating mechanism, riprap, and headwalls are in good condition;
- Inlet and outlet channels are open;
- Care is being exercised to prevent the accumulation of trash and debris near the structures and that no fires are being built near bituminous coated pipes;
- Erosion is not occurring adjacent to the structure, which might endanger its water tightness or stability.

Immediate steps shall be taken to repair damage, replace missing or broken parts, and remedy adverse conditions disclosed by such inspections.

Additional Requirements for Interior Drainage System

In addition to the prescribed inspection and maintenance program described above, the following measures are to be taken:

Gates

- The nuts and bolts on the slide gates will be inspected to ensure they are tight.
- The gate-leaf-and-frame bronze bearing surfaces shall be inspected for grit and adequate lubrication, and the bottom bearing sealing surface shall be inspected to be certain that it is free from silt or obstructions.
- The inside of the gate frame and the gate leaf, especially at the top, shall be inspected for cavitation.
- Once a year the gate-leaf and gate-frame bronze bearing strips shall be carefully cleaned with solvent and inspected for signs of unusual wear, indentations, or other roughness. They shall be re-lubricated with an even coat of waterproof grease that is brushed on the bearing surface.
- The stem nut, stem guides, threads, and operating stand gears shall be inspected and lubricated every 90 days.

- All nuts and bolts on flap-gate assemblies shall be inspected to ensure they are sufficiently tight and the hinges operating freely.
- Slide gates, whether manually operated or power driven, shall be operated once a year to determine that full travel is made, and that indicators of fully open and fully shut are present and indicate properly to avoid over or under travel when the position of the gate is not visually apparent.

Storm Drainage Facilities

Remove grates or covers during every inspection. Keep drain inlets, manholes, and gutters clear of debris or deposition that may interfere with the free flow of water. When necessary, unplug drain lines and protect adjacent facilities from flooding caused by inoperable drains following standard maintenance procedures adopted in other city storm-drainage facilities.

Clean out sediment sump as needed for the two CDS units installed near the upstream end of Laurel Street Extension and near the intersection of 3rd Street and Riverside Avenue. Inspect the screen of the CDS units for physical damage.

Subsurface Lines

All subsurface pipelines shall be flushed prior to every flood season and after each major storm to disclose obstructions in the line and subsurface failure of the pipe joints. Visual inspection should be made where possible. In pipes and culverts that penetrate levees or floodwalls. Video recording and verification of satisfactory internal conditions is required at least every five years prior to USACE periodic inspection.

Transitions, Collection Sumps, Manholes and Ditches

On Branciforte Creek, the toe-drain pressure-relief system shall be inspected immediately prior to the beginning of the flood season, immediately following each major high-water period and otherwise at intervals not exceeding 90 days. Similarly, the toe-ditch that abuts the wall shall be inspected to be certain that the bituminous paving has not separated from the wall.

Slide Gates

Operation of the Slide Gates. The slide gates installed in the wet wells at each gravity outlet are to be operated for emergency purposes only, except for maintenance and to test for proper gate operation. That is, the slide gates are to be closed on reversal of flow within the gravity outlet. Flow reversal indicates that the flap gate has been

held open by debris or silt and has failed to function properly and that there is insufficient head build-up on the interior drainage system to drain by gravity. The slide gates are operated through bevel gears in an operating stand at the top of the wet well. The slide gates shall not be used in conjunction with making a "wet-test" of a pump installation.

Trash Racks

During periods of heavy rainfall in which the interior drainage system is carrying a capacity load, all debris lodged against trash racks will be removed, keeping the inlets open. Particular attention shall be paid to the trash rack at Transition No. 14 on the old Pasatiempo Creek channel near Ocean Avenue. The 72-inch line laid in Pasatiempo Creek channel is designed to carry storm water to the San Lorenzo River through Gravity Outlet No. 16. Debris clogging the trash rack at Transition No. 14 causes overflows into the old creek channel and overloads the drainage system handled by Gravity Outlet No. 15.

9.6 San Lorenzo Lagoon

The mouth of the San Lorenzo River needs to be opened before the start of each flood season to ensure project performance in accordance with current environmental permits and following consultation with appropriate regulatory agencies.

9.7 Vegetation and Habitat Restoration

Habitat restoration improvements in Contracts 1, 2, and 3 included the following actions:

- Vegetation planted or allowed to grow on levees, banks, and along the river bed near levee toes and low flow channels
- Lagoon and in-channel enhancements such as root wads and tree trunks

Levee and Floodwall Vegetation Maintenance Requirements

The vegetation layout on levees, within 15 ft of levee toes and within 15 ft of floodwalls, shall be maintained as it was originally intended, as shown on Contract 1 and Contract 2 project drawings and Contract 3 as built plans (Appendix A) unless there are subsequent findings, approved by USACE, indicating changes should be made. New plantings may not be approved without an appropriately detailed and documented engineering evaluation to ensure that design intent and safety criteria are maintained as originally authorized. Any addition of landscape plantings to existing

flood-damage-reduction systems must comply with requirements in this O&M manual and Engineer Technical Letter (ETL) 1110-2-583.

Vegetation management include the following requirements:

- In general, the minimum vegetation-free zone on levees includes the crown, landside, and riverside portions of the levee, plus 15 ft on either side.
- Certain grass species are permitted for the purpose of erosion control.
- Replacing in-kind plants that do not survive is allowed. Additional plantings and volunteer growth are not allowed and should be removed.

During the project improvements (1999-2005), vegetation was allowed to be planted on agricultural fill placed on levee slopes on top of the engineered fill. Although certain vegetation elements included in the Original Project design, including fill on riverside levee slopes, are no longer compliant with USACE policy, vegetation along San Lorenzo River designed and planted during the authorized project improvements was compliant with USACE policy at the time of construction and, therefore, should continue to be maintained in accordance with this O&M Manual.

Annual Maintenance Program to Control Vegetative Growth and Animal Burrows

For each project, it is important that the OMRR&R manual include an annual maintenance program to control vegetative growth and animal burrows. It is also important that vegetation be managed in such a manner as to avoid the need for removal and associated embankment repair, and to avoid any incidental growth and subsequent presence of endangered species that might prohibit access and activities necessary for O&M (ETL 1110-2-583).

The Superintendent shall develop a vegetation management plan, which is reviewed and updated as needed each fall, for implementation during the following summer to fall. This schedule allows for vegetation maintenance prior to winter floods to meet USACE flood-channel maintenance requirements. Monitoring requirements and additional trigger points for vegetation removal are given in Section 11. Results of a thorough inspection by the Superintendent after seasonal maintenance, including any deviations from original plans, should be noted on forms showing the original plans. The results should be included with semiannual reports to USACE.

Vegetation Removal

Vegetation management is partially based on EP 1110-2-18, whose purpose is:

"This EP provides guidelines to assure that landscape planting and vegetation management provide aesthetic and environmental benefits without compromising the reliability of levees, floodwalls, embankment dams, and appurtenant structures. It is important to note that all minimum guidelines presented herein are just that – minimums. The dimensions of the vegetation-free and root-free zones defined in this document provide the minimum acceptable buffer between vegetation and flood damage reduction structures. For each individual project, the design team must consider whether these minimums are adequate to the specific needs and conditions of the project."

The Project includes both a leveed section below Highway One, and a non-leveed section above the Highway One Bridge. Vegetation management treatments differ between the leveed section of the Project and the non-leveed section of the Project.

For the leveed section, all vegetation shall be managed following guidelines outlined in EP 1110-2-18, or a vegetation variance shall be requested. This includes vegetation within the project improvement area that was designed and built after the authorized project was constructed, including the vegetation labeled as "non-approved" (out of compliance) in the 2012 Second Nature planting layout maps. Non-approved vegetation for purposes of the 2012 mapping effort referred to either vegetation existing in a non-approved zone or a species not on an approved species list. Non-approved shrubs refer to areas with existing (2012) shrubs that fell within the USACE defined 50-ft buffer zone for levee inspections. While waiting for the vegetation, the guidance revision to be completed and published vegetation removal are only required when it presents an unacceptable safety risk. Because all vegetation described in the original construction drawings (Contracts 1-2) and as-built plans (Contract 3) was compliant with USACE policy at the time of construction, it need not be removed.

