Delta Annex Chapter 11 Reclamation District 1601

11.1 Introduction

This new chapter of the Delta Annex details the hazard mitigation planning elements specific to the Reclamation District 1601 (RD 1601), a new 2016 participating jurisdiction to the Sacramento County Local Hazard Mitigation Plan (LHMP) Update. This chapter of the Delta Annex is not intended to be a standalone document, but appends to and supplements the information contained in the Base Plan document. As such, all sections of the Base Plan, including the planning process and other procedural requirements apply to and were met by RD 1601. This chapter of the Delta Annex provides additional information specific to RD 1601, with a focus on providing additional details on the planning process, risk assessment, and mitigation strategy for this District.

11.2 Planning Process

As described above, the District followed the planning process detailed in Section 3 of the Base Plan. In addition to providing representation on the Sacramento County Hazard Mitigation Planning Committee (HMPC), RD 1601 formulated its own internal planning team to support the broader planning process requirements. Internal planning participants, their positions, and how they participated in the planning process are shown in Table 11-1. Additional details on plan participation and RD 1601 representatives are included in Appendix A.

Table 11-1 RD 1601 Planning Team

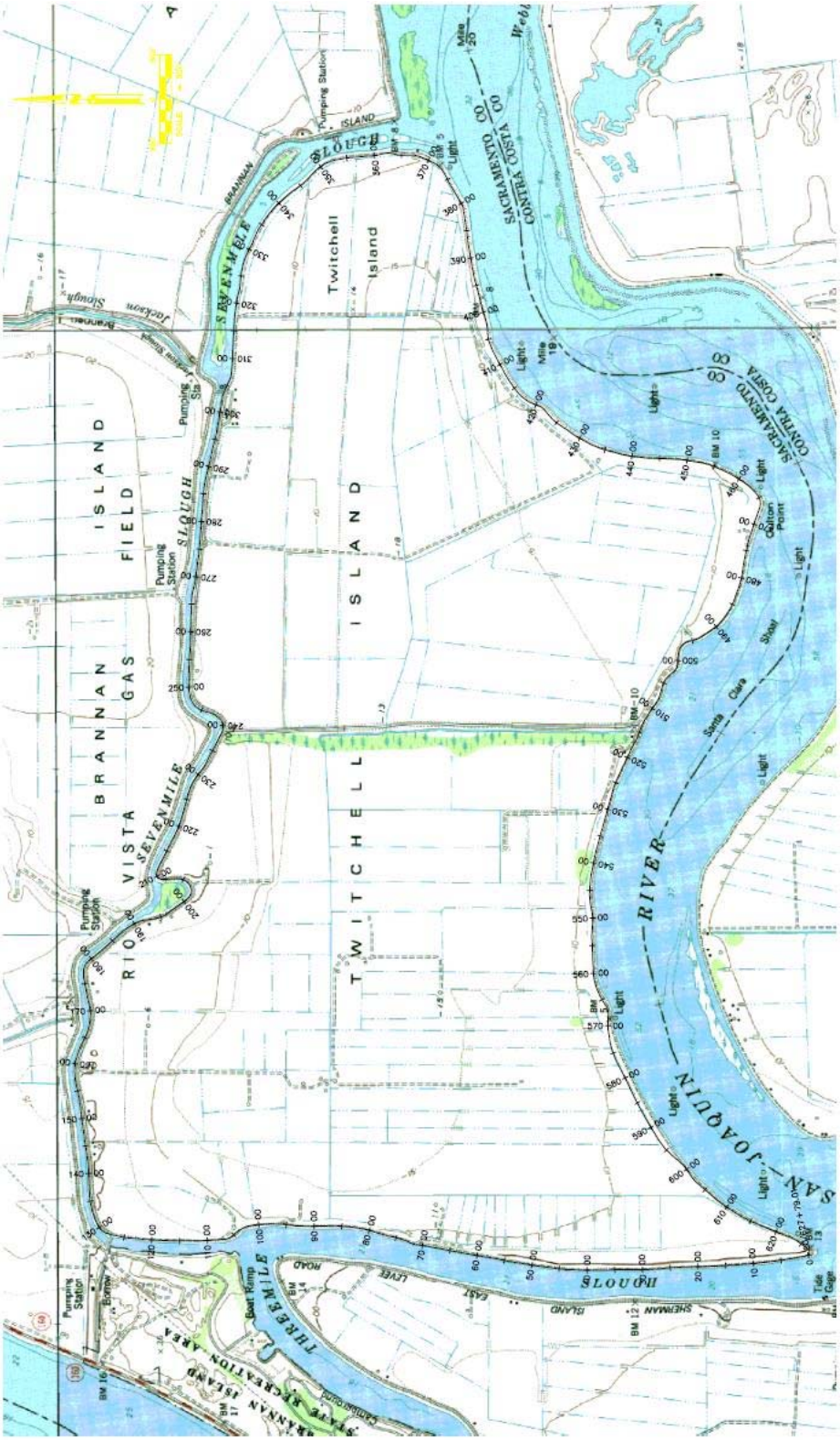
Name	Position/Title	How Participated
Chris Neudeck, KSN, Inc	District Engineer	Attended meetings, collected data, drafted text, reviewed draft docs
Bill Darcie, KSN, Inc.	Project Manager	Attended meetings, collected data, drafted text, reviewed draft docs
Brenna Howell, KSN, Inc.	Emergency Planner	Attended meetings, collected data, drafted text, reviewed draft docs

