US Army Corps
of Engineers ®
San Francisco District

PAJARO RIVER FLOOD RISK MANAGEMENT PROJECT
SANTA CRUZ AND MONTEREY COUNTIES
CALIFORNIA

CIVIL DESIGN
APPENDIX B APRIL 2018

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1.0 INTRODUCTION

This appendix documents the civil design for the Pajaro River Flood Damage Reduction Project General Reevaluation Report (Pajaro River GRR). The purpose of the Pajaro River GRR is to evaluate the levee improvements and measures necessary to reduce flood risk to the City of Watsonville and the town of Pajaro. The study area includes the Pajaro River Main-Stem, Salsipuedes and Corralitos Creeks. This appendix summarizes the design and site considerations required for construction of project features, access roads, staging areas, real estate requirements, relocations and quantities developed for the alternatives analyzed for Pajaro River GRR. Design consideration information includes floodwall and levee construction guidance, EM-1110-2-1913 Design and Construction of Levees, and ER 1110-2-1150 Engineering and Design for Civil Works Projects.

1.1 PROJECT LOCATION AND BACKGROUND

The project is located in the Pajaro River watershed on the Central Coast of California. The watershed is approximately 1,300 miles and includes portions of Santa Clara, San Benito, Santa Cruz, and Monterey counties. The focus of the GRR study is flooding along the lower Pajaro River and its tributaries, Salsipuedes and Corralitos creeks, in the vicinity of the city of Watsonville in Santa Cruz County and the town of Pajaro in Monterey County. There are six significant reservoirs in the Pajaro River Basin, all of which were designed solely for water supply purposes. Of the six reservoirs, only College Lake provides any significant reduction in downstream flooding. College Lake, a natural storage area, intercepts runoff from the Salsipuedes Creek watershed, and is located immediately upstream from the junction with Corralitos Creek. The existing flood protection project was constructed by the USACE in 1949, and consisted of levees along the Pajaro River from its mouth to levee Station 520+00 on the right bank (north) and Sta 575+00 on the left bank (south). Note that units are in feet. The 1949 USACE project also included construction of levees on Salsipuedes Creek from its confluence at the Pajaro River to levee Sta U 128+00. The original flood control project did not include Corralitos Creek. The following modifications and repairs have been made to the study levees:

- Four sites on Salsipuedes Creek were repaired in 1982.
- Three sites on Salsipuedes Creek were repaired in 1986.
- Damage to the entire study area was repaired following the 1989 Loma Prieta earthquake.
- Repairs to one site on Salsipuedes Creek in 1993.
- Repairs were made to a levee break in 1995 that occurred during the 1995 storm event.

• Levees were restored to their original profile in 1997 along Pajaro River and Salsipuedes Creek to account for foundation settling.

• Repairs were made to several sites along Pajaro River and Salsipuedes Creek damaged by the late 1996, early 1997 flood event.

• Repairs to 12 sites along the entire study area following the flood event of 1998.

• A sheet pile seepage cut-off wall was installed in Salsipuedes Creek (right bank) from the Pajaro River confluence to Highway 129 in 2002.

• Current analysis to repair several sites along Pajaro River (Santa Cruz County) and Salsipuedes Creek that were damage during the 2017 storms.

The Pajaro River GRR project area includes approximately 20 miles of levees corresponding with the boundaries of Santa Cruz and Monterey counties. Along the Pajaro Main-Stem the project is bound on the west by the city of Watsonville and on the east by the town of Pajaro. Along Salsipuedes Creek, the project is bound on the north and west by the city of Watsonville, and on the east by developed agricultural areas. Along Corralitos Creek, the project is bound on the south by the city of Watsonville and on the north mostly by developed agricultural areas. The project was originally split into eight reaches for technical evaluation. A description of the study reaches is shown on Table 1.1 and a graphical description is shown on Figure 1.1 below.

MAINSTEM TSP			
Reach	Left Levee Length (miles)	Right Levee Length (miles)	Beginning to End Description
1	Not in project	Not in project	Mouth of River to Highway 1 Bridge
2	1.75	1.7	Highway 1 to Union Pacific Railroad Bridge
3	0.65	0.7	Union Pacific Railroad Bridge to Salsipuedes Creek and Pajaro River Confluence
4	2.9	2.6	Confluence of Salsipuedes Creek and Pajaro River to West of Murphy Road
TRIBUTARY TSP			
5	Floodwall 1.0 mile long	1.8	Confluence of Salsipuedes and Corralitos Creeks (Highway 152) to the confluence with the Pajaro River Main Stem
6	1.8	1.1	Highway 152 to Green Valley Road
7	Not in project	Not in project	Area north-east of Highway 152 encircling Orchard Park Subdivision
8	Not in project	Not in project	Corralitos Creek: Green Valley Road to Airport Blvd

Table 1.1 Study Reaches

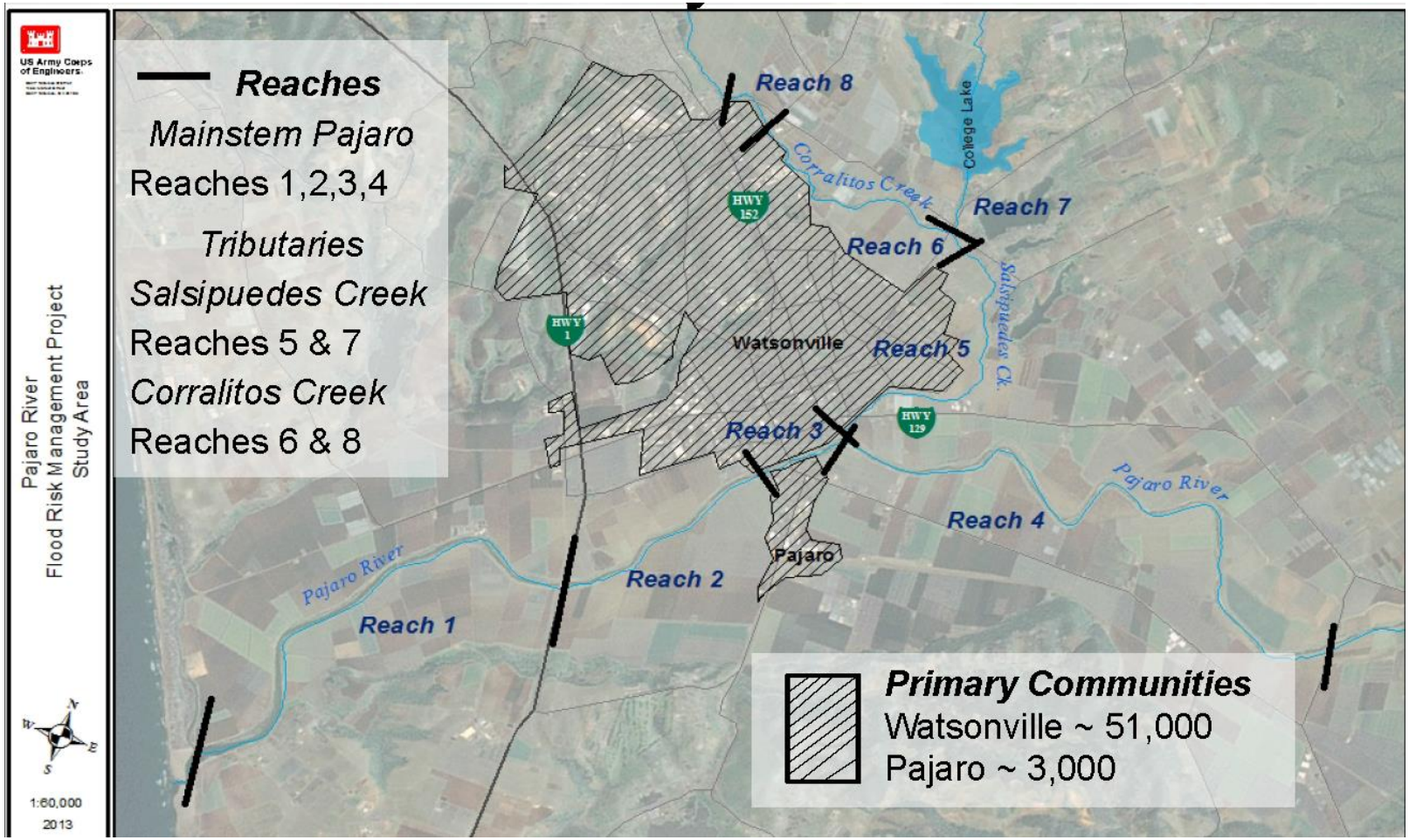


Figure 1.1: Study Area

1.2 COORDINATION

The project coordination team consisted of USACE San Francisco and Sacramento Districts. Non-USACE team members include the State of California, City of Watsonville, Town of Pajaro, Santa Cruz and Monterrey Counties.

2.0 GENERAL CONSIDERATIONS

2.1 TOPOGRAPHIC DATA

The topographic or terrain data used for the civil design horizontal and vertical alignments, 3D levee modeling and quantity estimates, was based on an existing Light Detection and Ranging (LIDAR) survey conducted in 2010 for the California Coastal Conservancy LIDAR Project. The elevations recorded are in feet and referenced to the North American Vertical Datum of 1988 (NAVD88) and the horizontal datum is referenced to the North American Datum of 1983 (NAD83), and California State Plane Coordinates Zone III.

2.2 LEVEE GEOMETRY

Acceptable levee design geometry was adopted by the San Francisco district, and Sacramento District Geotechnical Sections based on current USACE standards of practice. Levee geometry associated with new design geometry consists of the following:

a. Levee Crown 20 feet wide
b. Waterside Slope 3H:1V
c. Landside Slope 3H:1V

New levee construction would require-levee slopes on 3H:1V for increased levee safety and stability. Slope benching or notching into the existing bank details and potential areas where space on the land side is limited and/or too close to existing properties, for a 3H:1V landside slope configuration, will be addressed in the preconstruction engineering and design phase (PED).

Information on geology, existing levee reliability and performance, and recommendations for project alternatives can be found in the Geotechnical Appendix. A typical conceptual levee design cross-section is shown in Figure 2.1. Additionally, Plates 6 and 7 at the end of this appendix show representative cross-sections of a Levee/Floodwall combination and Floodwall respectively.