The non-leveed section extends from the Highway One Bridge north to the project limit (City Limit). In this section vegetation removal follows 33 CFR 208.10(g)(1) [Section 9.4] and should have as its focus to limb up trees and trim or remove vegetation that has the potential to slow flood flows during storms, especially near the Highway One Bridge and adjacent to the Tannery Live Works Studio housing project. Trees that have fallen into the river shall be removed to prevent their snagging river debris during high flows and blocking or slowing floodwater flows. The channel bottom width for this section should be approximately 100 ft wide (USACE 1962), and vegetation growth encroaching on the 100-ft wide channel should be removed.

This non-leveed section needs to be inspected annually to identify needed vegetation trimming or removal to maintain flow conveyance. Removal of trees that

have fallen into the river should be conducted in coordination with the responsible regulatory agencies. In the event of immediate danger prior to an imminent storm, however, removal should be taken on an emergency basis.

It should be noted that the guidelines for vegetation removal is currently being reviewed. Implementation guidance for Section 3013 of the Water Resources Reform and Development Act of 2014 has been developed. It states that the Non-Federal Sponsor does not have to remove vegetation unless it presents an unacceptable safety risk (USACE 2017):

"Section 3013(g)(1) does not prevent non-federal sponsors from making decisions regarding how to manage vegetation for the levee systems or segments for which they are responsible. Until the guidelines are revised, USAGE will not seek to require non-federal sponsors to make specific vegetation management decisions without documenting that vegetation presents an unacceptable safety risk."

The Superintendent has the discretion to decide when vegetation presents an unacceptable safety risk and requires removal. USACE engineers will also be inspecting the Project annually and may also determine when vegetation presents an unacceptable safety risk. At that time, they may ask for the vegetation to be removed.

Vegetation Ground Cover Requirements

In general, the only acceptable vegetative ground cover in the vegetation-free zone shall be perennial grasses. Their primary function shall be to reliably protect against erosion. They shall be maintained as necessary to ensure the health and vigor of the primary species providing erosion protection. The species selected for each project shall be appropriate to the local climate, conditions, and surrounding or adjacent land uses. Preference should be given to the use of native species. Invasive or weed species shall not be acceptable. The species selected must be able to tolerate mowing to heights as low as 3 in at least once each year for inspection, and in anticipation of flood conditions, and associated monitoring and flood-fighting activities (ETL 1110-2-583).

Recommended Vegetation Thinning Prescriptions by Reach

Vegetation thinning, bar ripping, and woody debris removal should be done according to Table 13 to maintain channel conditions that are consistent with USACE design assumptions.

Table 13. Vegetation Management Prescription

Reach	Vegetation Management Prescription (Annually)
Bankfull Channel Area Instream Channel Bed	Remove riparian vegetation that exceeds accepted USACE Manning's "n" roughness coefficient for the flood-control channel. A 5-ft edge of stream buffer area should be maintained on either side of the wetted edge.
Riverine Reach	Allow 10-ft wide strip of willow and alder along toe of levee. Willows allowed to grow to 3" dbh. Alders allowed to grow to 6" dbh. The lower limbs of the alder trees should be trimmed. The willows should be thinned to favor providing overhanging cover to the low-flow channel. Maintain a 5-ft buffer along wetted edges of channel, but thin groves and limb up trees. Remove any trees in 5-ft buffer area that are greater than 6" dbh.
Transitional Reach	A 10-ft-wide strip of woody riparian vegetation and tules and cattails should be maintained on the west bank. The east bank should be maintained to keep trees overhanging water. Trees or branches that fall in the water should be assessed for cutting into smaller pieces and may be removed entirely if they cause an immediate safety hazard. Sandbars should be maintained to allow volunteer groves to establish but remove all trees greater than 6" dbh.
Estuarine Reach	A 5-ft wide strip of willow, cattail, and tule should be maintained at the levee toe. Willows should have stem diameter of no greater than 0.5" and be limbed up and periodically thinned to create defined groves.

9.8 Bank Stabilization Wall (River Bend Reach)

Periodic inspections should be performed at a frequency of at least once every 6 months to determine the conditions of the wall's structural components and any repair or replacement required. Action for correction of deficiencies is to be taken immediately upon discovery.

Weep Holes

In view of the accessibility of the weep holes installed along the main soil nail wall, inspections are to be made concurrently with the in-channel planting elements. Weep holes installed along the upper soil nail wall should be inspected in accordance with the periodic inspection schedule. Maintain weep holes free of debris and dirt to insure free drainage of water is not obstructed.

Sculpted Facing

Inspect and note the condition of the exposed sculpted facing. In view of the accessibility of the main soil nail wall, inspections are to be made concurrently with the in-channel planting elements. The sculpted facing should be inspected in accordance with the periodic inspection schedule. Promptly report any development

of cracks, spalling of shotcrete, or other damages caused by vandalism. Graffiti should be promptly removed or covered over. Significant damages should be repaired.

Railings

Check the integrity and sign of distress of the fall protection railings installed at the top of the soil nail wall. When significant corrosion exists but the structural integrity of the railing is not impaired, the area should be cleaned appropriately, and a new protective coating should be applied. Damaged or weakened railings should be promptly repaired or replaced.

Evidence of the following signs of distress should be reported immediately to USACE

- Abnormal increase or decrease of flow from weep holes of the soil nail wall
- Significant cracking or spalling of the facing of the soil nail wall
- Exposure of the bottom of the soil nail wall caused by damage and dislodgement of the in-channel features or excessive erosion of the Purisima Formation rock

9.9 Gabions and Riprap

Displaced gabions and riprap shall be replaced so that the channel is maintained at design grade. They shall be replaced as soon as practicable after the recession of floodwater and before the next flood run-off. To insure that the above requirements are met, particular attention shall be given to:

- In areas where a fracture, scour, slip or settlement has occurred to such an extent as to expose a portion of the protected bank, the gabions or riprap shall be removed, the wash or scour filled with earth and the gabions or riprap replaced. New or additional gabions or riprap may be required to restore the damaged slope protection. Slope, grade, and thickness of the repaired slope protection shall conform to the existing bank facing. In case of emergency and when stone is not available, sandbags filled with gravel may be used for temporary repair measures;
- When isolated areas of wire-mesh strands of gabion baskets are damaged, corroded, or severely rusted, the remaining strands of wire mesh should be tied together with strands of galvanized wire that are at least 10 gage in size or equal to that used in the gabion construction. This applies to the twisted and welded wire gabions. The mesh replacement should have openings not greater than the existing openings or not greater than 4" on center each way.

In places where the extent of damage is greater than 5 square ft, a new piece of mesh should be installed. Gabions should be replaced if the damaged area encompasses one or more baskets.

- In the event an inspection reveals that because of scour, settlement, or other causes, slope protection on the levee or bank is required beyond the limits of the original construction; local interests shall provide additional stone protection or gabions as needed to protect completed work. The work shall be done in a manner acceptable under standard engineering practice; and
- Trees and brush should not be allowed to grow through the gabions or riprap to the extent that it displaces the stone or causes erosion of the bank.

If any adverse conditions are disclosed, immediate steps shall be taken to remedy them and a full description included in the semiannual report.

9.10 Maintenance Path

Pavement

Asphalt and concrete pavement of the maintenance path is to be maintained in original condition. Inspect the pavement surface for cracks, up-heaving, and spalling. All damaged path surfaces are to be repaired annually. Bituminous surfaces are to be cleaned down to firm undisturbed material and then patched or completely replaced, as required, with like materials thoroughly bonded to the undisturbed asphalt. Displaced or heavily damage concrete pavement that cannot be readily smoothed shall be removed and replaced according to normal engineering practice.