Source: RD 1601

11.3 Community Profile

The community profile for RD 1601 is detailed in the following sections. Figure 11-1 displays a map and the location of RD 1601 boundaries within Sacramento County.

Figure 11-1 Reclamation District 1601



Source: RD 1601 2010 5 Year Plan

11.3.1. RD 1601 Overview

Reclamation District No. 1601, also known as Twitchell Island, maintains 11.9 miles of levee made up of 2.5 miles of Federal Flood Control Project levee and 9.4 miles of non-project levee. The District is bordered by Sevenmile Slough, Threemile Slough and the San Joaquin River. Sacramento County maintains a paved road along Sevenmile Slough from levee station 127+50 to 303+00. The county road provides emergency evacuation to the East via Brannan-Andrus Island and State Highway 12 or to the West via State Highway 160.

11.3.2. District History and Background

The lands within the District were privately owned up until 1991 when the State of California purchased the majority of the property within the island. The State's interest in the island is primarily to ensure that the levees would be improved to protect against flooding of the island. Flooding in the Western Delta could severely degrade water quality within the Delta and impact the operations of the State and Federal water projects due to salt intrusion from areas downstream. Following the State's purchase of property on the island, the State, being the largest landowner, appointed the majority of the Trustee positions on the District's Board.

Continuous routine maintenance activities have occurred on the levees throughout the history of the island and include smaller projects not listed here. Types of work performed on a routine basis include erosion repairs, road repairs, debris removal, minor core trenching, ditch cleaning, pump repair and maintenance, vegetation control, and rodent control.

11.4 Hazard Identification

RD 1601's planning team identified the hazards that affect the District and summarized their geographic extent, probability of future occurrences, potential magnitude/severity, and significance specific to RD 1601 (see Table 11-2).

Table 11-2 RD 1601—Hazard Identification

Hazard	Geographic Extent	Probability of Future Occurrences	Magnitude/ Severity	Significance
Agricultural Hazards	Extensive	Occasional	Limited	Low
Bird Strike	Limited	Unlikely	Negligible	Low
Climate Change	Extensive	Occasional	Limited	Low
Dam Failure	Limited	Unlikely	Negligible	Low
Drought and Water Shortage	Extensive	Occasional	Critical	Low
Earthquake	Extensive	Occasional	Limited	Medium
Earthquake: Liquefaction	Significant	Occasional	Limited	Medium
Flood: 100/200/500-year	Extensive	Occasional	Catastrophic	High
Flood: Localized Stormwater Flooding	Extensive	Occasional	Critical	High
Landslides	Limited	Unlikely	Negligible	Low
Levee Failure	Extensive	Occasional	Catastrophic	High
River/Stream/Creek Bank Erosion	Extensive	Likely	Limited	Medium
Severe Weather: Extreme Temperatures – Cold/Freeze	Limited	Unlikely	Limited	Low
Severe Weather: Extreme Temperatures – Heat	Extensive	Likely	Limited	Low
Severe Weather: Fog	Extensive	Likely	Limited	Low
Severe Weather: Heavy Rains and Storms (Thunderstorms, Hail, and Lightning)	Extensive	Likely	Critical	Medium
Severe Weather: Wind and Tornadoes	Extensive	Likely	Critical	High
Subsidence	Extensive	Likely	Critical	Medium
Volcano	Limited	Unlikely	Negligible	Low
Wildfire:(Burn Area/Smoke)	Limited	Unlikely	Negligible	Low

Geographic Extent
Limited: Less than 10% of planning area
Significant: 10-50% of planning area
Extensive: 50-100% of planning area

Probability of Future Occurrences
Highly Likely: Near 100% chance of occurrence in next year, or happens every year.
Likely: Between 10 and 100% chance of occurrence in next year, or has a recurrence interval of 10 years or less.
Occasional: Between 1 and 10% chance of occurrence in the next year, or has a recurrence interval of 11 to 100 years.
Unlikely: Less than 1% chance of occurrence in next 100 years, or has a recurrence interval of greater than every 100 years.