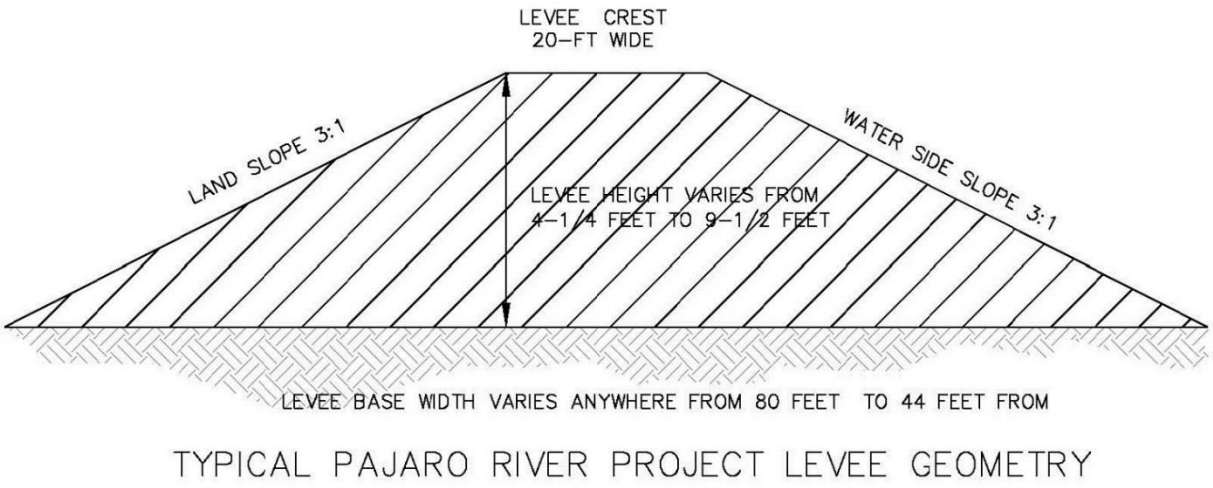


Figure 2.1: Typical Design Levee Geometry

2.3 ALIGNMENTS AND STATIONING

Levee stations were set at 100-foot intervals along the centerline of the crest following standardized notation norms and procedures. The horizontal alignments of the setback levees were adopted from the planning documents and reproduced in digital form over the existing terrain models. In areas where no setback was prescribed, the levee alignments follow the alignments of the existing levees such as in the case of Reach 3, and sections of Reach 2 and Reach 5.

2.4 UNDERGROUND AND OVERHEAD UTILITIES

Relocations were based upon and revised from the work previously done by MWH for the Pajaro Flood Damage Reduction General Reevaluation Report Civil Engineering Appendix, September 2012. A network of underground and overhead utility lines provides water, gas, electricity, sewer, cable, phone, fiber optics, and other utility services throughout the project areas. Utilities, such as electrical power lines, may be located above ground along the existing levees. However, in most cases, these utilities are buried underground near the existing levees. Utilities located within the floodplain must be relocated or abandoned before levee construction. The Project Delivery Team (PDT) has identified utility impacts throughout the study area. Affected utilities are described for each alternative plan by reach in Tables 2-1 through 2-8.

TABLE 2-1: UTILITIES AFFECTED IN PROJECT ALTERNATIVE PLAN IMPLEMENTATION

Reach	Bank	Item	Length (lf)	Ancillary Utilities	Notes	Required Modification*															
						Alt 1	Alt 2	Alt 3	Alt 4	T. Alt 5	T. Alt 6	T. Alt 7	T. Alt 8	RP							
1					NO IMPROVEMENTS																
1					NO IMPROVEMENTS																
1					NO IMPROVEMENTS																
1					NO IMPROVEMENTS																
1					NO IMPROVEMENTS																
1					NO IMPROVEMENTS																
1					NO IMPROVEMENTS																
1					NO IMPROVEMENTS																
2	LB	20" SDP	40		for storm drain in	c	c	c	c					c							
2	RB	30" RCP	132		for storm drain in existing levee	c	c	c	c					c							
2	LB	24" RCP	80		for storm drain in existing levee on Monterey County side	c	c	c	c					c							

TABLE 2-1: UTILITIES AFFECTED IN PROJECT ALTERNATIVE PLAN IMPLEMENTATION (CONTD.)

Reach	Bank	Item	Length (lf)	Ancillary Utilities	Notes	Required Modification*															
						Alt 1	Alt 2	Alt 3	Alt 4	T. Alt 5	T. Alt 6	T. Alt 7	T. Alt 8	RP							
2	LB	8" CMP	60		for storm drain in existing levee on Monterey County side	c	c	c	c					c							
2	LB	4" CMP	60		for storm drain in existing levee on Monterey County side	c	c	c	c					c							
2	LB	34 PG&E poles	9,450		34 power poles, for a total of 9,450 lf of 21KV overhead power lines within the reach	b	b	b	b					b							
2	RB	fiber optic lines	3,200		(MCI 1,600', Quest 800, Sprint 800) for a total of 3,200 lf of fiber optic lines within the reach	b	b	b	b					b							
2	LB	1 Ag well	n/a		agricultural well near the UPRR bridge	a	a	a	a					a							
3	LB	12" CMP	240	flap gate	for storm drain in the existing levee located near U.P.R.R. bridge	a	a	a	a					a							
3	RB	54" CMP	150	flap gate	for storm drain at Grove Street Pump Station	a	a	a	a					a							
3	RB	3-24" steel pipe	75	flap gate	for storm drain at Grove Street Pump Station	a	a	a	a					a							
3	RB	24" RCP	65	flap gate	for storm drain at Rodriguez Street Pump Station	a	a	a	a					a							
3	RB	30" RCP	120	flap gate	for storm drain at Main Street Bridge	a	a	a	a					a							
3	RB	60" RCP	230	flap gate	for storm drain at Union Street Pump Station	a	a	a	a					a							

TABLE 2-1: UTILITIES AFFECTED IN PROJECT ALTERNATIVE PLAN IMPLEMENTATION (CONTD.)

Reach	Bank	Item	Length (lf)	Ancillary Utilities	Notes	Required Modification*															
						Alt 1	Alt 2	Alt 3	Alt 4	T. Alt 5	T. Alt 6	T. Alt 7	T. Alt 8	RP							
3	RB	33" RCP	100	flap gate	for storm drain at Marchant Street Pump Station	a	a	a	e					a							
3	RB	33" RCP	65	flap gate	for storm drain at Marchant Street Pump Station	a	a	a	a					a							
3	RB	18" CMP	80	flap gate	for storm drain at Lincoln Street Pump Station	a	c	c	e					a							
3	RB	12" CMP	90	flap gate	for storm drain at the Coolidge Avenue Pump Station	a	c	c	e					a							
3	RB	8" CMP	110	flap gate	for storm drain at Loughhead Avenue Pump Station	a	c	c	e					a							
3	LB	30" CMP	80		for storm drain in existing levee on Monterey County side	a	a	a	a					a							
3	LB	15" CMP	80		for storm drain in existing levee on Monterey County side	a	a	a	a					a							
3	RB	12" gas pipe	500		located between the UPRR bridge and Main Street bridge	a	c	c	e					a							
4	LB	2-48" CMP	120		for storm drain in existing levee on the Monterey County side	c	n/a	b	c					c							
4	LB	18" RCP	120		for storm drain in existing levee on the Monterey County side	c	n/a	b	c					c							

TABLE 2-1: UTILITIES AFFECTED IN PROJECT ALTERNATIVE PLAN IMPLEMENTATION (CONTD.)

Reach	Bank	Item	Length (lf)	Ancillary Utilities	Notes	Required Modification*															
						Alt 1	Alt 2	Alt 3	Alt 4	T. Alt 5	T. Alt 6	T. Alt 7	T. Alt 8	RP							
4	LB	4-36" RCP	100		for storm drain in the existing levee	c	n/a	b	c					c							
4	RB	2-54"	100	flap gate	for storm drain in existing levee	c	n/a	b	e					n/a							
4	LB	4 PG&E towers	3,600		High-voltage transmission lines	b	n/a	b	b					b							
4	RB	14 PG&E poles	2,810		21KV overhead power lines	b	n/a	b	b					n/a							
4	LB	3 Ag wells	n/a		3 agricultural wells within the reach	a	n/a	a	a					a							
5	RB	8" PVC	280		from the sewer plant					c	c	c	c	c							
5	RB	15" PVC	520		with 4 manholes					c	c	c	c	c							
5	RB	36" RCP	150	flap gate	for storm drain at Blackburn Street pump station					c	c	c	c	c							
5	RB	24" RCP	130	flap gate	for storm drain at King's Highway Pump Station					c	c	c	c	c							
5	RB	60" RCP	115	flap gate	for storm drain					c	c	c	c	c							
5	LB	8" RCP	120		for storm drain in the existing levee on the Monterey County side					c	c	c	c	n/a							
5	LB	12" RCP	120		for storm drain in the existing levee on the Monterey County side					c	c	c	c	n/a							

TABLE 2-1: UTILITIES AFFECTED IN PROJECT ALTERNATIVE PLAN IMPLEMENTATION (CONTD.)

Reach	Bank	Item	Length (lf)	Ancillary Utilities	Notes	Required Modification*														
						Alt 1	Alt 2	Alt 3	Alt 4	T. Alt 5	T. Alt 6	T. Alt 7	T. Alt 8	RP						
5	LB	18" RCP	100		for storm drain in the existing levee on the Monterey County side					c	c	c	c	n/a						
5	LB	36" RCP	150	flap gate	for storm drain at storm pump station, Discharge #2					c	c	c	c	n/a						
5	LB	2-48" RCP	200	flap gate	for storm drain at Pajaro Village Pump Station					c	c	c	c	n/a						
5	LB	12 PG&E poles	2,300		21KV power lines					b	b	b	b	n/a						
5	LB	8" gas pipe	500		at Highway 129 bridge					c	d	d	d	a						
5	LB	10" water line	500		through the Highway 129 Bridge					c	d	d	d	a						
5	LB	1 Ag well	n/a		1 agricultural well in this reach					c	d	d	d	n/a						
6	RB	10" water line	500		through the Highway 152 Bridge					c	c	c	c	c						
8	RB	10" water line	200		through the Green Valley Road bridge					n/a	n/a	n/a	n/a	n/a						
8	LB	Sanitary PS	n/a		next to Green Valley Road Bridge (most likely a lift station for 8"to 12")					n/a	n/a	n/a	n/a	n/a						

Note:

* a – Remove and replace in original location
b – remove and relocate outside of proposed permanent easement
c – remove and replace, extend 100 feet
d – remove and replace, extend 225 feet
e – remove and replace, extend 50 feet

Key:

Ag = agricultural
Alt = alternative
CMP = corrugated metal pipe
KV = kilovolt
LB = left bank
lf = linear feet
LRP = locally requested plan
MCI = MCI, Inc.
PG&E = Pacific Gas and Electric
PS = pump station
PVC = polyvinyl chloride pipe
RB = right bank
RCP = reinforced-concrete pipe
SDP = steel discharge pipe
UPRR = Union Pacific Railroad
n/a = not applicable

2.5 LEVEE DESIGN: HEIGHT AND FOOTPRINTS

The Water Surface Elevation (WSE) was calculated by the hydraulic modeling efforts of the Sacramento District Hydraulic. Work on the 3D levees models and resulting levee heights and footprints were accomplished by the San Francisco District Civil Design section In accordance with EM 1110-2-1601 "Hydraulic Design of Flood Control Channels"; Section 2-6 "Special Considerations". The top of the levee was designed to provide 90% assurance of passing the 1% Annual Chance of Exceedance flood without overtopping. The design top of levee elevation include three additional feet to ensure that the desired degree of protection would not be reduced by unaccounted factors such as unforeseen embankment settlement, accumulation of silt, trash or debris etc. In short, the 3D models of all levees produced by Civil Design include the WSE, and the additional "assurance" height as indicated above and as recommended by the referenced EM. For additional detailed information concerning the hydraulics and the determination of WSE design; please consult the project Hydraulic Appendix.