Lighting

Inspect the luminaires along maintenance path to avoid interrupted lighting for safety reasons. When replacement of bulbs or luminaires is necessary, insure that the metal shields are installed properly per original design instructions such that directional lighting is provided.

9.11 Litter Control

Maintain paved and non-paved ground surfaces free of litter, plant debris, and garbage (e.g., planting areas, mulches areas, walkways, vent grates). Litter control should be performed at least once a week and more often as required.

9.12 Additional Maintenance Measures

Additional maintenance measures are:

- Any damage to concrete bridge piers, abutments, fins, or floodwalls shall be repaired or replaced with similar materials and thoroughly bonded to adjacent undisturbed materials.
- Scoured and eroded areas beneath structures shall be cleaned of all foliage and loose material to firm undisturbed material and filled with concrete or riprap properly designed to provide adequate bearing.
- Any displaced derrick stone or riprap shall be replaced and the channel floor grout up to grade.
- Any "sheet" erosion taking place in front of the setback levee on the left bank between Water Street and Soquel Avenue shall be repaired with similar materials by restoration to original ground level and compaction. This will be accomplished as soon as possible after high water.
- All repairs shall be made in accordance with standard engineering practice and by qualified personnel.
- The grade of the levees should be checked to ensure that settlement or sloughing has not lowered the protective height of the levee. Traverse data and elevation may be used for this purpose. In all cases where the levee grade or side slopes do not meet the original constructed elevations, fill material similar to that used in the original construction should be used to bring the levee to design grade and cross section. All objectionable material, debris, and surfacing should be removed, and the levee surface scarified to a depth of approximately 6 in prior to placing the new fill, which should be placed and compacted in layers.
- All displaced riprap or derrick stone shall be replaced as soon as practicable after the recession of the damaging high waters.
- Surfaces of the levee roads and access roads shall be maintained by periodic sealing with bituminous materials at not greater than three-year intervals. All holes, soft areas, and damaged road surfaces shall be repaired annually. Unsatisfactory materials shall be cleaned out to firm undisturbed material, and patched or completely replaced with similar materials and thoroughly bonded to adjacent undisturbed surfaces.
- Trees, bushes, shrubs or other vegetation with a heavy stem or large trunk and root system shall not be allowed to grow on riprap sections of the levee.

The methods used to remove or retard such growth prior to the flood season may be with chemical sprays or cutting close to the surface of the riprap.

9.13 Inspection Schedule and Reports

Semiannual Reports

In accordance with Paragraph 208.10 (a)(6) of the General Provisions of Regulations, the Superintendent is required to submit a semiannual report to the District Engineer covering inspection, maintenance, and operation of the project works. The inspections will typically be conducted pre-flood and post-flood, and the report will include statements concerning the following items:

- The physical condition of the protective works as summarized from logs of inspection;
- Flood-response activities during the report period and the behavior of the protective works during floods;
- Prosecutions for encroachment or trespass of any individuals that have affected the operation or maintenance of the project;
- Maintenance measures taken (date, temporary measures taken, permanent repairs, etc.);
- The cost of maintenance and operation for the report period;
- Permits issued relating to rights-of-way and use of rights-of-way;
- Permits issued for improvements or construction within the project right-of-way;
- Any unusual, abnormal, or unexpected conditions or occurrences bearing on the stability or effectiveness of the protective works; and
- Provide findings of inspection effort, including proposed maintenance plan or a statement that maintenance is not required.

The report is to be submitted to the District Engineer, San Francisco District, U.S. Army Corps of Engineers, ATTN: CESPN-OR-E, 450 Golden Gate Avenue, San Francisco, CA 94103-3404.

Inspection Checklist

Appendix D provides a suggested format for preparing the semiannual report. The checklists and instructions shall be followed for each levee system to insure that features of the project works are not overlooked during inspections by the Non-Federal Sponsor. These checklists should also be used to implement required repairs.

USACE Levee and Floodwall Inspections

The City shall provide adequate staff to accompany USACE staff to perform routine and periodic inspections of the Flood Control Works. The City will send Pre-Inspection reports and semiannual reports to USACE prior to the inspections.

Levee and floodwall systems to be inspected by USACE are defined by the connected areas of reduced risk behind them. Results of annual inspections conducted by USACE are also entered into the NLD. Each system is rated and reported separately. Three separate systems in the San Lorenzo River Project have been defined, given 4 character designations, and entered into the USACE National Levee Database (NLD):

- Right Bank System (SZRR)
- Left Bank Upstream System (SZRL)
- Left Bank Downstream System (BFCR)

USACE annual inspections also use the checklists shown in Appendix D and rate each of the three systems separately. Unacceptable ratings must be reported as specified in the associated instructions. Such ratings can affect eligibility for consideration for repairs under Public Law 84-99.

SECTION 10 FLOOD RESPONSE AND EMERGENCY OPERATIONS

10.1 INTRODUCTION

Flood emergencies include:

- Possible flooding – forecast of approaching storm includes appearances of possibility for enough rainfall and runoff to cause flooding in Santa Cruz.
- Potential flooding – forecast of an approaching large storm that appears able to produce enough runoff to cause flooding in Santa Cruz.
- Imminent flooding – a local forecast of significant continuing rainfall and runoff, local rain gages indicate recent and sustained high rates of rainfall, local stream gages indicate a recent and sustained high rate of rise in water surface elevation, possibly coinciding with predicted high tides, river water surface is within 3-ft of top of levee or floodwall.
- Actual flooding – areas on the landward side of the channel, levee, or floodwall are being inundated by river water.

This section addresses flood emergency-operation plans, procedures, and responsibilities for the project. The City of Santa Cruz has an Emergency Operations Plan as part of its Local Hazard Mitigation Plan (City of Santa Cruz 2007) that is not specific to the Project. This manual does not supersede those plans but is intended to supplement them, to the maximum extent possible. The Superintendent should consider if the development of a specific Emergency Operations Plan for the Project is warranted.

10.2 PREPARATION FOR FLOODING

Stream-flow and Rainfall Gages

Floods in the San Lorenzo River basin are of the "flash" type because the time of concentration at Big Trees is only about five hours and on Branciforte Creek at Santa Cruz, about three hours. This condition precludes long-range flooding forecasts. To plan protective measures in advance of a flood, the Superintendent should be cognizant of weather forecasts predicting the possibility of flooding in the San Lorenzo River drainage basin. The Superintendent should also organize a network of rain-gage observers in the headwater reaches to the basin that can keep him advised of the local precipitation and possibility of flooding.

Water-Surface Elevations

Date, time, and locations of rising water-surface elevations at incised channels, levees, floodwalls, bridges, and the initial overtopping section will be recorded as necessary to take actions recommended in Section 6.4 - Consequences of Floods Exceeding Present Capacity, to prevent access to threatened bridges and to evacuate areas threatened by imminent flooding.

Pathways

Prior to anticipated floods, as practicable, erect barricades and signs to limit access to the paths under bridges. Following inundation of pathways, inspect and clear all debris and sediment from the path and railings before removing the barricades and signs.

10.3 RESPONSIBILITIES

Lead Agency

The City of Santa Cruz is the lead agency in charge of Emergency Operations. As the lead agency, the City of Santa Cruz will maintain and staff an Emergency Operations Center (EOC) and manage all records. The EOC shall be on alert status for floods from October 1–May 1. All emergency operation records are to be available for inspection by USACE.

The City of Santa Cruz, County, and State Governments are responsible for emergency preparedness, including training and stockpiling flood-fighting supplies and materials. The USACE will assist with technical advice, supplies, materials, and flood fighting whenever necessary as described in Engineer Pamphlet (EP) 500-1-1, Engineer Regulation (ER) 500-1-1, and Public Law (PL) 84-99.