Magnitude/Severity
Catastrophic—More than 50 percent of property severely damaged; shutdown of facilities for more than 30 days; and/or multiple deaths
Critical—25-50 percent of property severely damaged; shutdown of facilities for at least two weeks; and/or injuries and/or illnesses result in permanent disability
Limited—10-25 percent of property severely damaged; shutdown of facilities for more than a week; and/or injuries/illnesses treatable do not result in permanent disability
Negligible—Less than 10 percent of property severely damaged, shutdown of facilities and services for less than 24 hours; and/or injuries/illnesses treatable with first aid

Significance
Low: minimal potential impact
Medium: moderate potential impact
High: widespread potential impact

11.5 Hazard Profile and Vulnerability Assessment

The intent of this section is to profile RD 1601's hazards and assess the District's vulnerability separate from that of the Planning Area as a whole, which has already been assessed in Sections 4.2 and 4.3 Vulnerability Assessment in the main plan. The hazard profiles in the main plan discuss overall impacts to the Planning Area and describes the hazard problem description, hazard extent, magnitude/severity, previous occurrences of hazard events and the likelihood of future occurrences. Hazard profile information specific to RD 1601 is included in this Annex. This vulnerability assessment analyzes the property, population, critical facilities, and other assets at risk to hazards ranked of medium or high significance specific to the District. For more information about how hazards affect the County as a whole, see Chapter 4 Risk Assessment in the main plan.

11.5.1. Hazard Profiles

Each hazard vulnerability assessment in Section 11.5.3, includes a description as to how the hazard affects RD 1601 and information on past occurrences. The intent of this section is to provide jurisdictional specific information on hazards and further describe how the hazards and risks differ across the Planning Area.

11.5.2. Vulnerability Assessment

This section identifies RD 1601's assets at risk, including values at risk, critical facilities and infrastructure, economic assets, natural resources, historic and cultural resources, and growth and development trends.

Assets at Risk and Critical Facilities

This section considers the District's assets at risk, with a focus on key District assets such as critical facilities, infrastructure, and other District assets and their values. With respect to District assets, the majority of these assets are considered critical facilities as defined for this plan:

> *Any facility (a structure, infrastructure, equipment or service), that is adversely affected during a hazardous event may result in interruption of services and operations for the District at any time before, during and after the hazard event. A critical facility is classified by the following categories: (1) Essential Services Facilities, (2) At-risk Populations Facilities, and (3) Hazardous Materials Facilities.*

Table 11-3 lists particular critical facilities and other District assets identified by RD 1601's planning team as important to protect in the event of a disaster. RD 1601's physical assets, valued at over $4.3 million, consist of the buildings and infrastructure to support RD 1601 operations.

Table 11-3 RD 1601's Critical Facilities, Infrastructure, and Other District Assets

Name of Asset	Facility Type	Address	Replacement Value	Hazard Info
Pump Station #1 (including all station components)	Essential Services	–	$2.0 mil	Flood, Levee Failure, Liquefaction

Name of Asset	Facility Type	Address	Replacement Value	Hazard Info
Pump Station #2 (including all station components)	Essential Services	–	$2.0 mil	Flood, Levee Failure, Liquefaction
Drainage Conveyances	Essential Services	–	#350 K	Flood, Levee Failure, Liquefaction, Severe Weather
Underground Electric Crossing*	Essential Services	–	–	Flood, Levee Failure, Liquefaction
Overhead Electric Crossings*	Essential Services	–	–	Flood, Levee Failure, Liquefaction
Siphons*	Essential Services	–	–	Flood, Levee Failure, Liquefaction
Electric Pullbox Underground Docs	Essential Services	–	–	Flood, Levee Failure, Liquefaction

Source: RD 1601

* These assets are not owned by the District, but are protected by its levees. No replacement value was available to the District Planning Team

The 2010 5-year plan noted that the total estimated value of the 3,634.88 acres of land within the District is $16,338,771.

Natural Resources

Twitchell Island has established a total of 15.12 acres of valuable permanent habitat and mitigation sites. Much of the habitat provided is riverine or palustrine, providing essential habitat for flora and fauna native to the Delta. The habitat areas provide a permanent, undisturbed environment for sensitive Delta species, as well as providing habitat, food and resting areas for migratory wildlife. The value of these habitat areas is undefined, but the loss of these areas could greatly impact the species that depend upon these valuable ecosystem components.