2.6 PAJARO RIVER KNOWN EXISTING LEVEE DEFICIENCIES

Unsatisfactory levee performance along the Pajaro River Main-stem and the Tributaries has been documented through the years primarily as a result of waterside erosion and levee overtopping. Localized seepage and under-seepage deficiencies were also documented during high water event floods in 1995 and 1998. It is not clear to what extent animal burrows and the effects of agricultural activity contributed to the observed damages from seepage and the other failure modes described. The most likely levee deficiencies and causes of failure can be attributed to erosion, seepage and to a lesser degree to agricultural activity as described below.

- Erosion: Erosion has been an ongoing problem since the project was constructed in 1948 to the present, in part as a result of significant rodent activity through the years, and in part due to the inability of the existing levees soils to grow and sustain adequate cover.

- Seepage: While not a generalized problem along the existing levees; localized seepage remediation occurred in the spring of 2002 when approximately 325 linear feet of sheet-piling was installed along the right bank of Salsipuedes Creek from Highway 129 to the confluence with the Pajaro River.

- Agricultural Impact: Agricultural activity adjacent to the levee toes has through the years impacted the geometry of the existing levees on the land side; to the extent that in some areas the slopes have been modified with vertical cuts at the toe by the seasonal activity of excavating agricultural drainage ditches. Farming activity such as plowing on the landside toe, and excavated drainage ditches have been consistently documented to encroach onto project right-of-way.

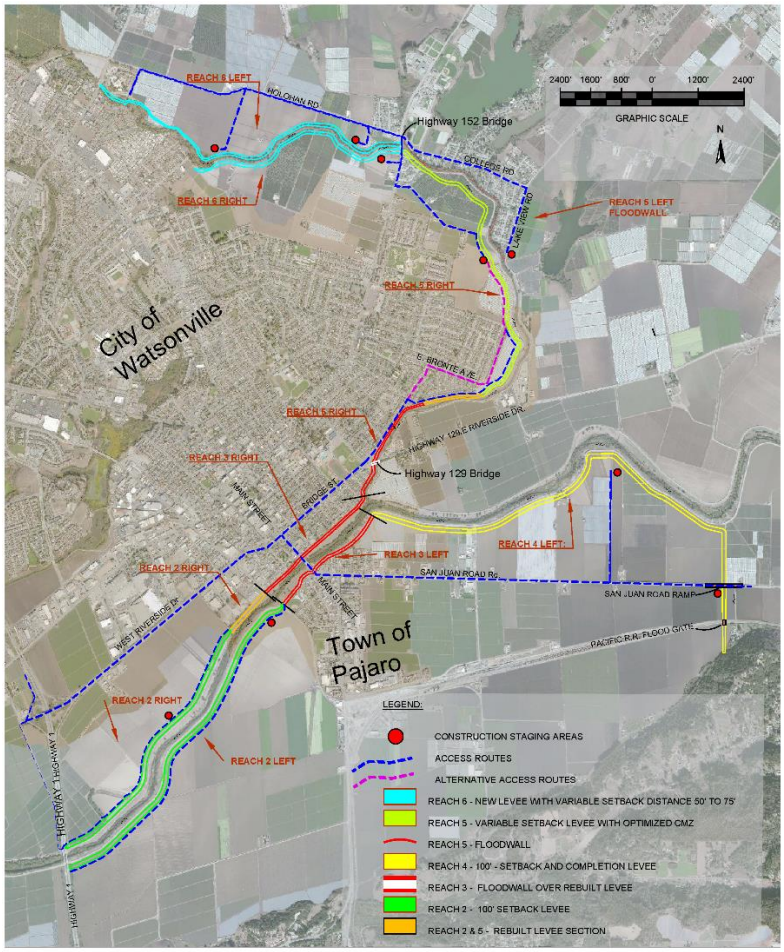
A detail summary of levee deficiencies can be found in the Geotechnical Appendix.

2.7 ROADS /ACCESS RAMPS

For all project alternatives where levees will be either raised in place or set back from their existing locations, existing roads and access ramps may be affected. For minor roads and access points not described within the RP, grading and/or realignment will be necessary to maintain egress and ingress along affected roadways. The extent of the impact will be investigated further during final design, when levee alignments and elevations are finalized.

2.8 CONSTRUCTION ACCESS - HAUL ROUTES AND STAGING AREAS

The PDT has identified at least 9 potential staging areas and access haul routes (See Figure 2. 2) throughout the project that are strategically positioned. Most of the staging areas are situated within agricultural land and are accessed by existing roads. The exact need for staging areas and actual identification of areas will be completed during the PED phase.



Pajaro TSP: Access, Haul Routes and Staging Areas

Figure 2.2: Construction Access, Haul Routes and Staging Areas

2.9 REAL ESTATE REQUIREMENTS

The Non-Federal Sponsor is responsible for the procurement of all lands, easements, relocations, rights-of-way, and disposal areas (LERRD) necessary for the construction, operation, and maintenance of the project.

Maintenance easements will be required for all improvements within the proposed project. Levee maintenance and inspection will likely be performed from both the toe of the proposed levees and from the levee crown. A 15-foot maintenance (permanent) easement will extend outward from the landside toe of all proposed levees. In addition to maintenance easements, any utility pole relocated may require further easement acquisition, depending on the placement of the relocated poles and overhead/underground utilities.

Temporary construction easements and stockpiling areas will also be required for this project, and have been assumed to be large enough for parking construction vehicles and equipment as well as to stockpile at least 400 CY of backfill material beyond the limits of the maintenance easement. In areas where the landside toe of the proposed levee falls within existing private property, there may be an opportunity to minimize temporary easements by performing construction activities from the levee crown. For the purposes of this study, in areas where there was minimal infringement of temporary easement on existing property/structures, the temporary easement was reduced in width. This variance will require further investigation during the final design.

Materials to be disposed of will be hauled to a landfill or other area to be identified during the design phase of the project. Borrow material, other than what will be derived from removing existing levees, is required to complete the levee construction in the proposed alternative plans. This borrow material will be obtained locally. The source of suitable borrow material has yet to be identified.

Maps and detailed information on easements and affected properties can be found in the Real Estate appendix.

2.10 OPERATION AND MAINTENANCE

The Inspection of Completed Works (ICW) program is an O&M program that provides for USACE inspections of federally constructed flood risk management projects. A draft O&M manual will be developed preceding a project's final design state and used by the counties and USACE to insure that the project is maintained to USACE standards. Annual and periodic 5–year ICW inspections will be performed for the Pajaro River Project which will be based on the O&M manual requirements and current USACE maintenance standards. The O&M manual will provide a detailed description of the management activities for levee, floodwall, vegetation, sediment, debris, bank erosion, culverts and other activities to provide the design flood conveyance capacity of the RP. During construction, maintenance of the levees that will remain in place will continue to be responsibility of the sponsor, such as the following levees; Reach 4 right along the Pajaro Main-stem and sections of levees on the left of Reach 5 along Salsipuedes Creek.

3.0 PROJECT DESIGN ALTERNATIVES AND SELECTED PLAN

3.1 FINAL ARRAY OF ALTERNATIVES

A wide range of features were considered and evaluated to reduce flood risk in the project area. Below is the focused array of alternatives that were analyzed:

Main Stem Alternatives:

Alternative 1 (Figure 3.1) 1% (1/100) Annual Chance Exceedance protection with 100-feet setback levees in reach 2 and on reach 4 left bank and same level of protection with a floodwall/levee combination in urban areas (reach 3). Completion levee with 4% (1/25) Annual Chance Exceedance (ACE) design level in reach 4 right bank (Agricultural Area). Note. Setback under this context is understood to be the linear distance from the centerline alignment of an existing levee to the centerline alignment of the new levee. (See Plate 4 at the end of document)

Alternative 2 (Figure 3.2) 1% (1/100) Annual chance exceedance protection with a ring levee around the Town of Pajaro and Protection to Urban Watsonville Area along the right side of reaches 2 and 3. Reach 2 right side protected with a 100 foot setback levee and reach 3 right side protected with a combination of floodwall/levee.

Alternative 3 (Figure 3.3) 1% (1/100) Annual chance exceedance protection with 100-feet setback levees in reach 2, likely a floodwall/levee combination in urban areas (Reach 3) and an Optimized Channel Migration Zone (CMZ) in Reach 4 left bank. Plus 4% (1/25) annual chance exceedance levee in Reach 4 -right bank (Agricultural Area).

Alternative 4 (Figure 3.4) 1% (1/100) Annual chance exceedance protection with a 100-feet setback levees along reaches 2 and 4 left bank, a floodwall/levee combination in urban areas (Reach 3). Plus a 50-feet setback completion levee with 2% (1/50) annual chance exceedance (ACE) design level in reach 4 -right bank (Agricultural Area)

Tributary Alternatives:

Alternative 5 (Figure 3.5) 1% (1/100) Annual chance exceedance protection. Floodwall/levee combination in urban areas at the downstream end of reach 5 right side and floodwall at the upstream end of reach 5 left side, variable setback levees along agricultural areas on the left and right sides of reaches 5 and 6, a levee and floodwall sections around Orchard Park (reach 7) and a levee on the left side of reach 8.

Alternative 6 (Figure 3.6) 1% (1/100) Annual chance exceedance protection. Floodwall/levee combination in urban areas at the downstream end of reach 5 right side and a floodwall at the upstream end of reach 5 left side, variable setback levees along agricultural areas on reaches 5 left and right sides and variable setback levee on reach 6 right side, levee and floodwall sections at the upstream end of reach 6 left side plus a ring levee around Orchid Park (reach 7).

Alternative 7 (Figure 3.7) 1% (1/100) Annual chance exceedance protection. Floodwall/levee combination at the downstream end of reach 5 right side , floodwall at the upstream end of reach 5 left side, variable setback levees along agricultural areas of reach 5 left and right sides, Optimized Channel Migration Zone (CMZ) levees along reach 6 left and right sides and a levee along reach 8 left side.