Technical Assistance from State and Federal Agencies

The USACE has the authority to assist in emergency actions in accordance with provisions of PL 84-99, as amended. During a flood alert, USACE may advise local authorities on flood-fighting methods and may respond to request for assistance in flood fighting either from the City of Santa Cruz or through the Department of Water Resources (DWR) Flood Operations Center. The DWR Flood Operations Center needs to be notified of all requests for assistance. In addition, Emergency Operations authority allows USACE to furnish required assistance in support of other agencies, as appropriate.

In addition to USACE and DWR Flood Operations Center resources, the California Emergency Management Agency (CalEMA) and the Federal Emergency Management

Agency (FEMA) may provide emergency assistance resources. FEMA should be notified immediately in case of a major emergency.

USACE assistance may include the following:

- Furnishing technical advice and assistance;
- Furnishing flood fighting materials; and
- Hiring equipment and operators for flood fighting operations.

Damage Repair Assistance

USACE may also assist in repairing flood-damaged flood control facilities under authority of PL 84-99, as amended. In such situations, the City of Santa Cruz must assess damages and make a specific request to the USACE, San Francisco District Engineer within 30 days of the flood event causing the damages.

During the PL84-99 Rehabilitation phase, the City shall document damages caused by any major disaster. Information about extent of damages that is sent to USACE shall include locations, photos, drawings, and survey data. Immediate measures shall be taken for public safety and containing further damages.

Police Authority

USACE personnel, whether military or civilian, are not vested with any civil police authority in performance of their engineering duties and they will not attempt to exercise such authority. The responsibility for protecting flood-control and recreational works against sabotage, acts of depredation, or other unlawful acts rests with the local interests through local and state government agencies. In the event that local law enforcement agencies prove inadequate, local interests, as provided by law, can request the aid of state forces and the aid of federal troops.

Disaster Relief

It is the responsibility of local, state, and municipal authorities supported by or working in connection with the American Red Cross to adopt measures for the relief of flood-disaster victims. Relief measures can be undertaken by the Department of the Army through its Army Area Commander under existing Army Regulations, but such measures will be undertaken only as a last resort in extreme cases and under compelling circumstances where local resources are clearly inadequate to cope with the situation. Disaster relief is generally not a responsibility of the Superintendent charged with the maintenance and operation of the Project.

10.4 Flood Mitigation Actions

The October 15, 1998 PCA requires the City of Santa Cruz to perform the following mitigation actions:

- Flood-proofing improvements to the Santa Cruz County Government Center;
- Flood-warning system; and,
- Emergency response plan.

The City of Santa Cruz also performs flood-mitigation actions by maintaining the Project as described in this manual. It is also noted that the City of Santa Cruz is voluntarily performing other flood-mitigation actions, as described in the Santa Cruz Local Hazard Mitigation Plan (City of Santa Cruz 2007) and Creeks and Wetlands Management Plan (City of Santa Cruz 2006). These voluntary efforts and new flood-mitigation actions are encouraged to further reduce the flood risk to the community.

10.5 Overtopping at the Initial Overtopping Section

Overtopping occurring on the right (west) bank between Highway 1 and the Water Street Bridge will begin to flow as a sheet into the mobile-home park next to the levee, and pond in this area up to a depth of 3–3.5 ft. See Section 6 (Project Performance) for a full description of overtopping consequences. Any time that high river flows are predicted, special patrolling, warning, and evacuation measures are required, particularly for the initial overtopping section. A close watch should be kept on storm rainfall and runoff predictions, sea level predictions for Monterey Bay, the rate of rise of the river along the entire project, the elevations of the San Lorenzo River and Branciforte Creek water surfaces, and the ability of interior drains and pumps to keep up with local rainfall and runoff. Residents, particularly in the area of the mobile home park landward of the initial overtopping section, should be given ample notice and assistance so they can evacuate before flooding begins.

10.6 Project Access During Emergencies

Access to project facilities shall be maintained during the flood season. If access is lost because of bank overtopping, or bank or levee failure, it shall be re-established as soon as it is safe and practicable. In instances where it is necessary to send emergency equipment over access roads or paths along riverbanks that are impassible because of mud, sand, brush, tree limbs, and other, passage can be provided by clearing debris and by the use of a plank road, aggregate base rock, or by means of steel or wire mats.

Local emergency procedures shall be followed according to the City of Santa Cruz Local Hazard Mitigation Plan and the project-specific Emergency Action Plan.

10.7 Emergency Operation Procedures

General

The Superintendent shall devise and implement by training and exercise a plan of operation for periods of flood and high water. At a minimum, the plan shall involve advance preparation for emergency communications and transportation, subsistence of emergency work crews, and removal of obstructions from the project right-of-way; continuous patrol and inspection activities on a sector basis during the flood period; efficient field office communications; and means for emergency protection and repair of threatened or damaged flood control project facilities. Preparations to evacuate persons and property, and to begin any other recommended procedures, must be made before inundation at the initial overtopping section becomes imminent. Reserve supplies of all materials and equipment needed during an extended flood emergency will be held immediately available at all times. Tours and inspection of the materials and equipment shall be provided to USACE inspectors on request. During emergency operations, close liaison shall be maintained with the office of the USACE San Francisco District Commander.

Methods for Combating Floods

Methods described herein and in Appendix F have been developed over many years of experience with the varied problems that arise during floods, but they are not intended to restrict the Superintendent or others concerned to a rigid set of rules. Neither should they be considered an exhaustive treatise on the subject. Rather, they should be considered as general guides to procedures that have been effective during past floods, and in themselves or with modifications indicated by an ongoing emergency, would probably be effective in the future.

If problems not covered in the exhibit are encountered, or the Superintendent has doubt as to a procedure to be taken, the DWR Flood Operations Center and the USACE, San Francisco District Commander may be consulted for information and advice.

10.8 Patrol and Inspection

During a flood emergency, continuing patrol and inspection on the sector basis established and marked as part of an emergency operations plan is of paramount

importance. Inspectors should be familiar with adjoining as well as assigned sectors. Local interests responsible for maintenance should form a skeleton organization capable of quick expansion, and assign individuals (Work Supervisors) to have charge of definite sections of levees. As an initial activity, each Supervisor should go over their entire sector and parts of adjacent sectors, making a detailed inspection, particularly with reference to:

- Reach/Sector limits (ascertain that the dividing line between sectors is plainly determined and, if necessary, marked);
- Condition of levees and recent repairs;
- Accumulation of debris at bridge foundations and the initial overtopping section;
- Condition of all drainage structures including culverts, flap gates, and pinch valves;
- Transportation facilities (road and rail);
- Material supply (quantity, location, and condition); and
- Communications (locate and check all necessary radios and telephones within the sector).

Particular attention should be given to the condition of the channel banks, especially sections recently repaired; the condition of culverts, pinch valves and flap gates; and the condition of road, railroad, and public utility crossings. Also, the inspector should know the location, type and quantity, and condition of emergency supplies and equipment in the sector area.

Preliminary Activities

Generally, some advance warning of impending flood runoff is available. After the initial inspection has been made, each Work Supervisor should recruit a labor crew and provide it with tools such as shovels, axes, wheelbarrows, and other. In addition, bulldozers, scrapers, trucks, and other, should be located and made ready for use in cases of emergency. Insofar as time permits, action should be taken to:

- Fill holes or washes on the bank slopes and landside berms. Rain washes and deep gullies may have developed along the unprotected new banks. Therefore, preparations should be made to combat wave wash and high velocity flow along the reach;
- Repair gaps where the top of the bank may have subsided to below grade. If it is necessary to use landside borrow pits to fill gaps, excavation for the material should be kept at least 50 ft from the top of the bank. Any filling

done in this connection should be tamped in place and, if in an exposed reach subject to wave wash or high velocity flow, the filled section should be faced with sand bags;

- Assure that all flap gates on culverts are closed and seated properly before they are submerged by floodwater;
- Ascertain that all roads to and along the levee are in a good state of repair. The Superintendent should obtain assistance from the city road forces to ensure that all roads can be safely driven;
- Locate necessary tools and materials (e.g., sacks, sandbags, brush, lumber, lights) and distribute and store at points where active maintenance is anticipated;
- Obtain lists of all team forces, motorboats, motor cars, and truck transportation that can be made available;
- Make thorough arrangements for necessary labor with reliable citizens of the community for the supply transportation, subsistence, and shelter;
- Investigate all drainage ditches leading to drain inlets along the project, and open drains if they are obstructed; and
- Assure that explosives of any kind are removed from the vicinity of project structures and the project right-of-way.

Flood Fighting

After the above preliminary organization and precautions have been completed, the "flood fight" itself commences. The methods of combating various defects in the earthen levee described in the following paragraphs have been proven effective during many years of use by the Department of the Army. Appendix F provides more-detailed descriptions of various flood-fighting techniques.

Drainage of Slopes

This work can be done economically while awaiting developments and will serve to make the levees more efficient. Crews should be organized to cut seep drains at all places on the levee when seepage appears. They should be V-shaped, no deeper than necessary, and never more than 6 in deep. Care must be taken not to unnecessarily cut the cover material. In all instances, drains should be cut straight down the levee slope or nearly so.

Wave Wash

Wave wash is to be expected whenever the levee is exposed to a wide stretch of open water and is serious if permitted to continue over a considerable length of time. The Superintendent and Sector Foreman should study the levee beforehand to determine

the possibility of wave wash. All such reaches will be located well in advance; and for use in an emergency, a reserve supply of filled sacks and rolls of cotton bagging will be kept on board flats. If the slope is well sodded, a storm of an hour's duration should cause little damage. During periods of high wind and high water, ample labor should stand by and experienced personnel should observe where washouts are occurring by sounding or by prodding along the submerged slope with a rod. Sections of canvas or polyethylene sheeting and sandbags should be placed on wave washed areas as shown in Appendix F.

Sand Boils

These danger spots are serious if discharging material. The common method of controlling sand boils consists of walling up a watertight sack ring around the boil, up to a height necessary to reduce the velocity of flow to a point at which material is no longer discharging from the boil. The sack ring around the boil should be large enough to protect the defective area immediately surrounding the boil. If several boils of sufficient force to displace material are observed, a sack sub-levee may be built around the entire nest of boils high enough so that none of the boils will discharge with enough force to displace any material (see Appendix F).

Scours

Scour may occur where velocity of flow is more than 2 ft/s or where the stream gradient is 2 ft or more per mile or where profiles show a high-water gradient of 2 ft per mile or greater. Scour may be found near the ends of old levee dikes; road-crossing ramps; and places where pipes, sewers, or other structures penetrate the levee. All scours should be carefully observed to determine the necessity and adequacy of repairs to be accomplished. Scour may also occur near bridge ramps or where pipes or other structures penetrate the banks. Careful surveillance should be made of the river side of the levee at all localities where high current velocities are observed. Scours are controlled by constructing deflection dikes of brush, lumber, filled sacks, stone, or some combination of these materials (see Appendix F).

Topping

The as-constructed grade line of protection, whether from the natural riverbank or structural flood-control feature (e.g., gabions, downstream levees, floodwalls, stone protection), must maintain the original design grades (elevations) for the life of the project. If any reach or localized area show signs of degradation below design grade, emergency grade raising should be conducted at once to restore the necessary grade and protect adjacent landowners. Emergency grade raising, or topping, should be undertaken as follows:

- *Sandbag Topping*. If, comparison of existing grade lines with those on the construction drawings shows any reach of bank grade below the previous high water, emergency topping should be immediately undertaken. Filled sacks may be used to raise the top of the bank about 3 ft. The sacks should be laid lengthwise along the bank for the first layer, crosswise for the second layer, etc. Sacks should be lapped at least 1/3 of their length and well fitted into place. When properly filled, placed, and tamped in place, one sack will give about 3 to 4 in of topping. If gravel is available, it should be used for front facing to avoid washing out (see Appendix F).
- **Lumber and Sandbag Topping.** This is the most commonly used emergency method to raise low sections along stream banks. In putting on this type of topping, a careful line of levels should be run and grade stakes set in advance. Then, 2" x 4" x 6' stakes should be driven 6 ft apart on the riverside of the crown, and 1" x 12" boards nailed to the landside of the stakes. This wall, backed with a single tier of sandbags, will hold out at least one ft of water. If a second ft is necessary, another layer of 1" x 12" boards can be nailed to the stakes and layers of sandbags increased and reinforced. The stakes should be driven 3 ft into the ground, and should project out 3 ft, thus providing, in extreme cases, a 3-ft topping if the wall is properly braced with sandbags and earth. In some instances, it may be practicable to back up the planking with tamped earth in lieu of sandbags (see Appendix F).

Mud Box Levee

Mud boxes consist of two parallel wooden walls placed near the water-ward edge of the bank and filled with available material. When built on a wide, clear bank, mud boxes may permit a portion of the bank to remain as a limited roadway. Mud Boxes are used when fill material has a soupy consistency. In this case, the inner face of the wall should be lined with canvas or polyethylene sheeting.

Water-inflated barriers

This emergency grade-raising technique is becoming more common because of its relative ease and speed of implementation. Water-inflated barriers can be filled via a fire hydrant and fire hose connections or pumped from the river for flow rates up to 1,500 gallons per minute. The bladders are produced from heavy-gauge polyvinyl chloride (PVC) reinforced with polyester.

Geotextile Berms (geotextile tubes filled with sediment)

This type of emergency grade raising is similar to a very large sandbag but is relatively easy to implement compared to sandbagging.

10.9 Liaison with District Engineer and Use of Government Plant

During emergency periods, close liaison will be maintained with USACE, whose objective of maintaining the integrity of the flood control works, will be attained by supporting local interests in their efforts or by assuming full charge of the flood fight when the problem is beyond the capacities of local interests. The District Engineer, U.S. Army Engineer District, San Francisco, California, is authorized to use or loan Government property and plant in cases of emergency where life is in danger and there is no opportunity to secure prior authority for such use. The authority also extends to saving property where no suitable private equipment is available, if such use is without detriment to the Government.

SECTION 11 SURVEILLANCE

11.1 PURPOSE

This section describes the monitoring and surveillance program for the constructed project. Surveillance includes the use of measurements, observations, and other activities to verify that project benefits are being obtained. Results of surveillance is evaluated to identify the need for additional maintenance, continued surveillance, or repair, replacement, and rehabilitation activities. Surveillance can be classified into three categories:

- Long-term routine surveillance
- Special surveillance specified in Inspection and Reports
- Special surveillance after floods or other emergencies

11.2 LONG-TERM ROUTINE SURVEILLANCE

The long-term surveillance consists of monitoring, measuring, and observing crest-stage gages; sediment and vegetation observations; and survey monuments.

Data Collection Methods and Instruments

Visual surveillance, sediment-survey stations, staff gages, and crest-stage gages can be used to determine the need for channel maintenance. Collecting these data by the City for future use is highly recommended.

Visual Inspection and Photographs

Visual inspection and photographs should be used to document damage to the Project, maintenance needs, and shoaling or excessive vegetation in the channel.

Sediment Survey Stations

As described in Section 9.4, fixed sediment-survey stations can be used to verify and quantify excessive shoaling and to aid in understanding long-term shoaling issues. Such stations can be supplemented with additional survey stations as needed to provide more detail of an observed excessively shoaled area.

Gages

Staff gages or measurement markings on the surface of the bridge pier are both easy ways of monitoring sediment accumulation. Currently, no staff gages are installed for such monitoring. Installing staff gages should be considered as needed for any areas of heavy sediment deposition that may be identified.

After a major flood, obtain the peak discharge from the two USGS stream gages (ID 11161000 and 11160500) in the project area, and peak discharges from all other gages that are routinely monitored. At a minimum, these readings should be taken annually.

Vegetation Monitoring

Vegetation conditions and their influence on hydraulic capacity can be evaluated at select cross-sections. Vegetation monitoring should be conducted during inspections at select cross-sections to determine changes in vegetation with time and, as needed, in other locations and times based on these observations.