Alternative 8 (Figure 3.8) 1% (1/100) Annual exceedance protection. Floodwall/levee combination at the downstream end of reach 5 right side, floodwall at the upstream end of reach 5 left side, variable setback levees along agricultural areas on both sides of reach 5, Optimized Channel Migration Zone (CMZ) levee on the right side of reach 6, levee on the left side of reach 8 and a ring levee around Orchid Park (reach 7). Graphic Maps of the final array of alternatives can be seen in Figures 3.1 through 3.8 below

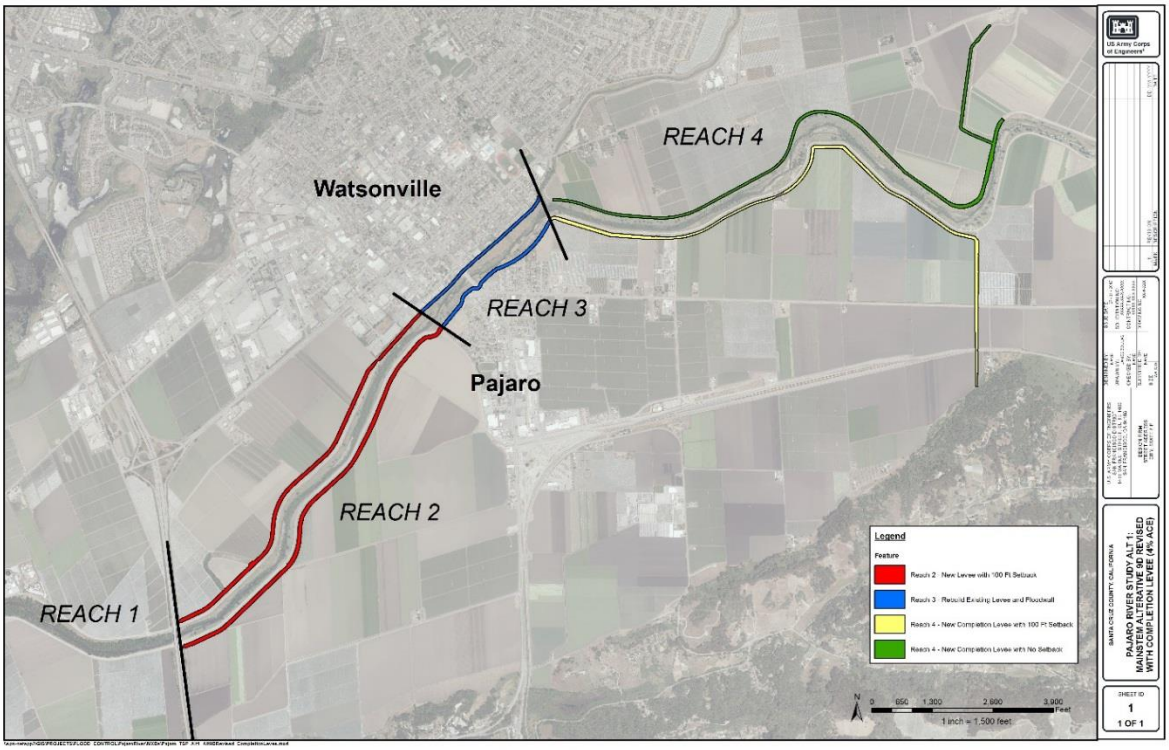


Figure 3.1: Alternative 1

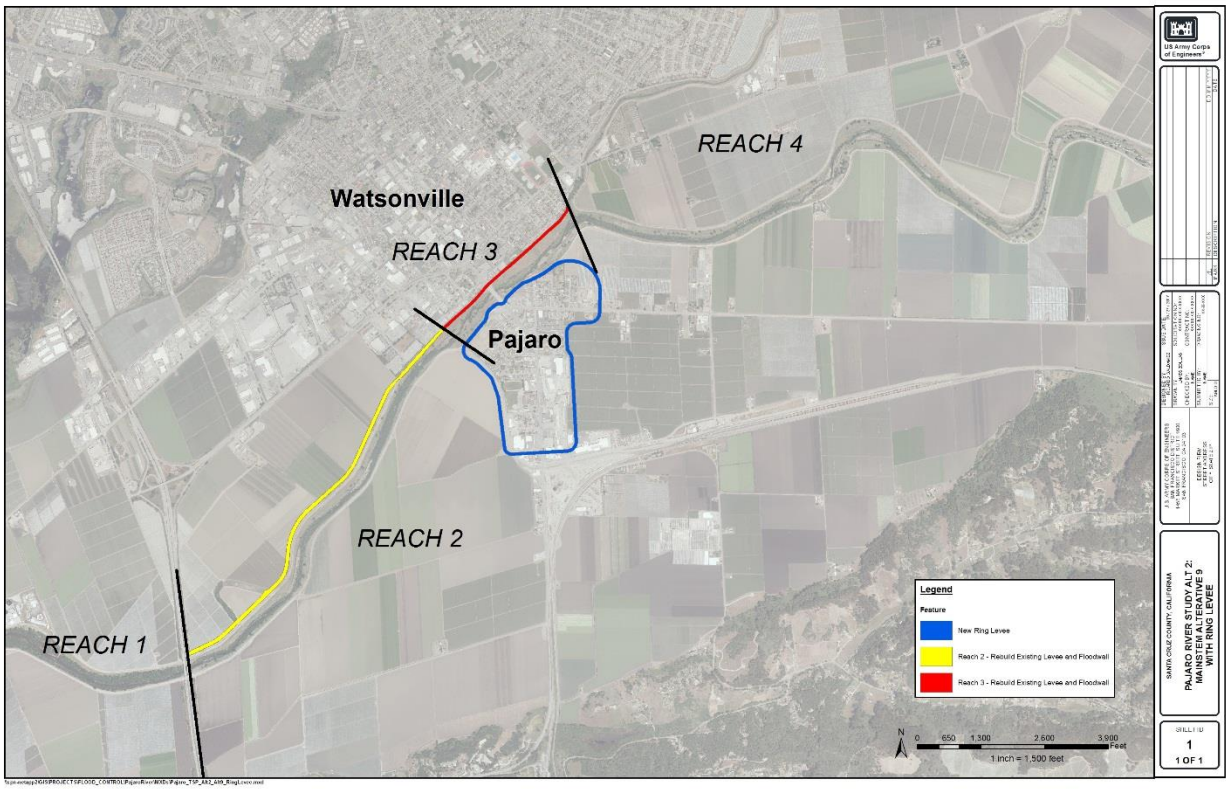


Figure 3.2: Alternative 2

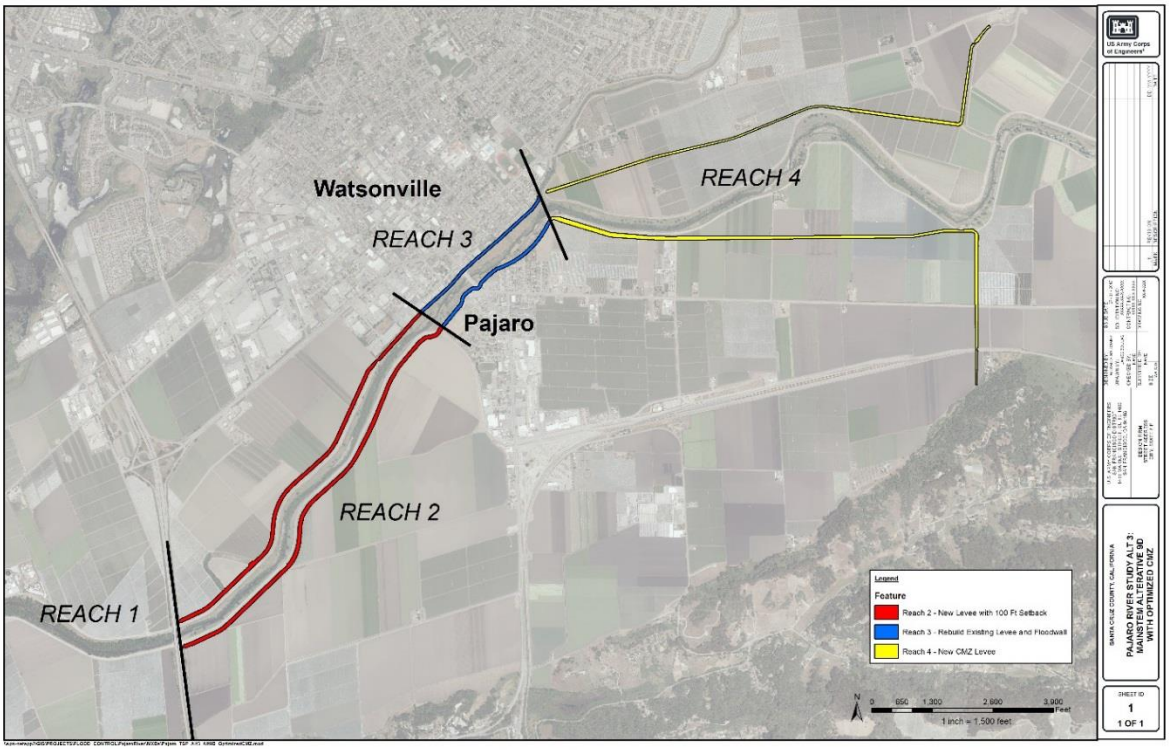


Figure 3.3: Alternative 3

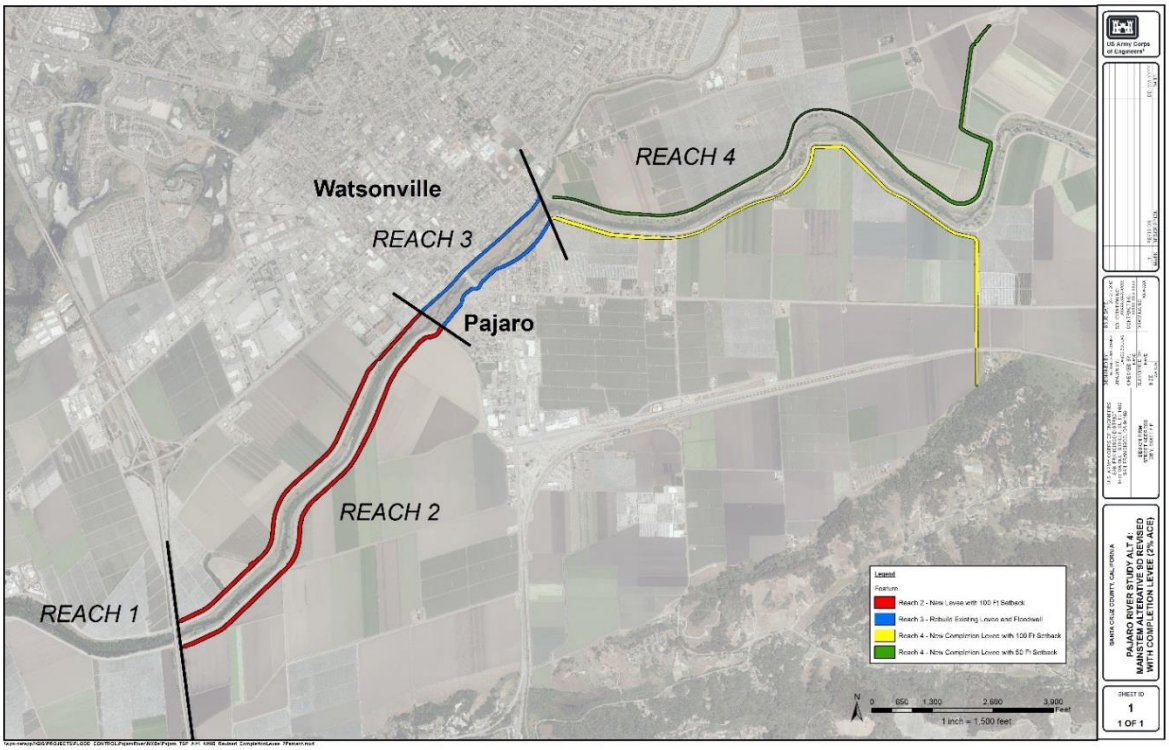


Figure 3.4: Alternative 4

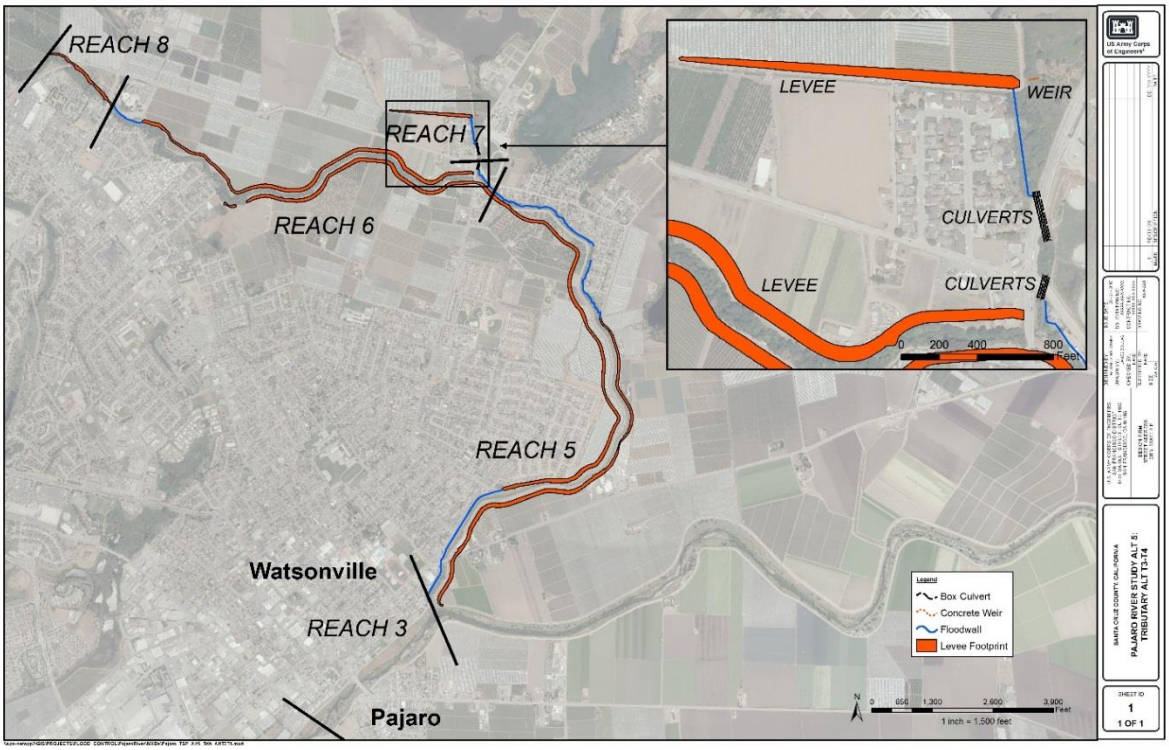


Figure 3.5: Alternative 5

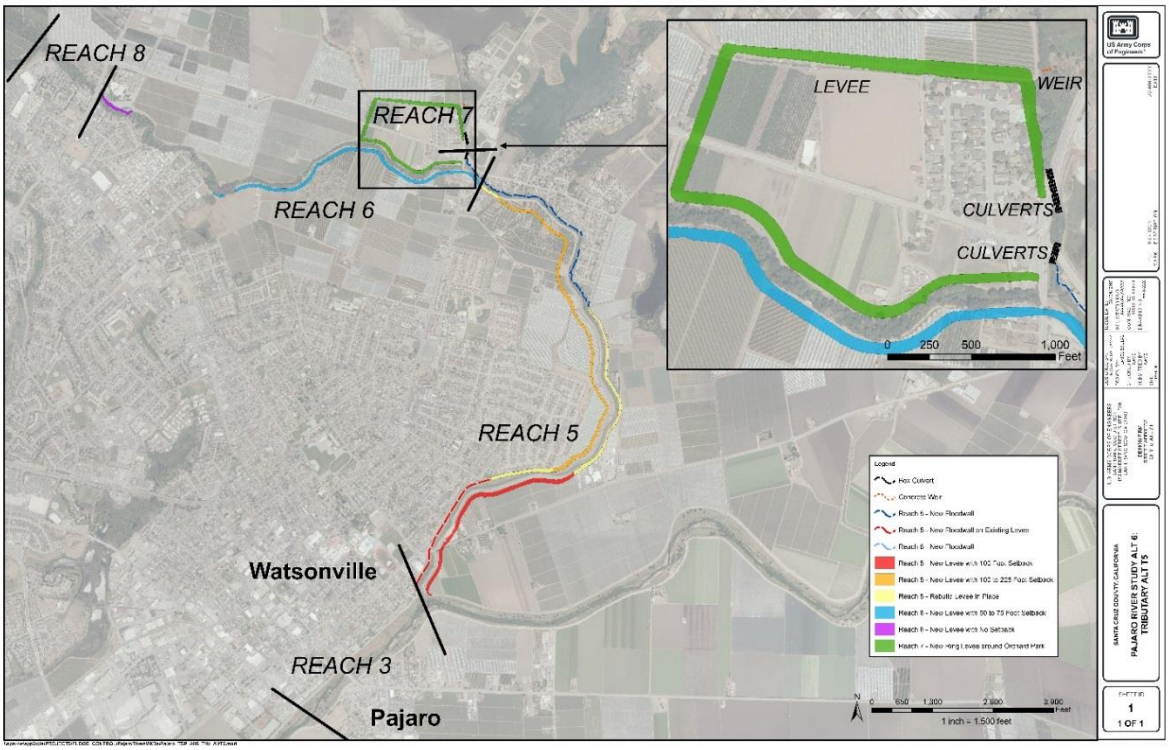


Figure 3.6: Alternative 6

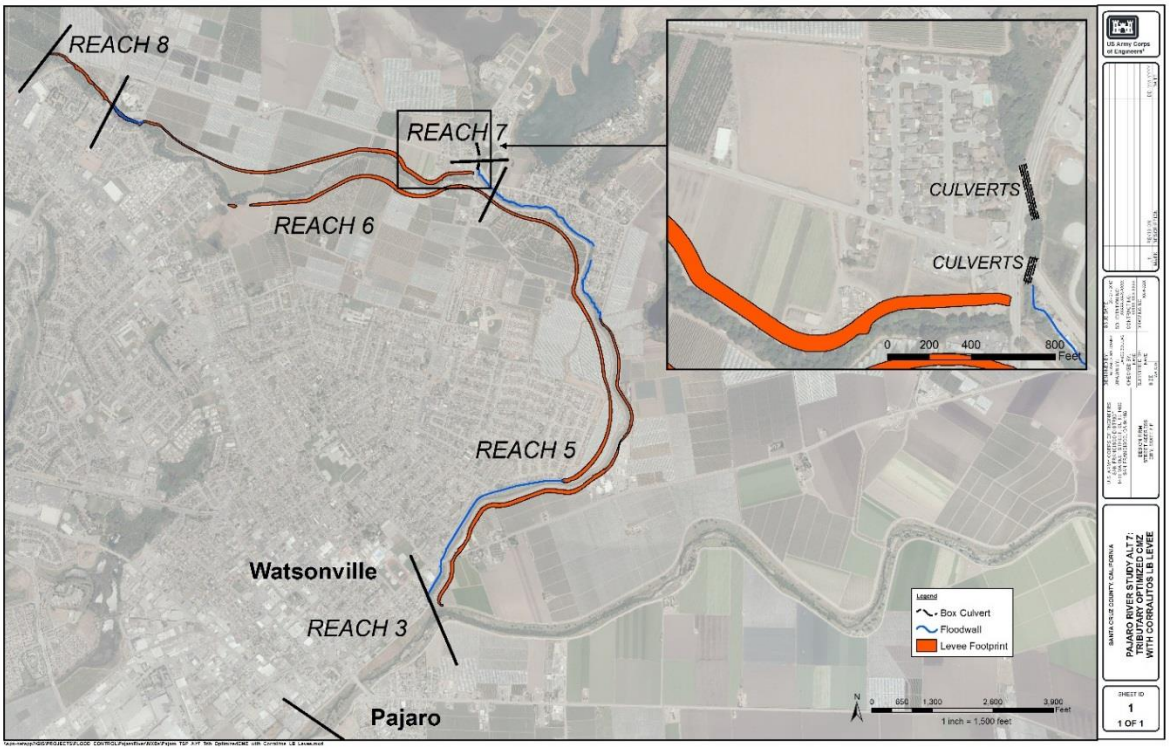


Figure 3.7: Alternative 7

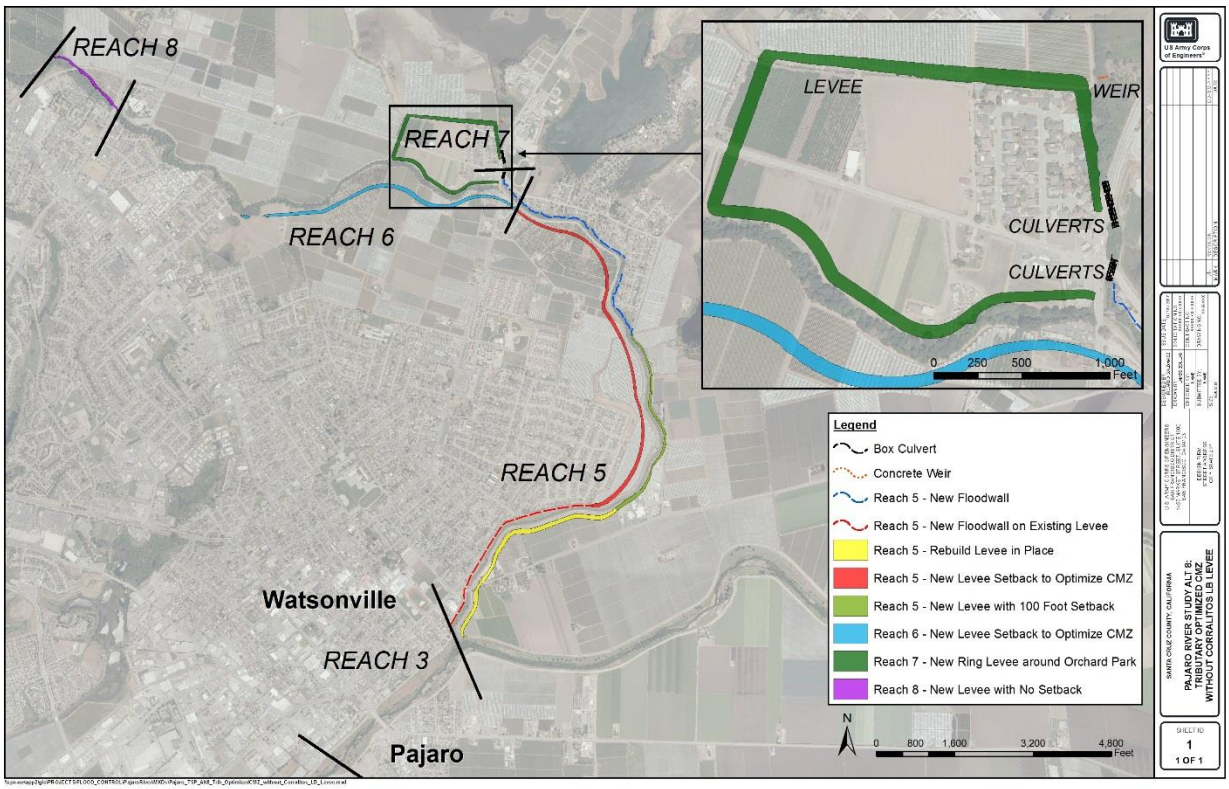


Figure 3.8: Alternative 8

3.2 RECOMMENDED PLAN

The recommended Plan (RP) was derived from the combined set of protective measures found on Alternative 1 on the Mainstem of the Pajaro River and Alternative 6 of the Tributaries alternatives as described above on section 3.1. For economic reasons the plan initially excluded all improvements on the right bank of the Mainstem Reach 4, and any other improvements on the left bank of Reaches 5, 6; but realizing that it was more economically beneficial to protect those areas from induced flooding, except for Reach 4 right bank, which is agricultural land, the plan now includes a 4% (1/25) annual chance exceedance level of protection levee on the left side of reach 6 and a 4% (1/25) annual chance exceedance level of protection floodwall on the left bank of reach 5. The improved Tentatively Selected Plan as explained below, now meets the study objectives of reducing flood risk and flood damages to people and property in the project area and provide benefits to 12,600 residents in the area. For a detailed map of the RP, See Figure 3.9 RP Plan.

Recommended Plan (Mainstem Area)

The plan for the Mainstem of the Pajaro River includes improvements on both banks of Reaches 2, 3, and the left bank of reach 4. Improvement on Reach 2 includes demolition of the existing levees (with the exception of a 1,343-ft section of levee on the right side) and construction of new 100-foot setback levees on both sides of Reach 2. The improvements on Reach 3 are constrained by the boundaries of the Town of Pajaro and the City of Watsonville and because of this the plan calls for rebuilding the existing levees in place topped by the construction of a floodwall on the crest. The improvements along Reach 4, are limited to the left bank where the existing levee will be demolished and a new 100 foot setback levee will be constructed and will join a one whole structure a new "completion" levee segment that will tie into high ground on the south east end. All these Levees and floodwalls will be constructed to provide 90% assurance of passing the 1% (1/100) Annual Chance Exceedance (ACE) event without overtopping. There will be no improvements to the right bank of Reach 4 since it was not economically justifiable. These levees and/levee floodwall combination on the Mainstem would range from 3 to 15 feet in height. For better and more comprehensive set of details related to the Tentatively Selected Plan, along the Mainstem area, please see Plates 1, 2 and 3 at the end of this document.

Recommended Plan (Tributary Area)

The improvement plan for the Tributary area of the Recommended Plan, which includes Salsipuedes and Corralitos Creek calls for a combination of reconstructed levees, new variable setback levees and the construction of floodwalls. The improvements along the right bank of Reach 5, consists of rebuilding a levee section approximately 4,325-ft of which approximately 3,100-ft will have a floodwall (similarly to the Levee/Floodwall combination on Reach 3). Reach 5 right will also have a new variable setback levee approximately 8,492-ft long with a maximum setback distance up to 245-ft from the existing levee, which will be demolished. On the left of Reach 5, a 4% (1/25) annual chance exceedance level of protection floodwall, approximately 5,100-ft long will be constructed to mitigate induce flooding as a result of the 1% (1/100) flood protection measures on the right bank. Finally, the improvements on Reach 6 will consist of new Levees on both banks having a variable