Surveillance for Channel Maintenance

The following procedures explain how surveillance data (gage readings, cross sections, photographs, and other data) can be used for channel maintenance

- Channel cross-sectional information can be used to verify the need for sediment removal.
- Photographic documentation of vegetation growth can be used to determine if vegetation maintenance is required in addition to or in lieu of sediment maintenance.
- Crest-stage gages will provide water-surface elevation data corresponding to the peak discharge of a given flood. These elevation data can then be compared to the rating curves developed at each bridge, or numerical hydraulic models to indicate if channel maintenance is required (elevation data higher than rating curves or model results may indicate excessive vegetation or sedimentation or both).
- If channel maintenance is suspected, a survey and estimate of vegetation roughness should be performed at each appropriate sediment-survey station. The survey data should be compared to the as-built drawings to determine the extent of sediment and vegetation removal required. Channel capacity estimates using a hydraulic model are highly recommended.

Survey Monuments

Permanent survey monuments or temporary survey markers provide both vertical and horizontal location data. They are installed to monitor structural movement. Survey monuments can also be located on levees and earthen structures to monitor settlement and deformation. Temporary survey markers may be installed for monitoring movement of structures for shorter periods, typically less than two years. Survey monuments installed on structures less than five years old are also

considered temporary markers. Structures recommended for surveillance include retaining walls greater than 8 ft high, floodwalls, bridge piers, levees, inlet weirs to box culverts, box culverts, and retaining walls near bridge piers or abutments. Long-term surveillance of the survey monuments plays an important role in ensuring continued realization of project benefits by allowing identification of potential problems that are not apparent during routine maintenance activities.

Survey monument, triangulation station, and benchmark locations listed in the OM manual for the Original Project (using the original datum) are shown in Table 14. The reference benchmark was USC & GS "Santa Cruz" located at the corner of Locust and Center Streets.

Table 14 Survey monuments

Monument No.	North Coordinate (ft.)	East Coordinate (ft.)	Elevation (ft. MSL)	Description
S-L-R-M1	173,960.750	1,558,173.113	18.43	IN SIDEWALK ON BRIDGE
S-L-R-M2	173,975.647	1,556,556.295	16.67	IN SIDEWALK ON BRIDGE
S-L-R-M3	174,618.548	1,555,158.612	10.69	IN SIDEWALK
S-L-R-M4	175,318.832	1,555,612.097	11.95	IN SIDEWALK
S-L-R-M7	176,402.181	1,555,268.739	12.18	IN SIDEWALK
S-L-R-M5	175,010.195	1,556,863.712	6.81	IN SIDEWALK
S-L-R-M9	178,011.496	1,555,195.019	22.11	IN SIDEWALK
S-L-R-M13	179,251.895	1,555,620.539	27.19	IN SIDEWALK
S-L-R-M8	178,143.292	1,554,018.820	17.48	IN SIDEWALK
S-L-R-M14	179,170.461	1,553,493.374	23.27	IN SIDEWALK
S-L-R-M15	180,187.908	1,553,872.342	32.04	TOP OF 6" X 36" RD. CONC. MON.
S-L-R-M16	180,550.733	1,555,097.514	65.68	IN CURB
S-L-R-M19	181,611.596	1,554,306.254	67.49	IN CURB
S-L-R-M20	182,212.774	1,552,988.797	39.84	TOP OF 6" X 36" RD. CONC. MON.
BC-M6	177,027.351	1,556,715.151	19.52	IN SIDEWALK
BC-M10	177,767.869	1,556,813.999	20.67	IN SIDEWALK
BC-M12	179,161.434	1,556,596.186	26.96	IN SIDEWALK
BC-M11	179,444.945	1,558,237.117	81.20	IN SIDEWALK
BC-M17	180,138.886	1,557,399.405	31.18	IN SIDEWALK
BC-M18	180,452.419	1,557,847.614	35.29	IN CURB
BC-M12	No coordinates provided.		14.39	CORPS OF ENGINEERS

Coordinates in California Coordinate System, Zone 3, NAD 27

Surveys of the monuments by a professional land surveyor or licensed civil engineer should be performed annually, and after the following:

- Repairing, replacing, or rehabilitating (RR&R) that resulted in vertical or horizontal displacement of survey monuments;

- RR&R the existing survey monuments; and
- Installing a new survey monument.

EM 1110-1-1002, Survey Markers and Monumentation, provides additional information on survey monuments.

11.3 Special Surveillance Related to Inspection and Damage Reporting

Special surveillance is usually recommended by the Superintendent based on reviewing inspection reports prepared during routinely scheduled inspections. The inspection reports record areas that have or may have experienced distress or damage. A condition code of Minimally Acceptable and Unacceptable requires surveillance. If no imminent danger exists, the follow-up action defaults to the next inspection. Otherwise, the report should indicate more-specific follow-up instructions or require immediate action. As part of the surveillance program, these areas are monitored to determine if undesirable changes are occurring or to ensure that the repairs and corrective actions are successfully completed.

If special surveillance reveals that immediate repair or replacement is required, the Superintendent shall notify USACE (ICW Program Manager) and immediately begin repair or replacement of the distressed structures. If no immediate repair or replacement is required, the Superintendent shall prepare a surveillance program, and schedule and budget the RR&R work. The status of the scheduled RR&R and the completed RR&R shall be reviewed and inspected by USACE with assistance from City staff.

If the completed RR&R work eliminates or corrects the damages or distresses and the work remains stable for a predetermined period, the structure shall be removed from the surveillance program and returned to routine inspection. Otherwise, if a deficiency is found during the scheduled surveillance monitoring, further investigation and repairs should be made to correct the deficiency and eliminate the causes of the distresses or damages.

11.4 Special Surveillance After Emergency Events

Special surveillance is required after emergencies – e.g., floods, high-water flows, and earthquakes – to quickly identify any damage. Special surveillance is used to establish suitable maintenance and RR&R needs that address damage caused by emergencies. In addition to O&M and inspection requirements in Section 9 and the

inspection items included in Appendix D, the following items are of particular concern following emergencies:

Levees and Earthen Channels

- Sand Boils – These usually occur on the landside of levees or embankments. They are caused by rupture of the upper foundation surface by excessive hydrostatic pressure. Such boils can erode subsurface channels and eventually lead to settlement and failure of levees and embankments. Sand boils can be identified by localized discharge of water with sand or silty material at the surface. Surveillance should include checking for signs of sand boils within 300 ft landward of the levee toe. Inspection Reports should identify the location, estimated flow rate, clarity of discharge, and proximity to other observed damages.
- Internal Erosion – Internal erosion, or piping, involves water seepage through the earthen structure because of internal erosion. Piping during an emergency usually occurs when hydrostatic pressure is high enough to erode permeable subsurface material. Surveillance should look for unusual wetness on the landside. Inspection Reports should identify the location, extent, and clarity of water being discharged.
- Bank Erosion – Erosion of levee slopes or riverbank slopes is the most common damage observed after an emergency. Although such erosion may not be considered critical, such erosion often exposes weak or permeable core material that can lead to progressive erosion or stability failure. Surveillance should note the location, extent, and depth of erosion in the Inspection Reports.
- Settlement and Deformation – Earthen structures can undergo settlement or deformation failure in embankment slopes and foundation material. Surveillance should look for signs of settlement or deformation including cracks, localized depressions on embankment surfaces, and unusual movement of soil or disturbance of vegetation on slopes. Inspection Reports should include information on the location; the estimated size of the cracks, movement, or settlement; and a sketch showing the extent and geometry of the damage.

Floodwalls

- Trees – Damage from any fallen trees should be noted as well as the severity of the damage to the floodwall's function.