setback distance between 50 to 75 feet from the existing channel banks. The main differences between the two new Levees on the left and right sides of Reach 6 is the level of protection offered with a 1% (1/100) annual chance exceedance level of protection on the right bank levee and a 4% (1/25) annual chance exceedance level of protection on the left bank levee. The levees and levee/floodwall combination along the Tributary will range in height from 3 to 15 feet. For better and more comprehensive set of details related to the Tentatively Selected Plan, along the Tributary area, please see Plates 4 and 5 at the end of this document.

Table 3-1 Recommended Plan Area Details (Mainstem)

Reach	100-feet setback	Setback Area	Rebuilt Levee	Floodwall over Rebuilt Levee	Completion Levee
2 Right	7,400-ft.	6.0 AC	1,343-ft.	-	-
2 Left	9,212-ft.	8.0 AC	-	-	-
3 Right	-	-	3,614-ft.	3,614-ft.	-
3 Left	-	-	3,388-ft.	3,388-ft.	-
4 Right	Not In Project	Not In Project	Not In Project	Not In Project	Not In Project
4 Left	10,600-ft.	11.0 AC	-	-	3,237-ft

Table 3-2 Recommended Plan Area Details (Tributaries)

Reach	Variable Setback	Setback Area	Rebuilt Levee	Floodwall over Rebuilt Levee	Stand Alone Floodwall
5 Right	8,492-ft	20.4 AC	1,325-ft	3,000-ft	-
5 Left	-	-	-	-	5,100-ft
6 Right	6,114-ft	9.0 AC	-	-	-
6 Left	9,308-ft	7.0 AC	-	-	-

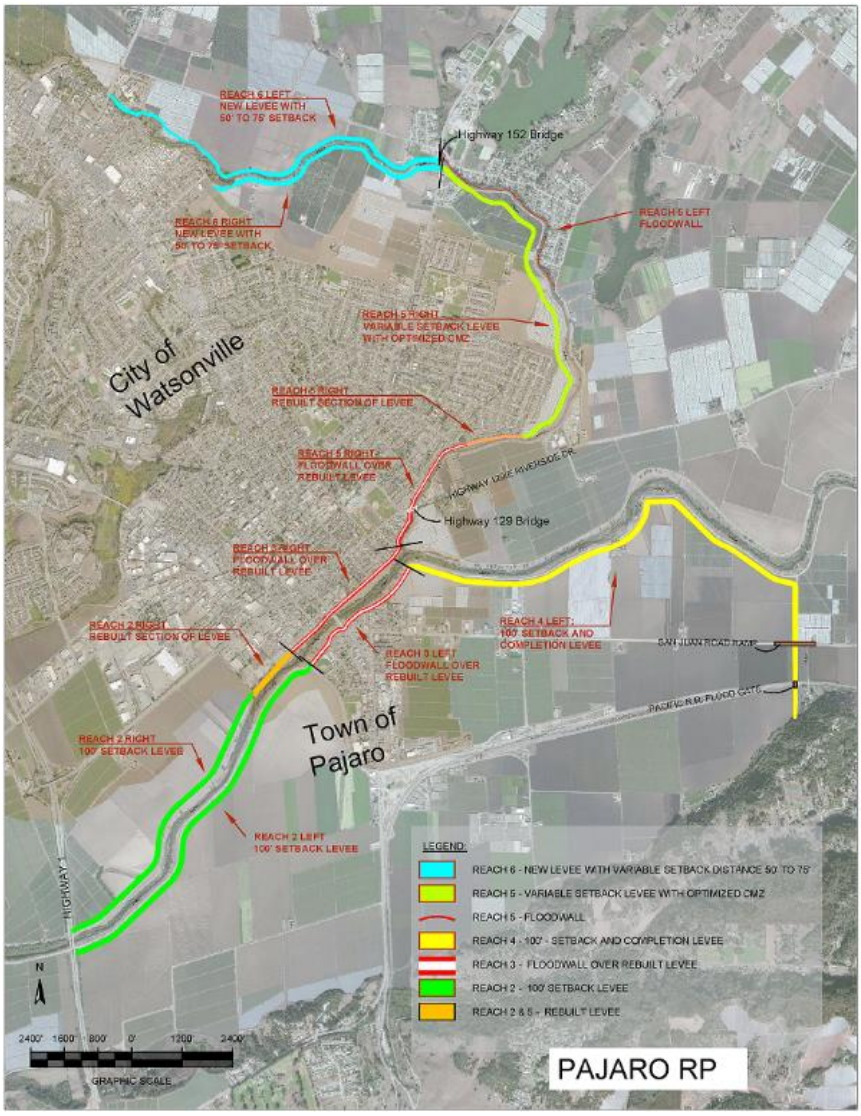


Figure 3.9: Recommended Plan

3.3 CIVIL QUANTITY ESTIMATES

Earthwork construction quantities estimates for excavation, stockpiling and backfill were calculated utilizing digital terrain models, which were based on a LIDAR survey of 2010 (see paragraph 2.1 Topographic Data). For the construction of the new levees, it is assumed that about 75% of the existing levee material could be reused; however of great concern is the expectation that the existing levee material may not entirely be acceptable according to current USACE standards for levee construction. Additional construction quantity estimates include reinforcing steel rebar tonnage for floodwall construction, concrete, concrete forms, utility relocation, ramp edification, and Rip-Rap for levee embankment protection. The estimated quantities of borrow material needed to construct each one of the Selected Plan reaches are presented in Tables 3.3 and 3.4 below.

Table 3.3: Estimated Earth Borrow for the Construction of the RP

REACH	2	3	4	5	6	Totals
Right Side Levee	214,378 CY	13,081 CY	Not In Project	135,388 CY	121,701 CY	484,548 CY
Left Side Levee	264,600 CY	11,735 CY	415,538 CY	Not In Project	145,641 CY	837,514 CY
Estimated Borrow AC/Foot	11.00 AC/Foot	1.0 AC/Foot	9.5 AC/Foot	3.0 AC/Foot	6.25 AC/Foot	30.5 AC/Foot
Note: Borrow volumes include a + 25% added factor to account for soil shrinkage, hauling and other losses. (EM 1110-2-1913; Chapter 4; Borrow Areas;)						

Table 3.4: Estimated Reinforced Concrete for the Construction of Floodwalls*

REACH	3	5	Totals
Right Side Volume of Concrete	1,648 CY	1,550 CY	3,198 CY
Right Side Steel Tonnage	47 Tons	44 Tons	91 Tons
Right Side Floodwall Length and Average Height	3,613-Feet Long 4.0-Feet High Above Levee	3,100-Feet Long 4.0-Feet High Above Levee	6,713-Feet of Floodwall
Left Side Volume of Concrete	1,508 CY	3,228 CY	4,736 CY
Left Side Steel Tonnage	43 Tons	107 Tons	150 Tons
Left Side Floodwall Length and Average Height	3,388-Feet Long 4.0-Feet High Above Levee	5,129-Feet Long 6.75-Feet Above Ground	8,517-Feet of Floodwall
* Design features may change and quantities will be subject to revision during PED			

3.4 RIPRAP PROTECTION ESTIMATE

The extent of riprap protection for the Selected Plan is the result of H&H modeling, which includes an overall estimation of the locations where flow velocities would be at or in excess of 4 Feet/sec. The amount of riprap protection is believed to be adequate for the selected plan. The estimated volumetric quantity and weight of riprap in Tons assume an average riprap stone diameter of 15", an average riprap layer 2-feet thick with a void ratio of 25%. All assumptions and results leading to determination of riprap quantities and placement will be revised during PED. See Table 3.4 below

Table 3.5: Estimated Riprap Volume and Weight for the RP Plan *

REACH	2	3	4	5	6	Totals
Riprap Volume Right Side (CY)	824 CY	2,136 CY	No in Project	3,417 CY	2,667 CY	9,044 CY
Riprap Weight Right Side (TONs)	1,360 Tons	3,525 Tons	No in Project	5,638 Tons	4,400 Tons	14,923 Tons
Riprap Volume Left Side (CY)	783 CY	2,136 CY	10,990 CY	Not in Project	2,667 CY	16,576 CY
Riprap Weight Left Side (TONs)	1,292 Tons	3,525 Tons	18,134 Tons	Not in Project	4,400 Tons	27,351 Tons
* Quantities will be subject to a thorough revision during PED						

3.5 CONSTRUCTION DURATION ESTIMATES

The estimated duration for the construction of the levees for the Recommended Plan was calculated based on a projection of the actual construction duration of a levee in Avondale LA, herein referred to as a Pilot levee. That levee utilized 1,152,000 CY of compacted soil and it took 14 months to complete.

Notable differences between the construction of the Pilot levee and the Pajaro levees is the fact that the Pilot levee material was borrow from the adjacent right of way making it easier and quicker for transporting it to site. Another difference is that the Pilot levee was constructed in a non-populated area and did not include construction of floodwalls and demolition of existing levees.

A linear interpolation solely based on the quantity of material and compacted fill was not applied because the construction settings and the scope of work for both projects is somewhat different; and to compensate for the differences mentioned above, an adjustment factor of +75% was added to the construction time estimate for the earthwork and additional factor of + 50% added for the construction of the Floodwalls. See Table 3.6 below

Construction projects larger than 6 months may likely require several construction seasons due to various constrains including flood season limits by California Code of Regulations, Title 23 Waters, which restricts construction or modification on levees during flood season (1 NOV to 15 APR). Also, the construction of setback levees assume that material from existing levees will be reused thus in order to reuse that material at some point or another demolition of existing levees would have to be conducted outside the flood window.

Table 3.6: Estimated Construction Duration for the Recommended Plan

Selected Plan	Estimated Construction Period in Years *
Reach 2 (left and Right Levees)	2 Years
Reach 3 (Left and Right Levees & Floodwalls)	2 Years
Reach 4 (Left Levee)	2 Years
Reach 5 (Right Levee, Right and Left Floodwall)	1 Year
Reach 6 (Left and Right Levees)	1 Year
Total Estimated Construction Duration	8 Years
* A construction season is limited to 6 months. Any duration greater than 6 months is considered a 1 year Duration. Note: The borrow location is yet to be identified. The assumption is that the haul distance round trip is 35 miles within populated areas. Time of construction assumes that each reach will be constructed separately, one at a time.	

3.6 ACRONYMS AND ABBREVIATIONS

CMZ -Channel Migration Zone

ACE –Annual Chance Exceedance

AC/Foot –Acre-Foot

GRR -General Reevaluation Report

ICW -Inspection of Completed Works

LERRD -Lands, Easements, Relocations, Rights-of-way, and Disposal area

LIDAR -Light Detection and Ranging

NAD National American Datum

NAVD National American Vertical Datum

NGVD National Geodetic Vertical Datum

O&M - Operations and Maintenance

PDT -Project Delivery Team

PED -Preconstruction Engineering and Design

NED -National Economic Development

TSP -Tentatively Selected Plan

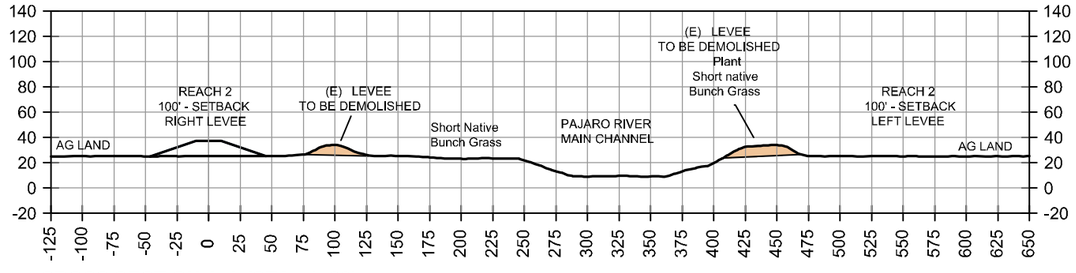
RP – Recommended Plan

STA -Station

USACE -U.S. Army Corps of Engineers

WSE -Water Surface Elevation

H:V – Horizontal to Vertical



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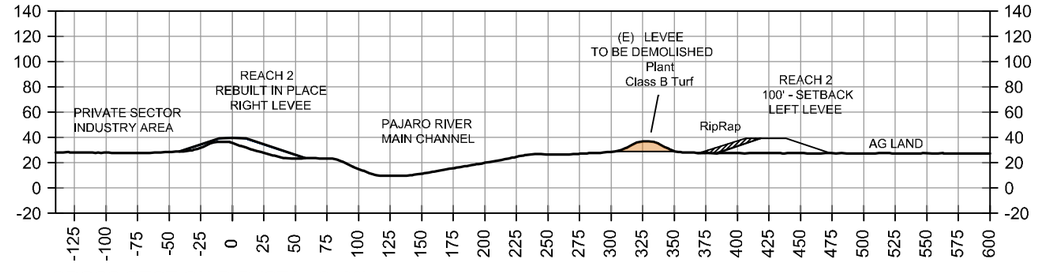


CROSS SECTION B-B (STA 78+00)
NOT TO SCALE

LEGEND:

- REACH 2 - 100' SETBACK LEVEE
- REACH 2 - REBUILT LEVEE IN PLACE SECTION

DATE: FEB 2018 **PAGE 1 OF 5**

600' 0' 600'
GRAPHIC SCALE

PLATE 1

REACH 2
PAJARO RIVER FLOOD RISK STUDY
RECOMMENDED PLAN

US Army Corps of Engineers
San Francisco District

CROSS SECTION A-A (STA 22+00)
NOT TO SCALE

LEGEND:

REACH 3 LEFT AND RIGHT: - FLOODWALLS OVER REBUILT LEVEES (BOTH SIDES)

DATE: FEB 2018 **PAGE 2 OF 5**

250' 0' 250'
GRAPHIC SCALE

PLATE 2

REACH 3
PAJARO RIVER FLOOD RISK STUDY
RECOMMENDED PLAN

US Army Corps of Engineers
San Francisco District

City of Watsonville

HIGHWAY 129 BRIDGE

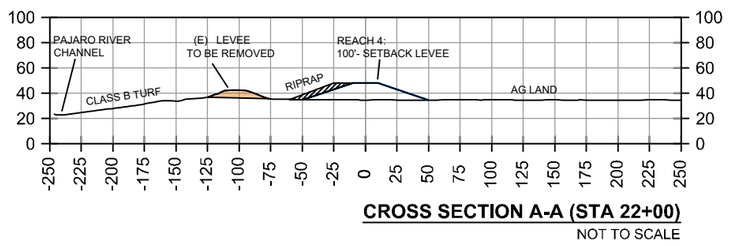
REACH 4: 100'-SETBACK LEFT LEVEE

REACH 4: COMPLETION LEVEE

SAN JUAN ROAD RAMP

PACIFIC R.R. FLOOD GATE

Town of Pajaro



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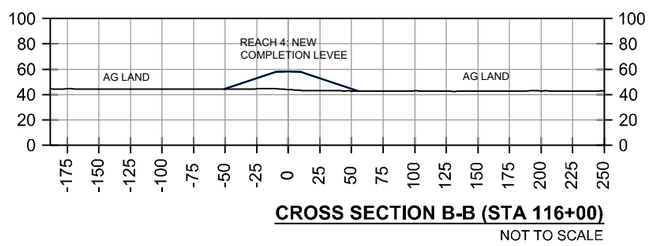


CROSS SECTION B-B (STA 116+00)

NOT TO SCALE

LEGEND:

- REACH 4 LEFT: 100' SETBACK AND COMPLETION LEVEE
- REACH 4: VARIOUS INFRASTRUCTURE
  - a) HIGHWAY 129 BRIDGE
  - b) SAN JUAN ROAD DIRT RAMP AND
  - c) PACIFIC R.R FLOOD GATE

DATE: FEB 2018 **PAGE 3 OF 5**

800' 0' 800'

GRAPHIC SCALE

PLATE 3

REACH 4
PAJARO RIVER FLOOD RISK STUDY
RECOMMENDED PLAN

US Army Corps of Engineers
San Francisco District

REACH 5 RIGHT FLOODWALL OVER REBUILT LEVEE

REACH 5 RIGHT REBUILT LEVEE

REACH 5 RIGHT VARIABLE SETBACK LEVEE WITH OPTIMIZED CMZ

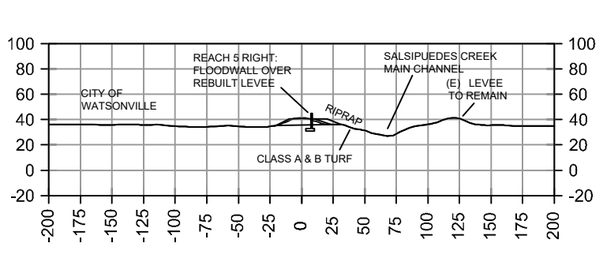
REACH 5 LEFT FLOODWALL

HIGH GROUND

Highway 129 Bridge

HIGHWAY 129/E RIVERSIDE DR.