- Concrete Surfaces – Surveillance should note any damage to concrete surfaces other than negligible spalling, scaling, or cracking. If the concrete surface is weathered or holds moisture, it is still satisfactory but should be seal coated to prevent further damage.
- Tilting, Sliding or Settlement of Concrete Structures – Surveillance should note any significant areas of tilting, sliding, or settlement that would endanger the integrity of the structure. (The Superintendent should have been monitoring any observed movement to verify whether the movement is active or inactive.)
- Foundation of Concrete Structures – Surveillance should include checking for active erosion, scouring, or bank caving that might endanger the structure's stability.
- Monolith Joints – Surveillance should check that the joint material is in good condition, the exterior joint sealant is intact and cracking or desiccation is minimal, and the joint filler material or waterstop is not visible at any point.
- Underseepage Relief Wells/ Toe Drainage Systems – Toe drainage systems and pressure relief wells should be checked that no sediment is observed in the horizontal system (if applicable). Note any observations that would indicate that the drainage systems would not function properly during the next flood.
- Seepage – Check for evidence or history of unrepaired seepage, saturated areas, or boils.

Bridges

- Obstructions – Note any floating debris that remains lodged against upstream faces of the bridge or piers that will obstruct flow in the channel.
- Concrete Surfaces – Surveillance should note any damage to concrete surfaces other than negligible spalling, scaling, or cracking. If the concrete surface is weathered or holds moisture, it is still satisfactory but should be seal coated to prevent further damage.
- Tilting, Sliding or Settlement of Concrete Structures – Surveillance should note any significant areas of tilting, sliding, or settlement that would endanger the integrity of the structure. (The Superintendent should have been monitoring any observed movement to verify whether the movement is active or inactive.)
- Foundation of Concrete Structures – Surveillance should include checking for active erosion, scouring, or bank caving that might endanger the structure's stability.

- Monolith Joints – Surveillance should check that the joint material is in good condition, the exterior joint sealant is intact and cracking or desiccation is minimal, and the joint filler material or waterstop is not visible at any point.

Box Culverts and Concrete and Steel Structures

- Debris and sediment deposits – Floods cause debris and sediment deposits in box-culvert and bridge-support structures. This can impede the culvert-flow conveyance, result in structural damage caused by debris movement, and cause fish to become trapped in stagnant pools in the culvert. Post-flood inspections should note any unusual accumulation of debris (greater than 1 cubic ft) or sediment (thicker than 2 ft) near flood-control structures and recommend removal by maintenance operations.
- Damage to concrete from overstressing or impact – Post-emergency inspections should include looking for cracks in concrete structures. Inspections should note the locations and extents of any new cracks for continued monitoring. Cracks or spalling of concrete indicate distress.
- Deformation or movement of structures – Noticeable deformation or movement of structures after an emergency should be note, and additional investigation or repairs should be initiated. Where appropriate, field surveys should be conducted to estimate the magnitude of movement.

Revetments

Revetments consist of gabions, concrete cellular matting (CCM), grouted riprap, stone protection, bridge-support protection, and grade-control structures. The following conditions are of particular concern after an emergency:

- Localized displacement of revetments including sliding of gabions, uplifting of CCM elements, sliding of riprap, and settlement of grade-control structures.
- Erosion or undercutting of foundation areas below gabions, CCM, or riprap caused by high-velocity flows during floods; and
- Accumulation of debris at slope protection and grade-control structures.

Surveillance should note the location, extent, and nature of the damage in the Inspection Reports. Also, post-earthquake maintenance personnel should be aware that some revetments may not be stable and could be hazardous to maintenance crews during aftershocks.

Utility Facilities

Utility facilities consist of interior drainage structures and utility crossings. The following conditions are of particular concern after an emergency:

- Erosion in the channel bed at utility crossings;
- Accumulation of debris and structural damage near flap gate or outlet structures; and
- Joint movement or misalignment of utility lines.

Site Security and Access

It is critical that site security be maintained immediately following an emergency. Immediate surveillance of project features will ensure that public access to potentially hazardous conditions is restricted.

Environmental Facilities

Uprooting of trees and shrubs and collection of debris during floods are the primary issues of concern during a flood. Surveillance should identify the location and extent of uprooted vegetation and collected debris to ensure that flood capacity is addressed by subsequent maintenance activities.

Recreational Facilities

Most recreational areas are located near the riverbank or close to flood-control structures. This proximity to the river suggests a higher likelihood of flooding of recreational areas. The following surveillance should occur shortly after the floodwaters subside:

- Check benches for security and safety to the public;
- Check for debris caught by structures and mounds;
- Check pedestrian bridges, river walks and stairs for damage and debris;
- Check for silt deposited over walkways, stairs, and concrete surfaces;
- Check for debris caught on railing or light fixtures; and
- Check condition of lighting fixtures.

11.5 COORDINATION

Special surveillance related to inspections and damage reporting shall be coordinated with operation, maintenance, and inspection requirements discussed in Section 9.

Special surveillance after emergencies shall be coordinated with emergency operations discussed in Section 10. This surveillance shall be performed during, or as soon as possible after the event. During the special surveillance, damages or distress shall be recorded in a detailed Inspection Report and provided to the Superintendent, who at their discretion, report it to the USACE. If signs of structural damage or distress are found, the structure shall be included in the long-term routine surveillance program described above and appropriate actions shall be taken.

11.6 Reporting and Documentation

The locations of the sediment survey stations, survey data, estimates of channel capacity, and vegetation monitoring shall be documented and included in the winter semiannual report. All other surveillance data should also be documented and submitted in the semiannual report.

Inspections for special surveillance after emergencies shall be conducted using the semiannual inspection checklists provided in Appendix D. Many of the items require eyewitness accounts during the event.

All monitoring, measurements, and repair shall be recorded in the surveillance record and included in the semiannual report to USACE.

These procedures should be used as needed to develop historical information for OMRRR&R activities and any future project modifications. Proposed program activities, data, and conclusions, together with proposed maintenance for the following season, should be presented to the USACE ICW program manager at least annually. Any maintenance activities that may affect project performance shall be approved in advance by the USACE District Commander or representative.

SECTION 12 REPAIR, REPLACEMENT, AND REHABILITATION

12.1 PURPOSE

This section discusses the RR&R for project features.

- **Repair** is considered to entail activities of a routine nature that maintain the project in a well-kept condition.
- **Replacement** covers those activities taken when a worn-out element or portion thereof is replaced.
- **Rehabilitation** refers to a set of activities as necessary to bring a deteriorated project back to its original condition, or to modify the original construction to meet new standards (the latter is also referred to as Rehabilitation for Corrective Maintenance).

The need for RR&R is identified during inspections (Section 9) and surveillance (Section 11). RR&R actions are to conform to the project as-built plans and specifications unless other arrangements are made with the District Commander. These activities are the responsibility of the City. This section covers any RR&R activities not covered in previous sections that may require unusual treatment.

12.2 FLOOD-CONTROL FACILITIES

Earthen Structures

Given the inherent variability in subsurface conditions, specific RR&R should be prepared by a licensed civil engineer to address a given problem identified during inspections or surveillance. The following factors should be considered in implementing RR&R:

- Extent of damage and risk of failure – Prior to defining RR&R activities to address a specific problem, an evaluation of the extent of damage and risk of failure of earthen structures shall be conducted. Evaluation of these factors will determine the nature and extent of additional investigations and analyses that are needed to develop RR&R activities.
- As-built (record) plans – The RR&R activities shall be designed to restore earthen structures to reflect the conditions presented in the as-built plans. Any variations from as-built conditions are subject to approval by USACE.
- Fill materials – Restoring failed earthen structures requires careful consideration of fill materials. Cohesive soils are usually considered suitable because of a low potential for seepage. Saturated cohesive soils, however, can

lead to unstable conditions and should be evaluated prior to their utilization. Chapter 7 of USACE Engineer Manual 1110-2-1913, Design and Construction of Levees, provides more detailed guidelines for use of fill materials in levee and embankment construction.