Highway 152 Bridge



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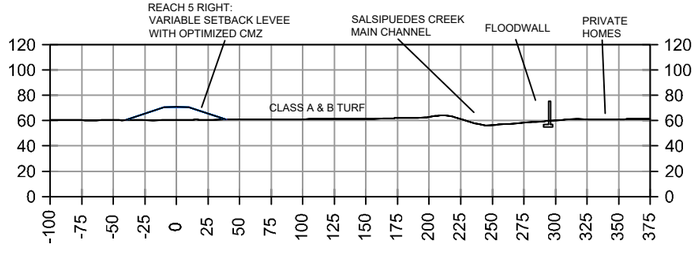


CROSS SECTION B-B (STA 108+00)
NOT TO SCALE

LEGEND:

- REACH 5 RIGHT: VARIABLE SETBACK LEVEE WITH OPTIMIZED CMZ
- REACH 5 RIGHT: FLOODWALL OVER REBUILT LEVEE
- REACH 5 LEFT: FLOODWALL
- REACH 5 RIGHT: REBUILT LEVEE
- INFRASTRUCTURE: BRIDGE

DATE: FEB 2018 **PAGE 4 OF 5**

800' 0' 800'
GRAPHIC SCALE

PLATE 4

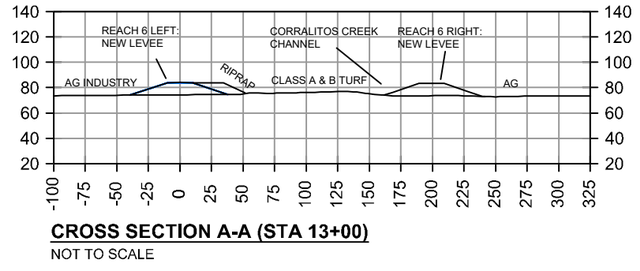
REACH 5
PAJARO RIVER FLOOD RISK STUDY
RECOMMENDED PLAN

US Army Corps of Engineers
San Francisco District

REACH 6 LEFT: NEW LEVEE
WITH VARIABLE SETBACK

REACH 6 RIGHT: NEW LEVEE
WITH VARIABLE SETBACK

Highway 152
Bridge



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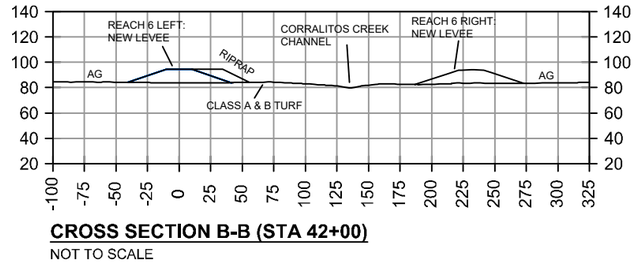


CROSS SECTION B-B (STA 42+00)
NOT TO SCALE

LEGEND:

- REACH 6: - NEW LEVEE WITH 50' TO 75' VARIABLE SETBACK
- REACH 6: INFRASTRUCTURE - BRIDGE

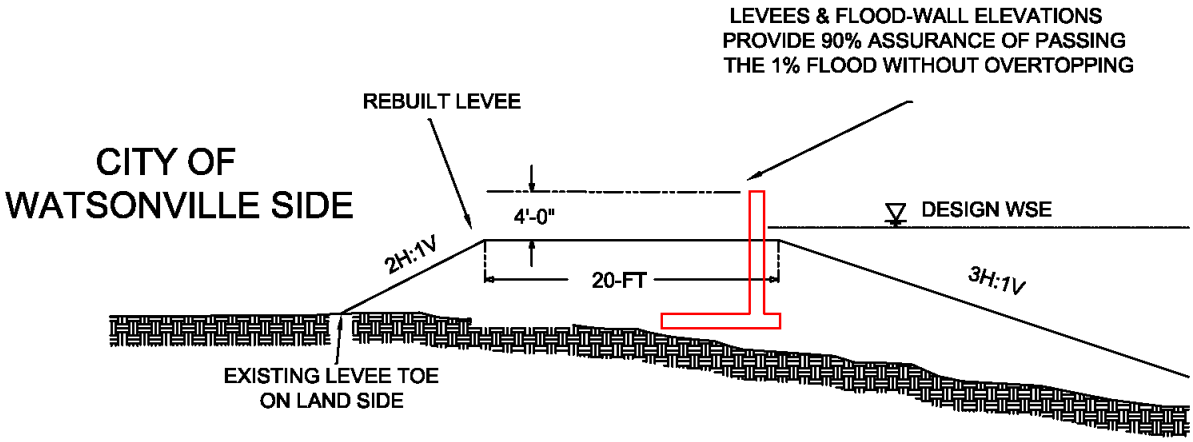
DATE: FEB 2018 **PAGE 5 OF 5**

600' 0' 600'
GRAPHIC SCALE

PLATE 5

REACH 6
PAJARO RIVER FLOOD RISK STUDY
RECOMMENDED PLAN

US Army Corps of Engineers
San Francisco District



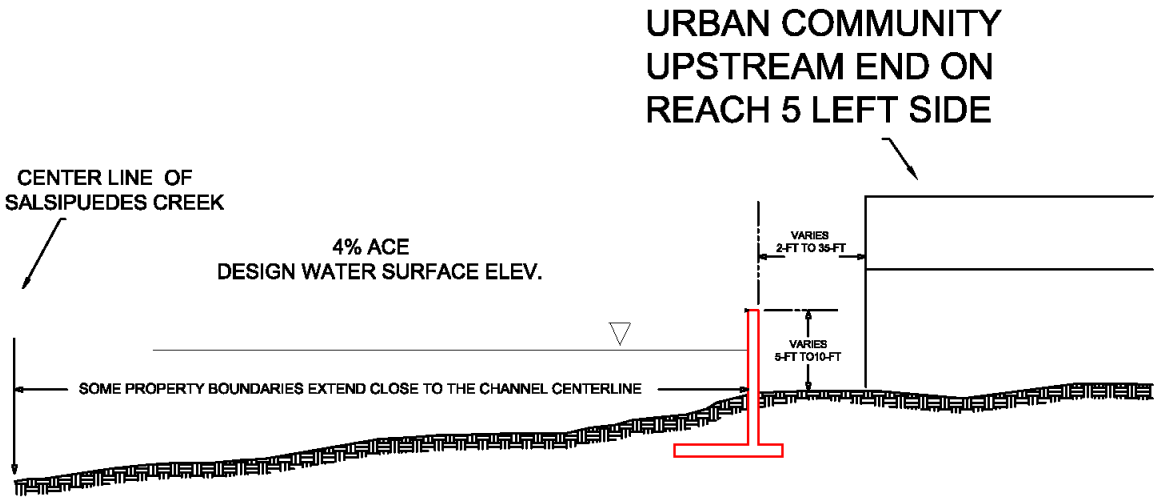
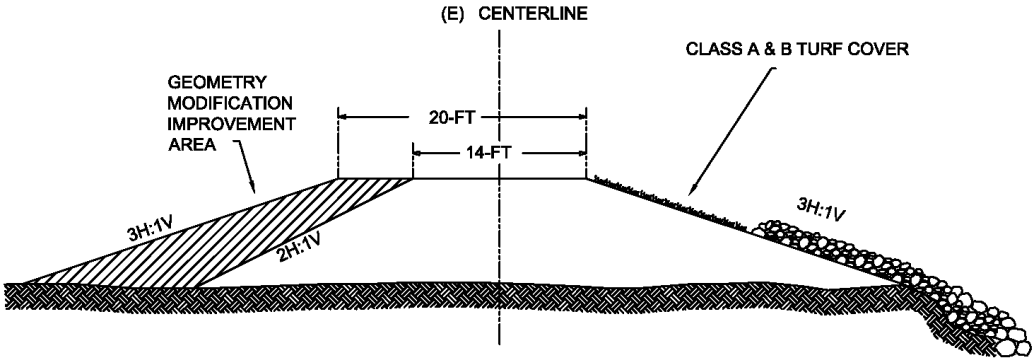


Plate 6 Top: Levee/Floodwall Cross-Section Representative of levees along urban areas such as Reaches 3 (looking upstream)

Bottom; Floodwall Cross-section Representative of Reach 5 on the left side. There a standalone floodwall is proposed where construction of a levee would significantly reduce channel conveyance capacity (looking upstream).



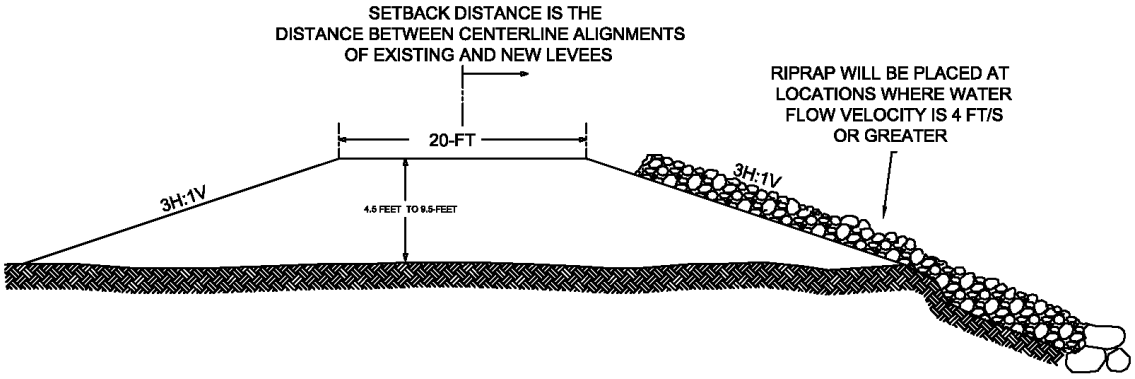


Plate 7 Top: Typical section of levee to be improved in place by geometry modification. This Section is representative of areas where a setback levee transitions into an existing levee alignment and /or where space limitations are not a concern.

Bottom: Typical section representative of all setback levees such as reaches 2, 4 and 5 and new levees like on the left and right sides of reach 6.