- Geotechnical investigations – If existing available data on subsurface conditions are insufficient to address the problem, additional geotechnical explorations should be considered.
- Selecting suitable RR&R action – The extent of damage identified in the Inspection and Damage Reports usually defines the need for RR&R of the embankment. Localized failures or minor seepage problems can usually be repaired by using suitable slope- and erosion-protection measures. Extensive damage caused by seepage through the embankment or a major slope failure will require replacing the structure with an engineered section. Rehabilitating an embankment using advanced techniques such as in-situ ground improvement is required when removing and replacing the embankment cannot be performed without having significant impact on flood-control operations.

Box Culverts, Concrete and Steel Structures Including Bridges and Floodwalls

Typical conditions that may warrant RR&R of box culverts and concrete and steel structures include large cracks in the concrete or large movements of the structure. Loss of support from the adjacent soil requires RR&R. Understanding the source of large cracks or movement is essential to ensuring the integrity of the structure. Failure to repair large cracks or movements may accelerate deterioration and potentially lead to the failure of the structure. In recommending a repair or replacement strategy, the specialist should consider the following:

- Performing additional design analysis;
- Using temporary supports to stabilize an unsafe area;
- Re-compacting loose adjacent supporting soil and replacing unsuitable soil;
- Timing repairs such that they are completed prior to the next flood season, when additional damage could occur; and
- Using barriers around the damaged area to protect the public.

Revetments

Gabions

To ensure that design grades and slopes are maintained in a stable condition, damage to gabions shall be repaired, replaced, or rehabilitated as soon as practicable. Typical conditions that may require RR&R include significant

deformation of gabion containers caused by loss of rock, settlement that results in loss of support of an adjacent structure, or conditions that could lead to a failure that threatens the ability of the project to function as designed. RR&R should include, but not be limited, to the following:

- Significant deformation of gabion baskets – When the stone fill inside the baskets becomes consolidated, broken, lost, or disintegrated; the gabion baskets may become deformed. In this case, the gabion containers should be opened and more stones should be added to restore the gabion to the original grade and condition and provide proper support for the adjacent gabion container.
- Fracture, cracking, scour, slip, or slope movement – In areas where fracture, cracking, scour, slip, or slope movement has occurred to such an extent as to expose a portion of the protected bank, the gabions should be removed, the area brought back to original grade by fill placement and compaction, and filter fabric replaced prior to gabion replacement. New or additional gabions may be required to restore the damaged slope protection. Slope, grade, and thickness of the repaired gabion should conform to the original construction. For temporary repairs, riprap with appropriate filter protection can be used in lieu of gabions. Permanently restoring the original design should be implemented.

Grouted Riprap/Stone Protection; Erosion and Riprap Loss

Erosion, undercutting, or riprap loss should be repaired, replaced, or rehabilitated as follows:

- Clean out any debris, loose soil, and loose rocks. Damaged geotextile should be replaced. Backfill with engineering material if needed. Place geotextile on compacted sub-grade.
- Place riprap in such a manner that individual rocks interlock.
- For grouted riprap, clean the surfaces of the rocks, moisten the surfaces, and place grout to fill all the voids. Spade and rod into place. After the grout has been placed, thoroughly sweep the surface from the bottom up to expose the surface of the rock and fill all surface voids.
- Major cracks in grouted riprap should be repaired with non-shrink grout (minimum compression strength of 2,000 psi in two hours). Fill the crack completely with non-shrink grout.

Grade Control Structures

Grade control structures should be repaired, replaced, or rehabilitated as follows.

- Repair or replace any damaged, deteriorated, or missing cedar logs, chains, turnbuckles, galvanized eyebolt anchors, and other hardware. Replacement logs must be left untreated to prevent any chemicals leaching into the water.
- Repair or replace any sections of damaged or missing riprap rock, gravel, and clay/silt layers with similar materials of the same thickness as indicated in the construction drawings included in Appendix A.
- Plunge pools may have severe scouring, buildup of sediment and debris, or missing stones or cobbles. Clean out sediment and debris, repair any damage, and replace any missing stones or cobbles.

12.3 Interior Drainage Structures

Significant settlement and misalignment of these structures, serious erosion adjacent to the structures, and damages to the structures should be repaired, replaced, or rehabilitated as follows:

- Settlement of structures – A settled structure should be removed and reinstalled after its foundation has been backfilled and re-compacted to its original grade.
- Misalignment of the structures – Structures or drainpipes should be repaired and realigned to allow proper drainage.
- Erosion – Erosion adjacent to an interior drainage structure that will compromise the structure's stability should be repaired and the erosion sources eliminated.
- Damaged structures – Damaged structures or drainage pipes should be repaired or replaced to their original material and grade.

12.4 Utility Crossings

Repairs to utility crossings should conform to existing environmental compliance requirements. For all repairs, all applicable permits (current or latest) should be reviewed. A Streambed Alteration Permit for Maintenance actions may be necessary. Application for new permits and notification of required agencies should be completed as applicable.

12.5 Site Security and Access

The majority of the maintenance issues for site security and access elements can be addressed by the routine maintenance activities listed in Section 10. The RR&R of damaged security facilities should maintain the same alignment, height, material and installation conditions of the facilities as originally constructed. Repairs should be completed within 30 days.

12.6 Environmental Facilities

Section 9 covers inspection and maintenance requirements. Appendix A contains original placement and cultivation details.

12.7 Recreational Elements

Activities that may involve RR&R of recreational elements include repairing and replacing irrigation systems, restoring extensive flood damage to landscaped areas, and replacing furniture.

SECTION 13 NOTIFICATION OF DISTRESS

13.1 PURPOSE

This section prescribes the responsibilities and procedures for the immediate notification to the USACE of evidence of distress or potential failure of any project element in accordance with ER 1110-2-101, Reporting of Evidence of Distress of Civil Works Structures. Any evidence of distress shall be reported to USACE through the ICW Project Manager.

13.2 RESPONSIBILITIES

The USACE chain of command should be informed by immediate reporting, inspection, and follow-up evaluation of conditions that demonstrate evidence of distress or conditions that could result in a potential hazard at civil works projects. Initial reporting should be via telephone with a follow-up written summary, including appropriate photographs.

Evidence of distress at USACE projects will be immediately reported to the District Office. The San Francisco District Levee Safety Officer will confirm the situation, determine if an engineering evaluation of the condition is required, if remedial measures will be required. The officer will immediately report the conditions, through command channels, to the Headquarters USACE (HQUSACE) Levee Safety Officer. If the HQUSACE Levee Safety Officer cannot be contacted, the reporting major subordinate commands or field office will follow the notification of the Division and District Levee Safety Officers and coordination of all information with their counterparts in the Emergency Management element. The HQUSACE Levee Safety Officer will notify the Director of Civil Works and the Commander, USACE.

13.3 PROCEDURES

Procedures for reporting evidence of distress are outlined in ER 1110-2-101. The extent and significance of distress signals should be reviewed by a licensed engineer before reporting requirements are finalized. Typical distress signals include the following:

- Sloughs, settlement, or slides in embankments, such as urban levees, and bridge abutments, and channels
- Evidence of piping, muddy water boils in the areas of the structures
- Any increase in seepage quantities through or under levees or abutments
- Any significant change in uplift pressures under concrete structures

- Unusual vertical or horizontal movement or cracking of levee embankments or abutments
- Significant cracking of mass concrete structures
- Sinkholes or localized subsidence in the foundation of or adjacent to levees or other pertinent structures critical to the safe operation of the project
- Excessive deflection, displacement, or vibration of concrete structures (e.g., tilting or sliding of bridge piers, or floodwalls)
- Significant damage to any structure
- Significant damage to, or changes in, structures, foundations, groundwater conditions, and adjacent terrain because of seismic events (special inspections for damages should be made immediately following an earthquake as described in ER 1110-2-1802)
- Any other indications of distress or potential failure that could inhibit the operation of a project or endanger life or property
- Abnormal increase or decrease of flow from weep holes of the soil nail wall
- Significant cracking or spalling of the facing of the soil nail wall
- Exposure of the bottom of the soil nail wall because of damage and dislodgment of the in-channel features or excessive erosion of the Purisima Formation rock

SECTION 14 REFERENCES

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