A habitat assessment was done in 2001 for the District. Findings from that were:

- One special-status plant (Blue Elderberry) was observed along the levee during the field survey.
- No special status animals were observed during field work;
- The Shaded Riverine Aquatic Habitat was found to total 1,642 lineal feet;
- The Riparian Forest habitat on the waterside of the levee consisted of individual trees or extensive reaches of continuous canopy. The Riparian Forest was found to total 3,285 lineal feet;
- The Shrub/Scrub habitat consists of willow, and blackberry on the waterside of the levee. The Shrub/Scrub was found to total 7,917 lineal feet;
- The Freshwater Marsh habitat of tules along the levee waterside toe was found to total 7,781 lineal feet;
- The landside levee slopes consisted of bare ground, ruderal vegetation, urbanized environment with cultivated plants, small areas of Shrub/Scrub habitat, and Riparian Forest of individual trees or continuous canopy with varying amounts of understory;
- The landside Riparian Forest along the levee was found to cover 465 lineal feet. The majority of this habitat was found along levee station 38+959 to39+396 in the toe ditch;
- The landside Shrub Scrub habitat along the levee was found to cover 177 lineal feet.

In 1993, a 4.04 acre habitat mitigation site was established and planted from Stations 545+00 to 560+00 and Stations 570+00 to 600+00, with a Conservation Easement established specifically for the mitigation site between stations 545+00 and 560+00. The overall mitigation site was designed to consist of 1.12 acres of palustrine emergent (freshwater marsh) habitat, 1.92 acres of lacustrine (open water) habitat, 2.3 acres of palustrine forest (riparian woodland) habitat, and 0.65 acres of annual grassland habitat. The flora planted were predominantly tule and cattail in the freshwater marsh, and white alder, red willow and sandbar willow in the riparian woodland. Two ponds totaling 1.92 acres were excavated to approximately 6 feet deep with approximately 1:1 side slopes to provide the open water habitat. The open water and annual grassland did not require plantings.

In 1999, an 8.08 acre habitat mitigation site was transferred to the Department of Fish and Game via a Transfer of Control and Possession and Conservation Agreement. The site runs parallel to the drainage canal at the District Pump station, reaching 5,440 feet northward along the canal from approximately Station 585+00, and provides various types of protected habitats, including palustrine shrub and scrub, palustrine forest, and fresh water marsh habitats. The site was initially established to mitigate 5.78 acres of palustrine emergent habitat lost due to levee repairs and rehabilitation at Stations 0+00 to 127+00 and 360+00 to 396+00. Much of the mitigation site was originally planted with feed corn). The site was enhanced in 2007 when 35 black willow trees were planted along the canal.

In 2000, a 3.0 acre habitat site was planted between levee Stations 570+00 and 600+00 that provides 1.4 acres of emergent tidal marsh habitat and 1.6 acres of shaded riverine aquatic habitat. This habitat area was created between the original levee and a new setback levee.

Openings were cut into the original levee, allowing water to circulate between the levees. The levee crown and landside slope of the old levee was re-vegetated, and the tidal bench and waterside slope of the setback levee were planted with native woody and herbaceous vegetation. Woody plants included willows, ash, box elder, alder, cottonwood, valley oak, dogwood, button willow, wild rose, wild blackberry, blue elderberry, and wild grape. Herbaceous plants included California hibiscus, grasses, sedges, rushes, and tules. The setback levee slope was planted with grasses only for maintenance purposes.

The habitat mitigation sites on Twitchell Island provide a variety of protected habitats. In general, Delta lands provide forage and cover for local and migratory populations of birds and terrestrial wildlife including many special status species. The levees also provide important waterside habitat and shoreline for various fisheries that includes several special status species.

Historic and Cultural Resources

The District Planning Team noted that there are no known historic and or cultural resources in the District at this time.

Growth and Development Trends

The District Planning Team noted that there has been no growth and development in the District since the last planning period.

11.5.3. Vulnerability to Specific Hazards

This section provides the vulnerability assessment, including any quantifiable loss estimates, for those hazards identified above in Table 11-2 as high or medium significance hazards. Impacts of past events and vulnerability of the RD 1601 to specific hazards are further discussed below (see Section 4.1 Hazard Identification in the Base Plan for more detailed information about these hazards and their impacts on the Sacramento County Planning Area). Methodologies for calculating loss estimates are the similar to those described in Section 4.3 of the Base Plan and are based on data provided by the District as described further below. In general, the most vulnerable District assets include the levees and supporting structures that the District owns such as the two pump stations, the drainage conveyances and the natural resources within the island.

An estimate of the vulnerability of RD 1601 to each identified priority hazard, in addition to the estimate of probability of future occurrence, is provided in each of the hazard-specific sections that follow. Vulnerability is measured in general, qualitative terms and is a summary of the potential impact based on past occurrences, spatial extent, and damage and casualty potential. It is categorized into the following classifications:

- **Extremely Low—**The occurrence and potential cost of damage to life and property is very minimal to nonexistent.
- **Low—**Minimal potential impact. The occurrence and potential cost of damage to life and property is minimal.
- **Medium—**Moderate potential impact. This ranking carries a moderate threat level to the general population and/or built environment. Here the potential damage is more isolated and less costly than a more widespread disaster.
- **High—**Widespread potential impact. This ranking carries a high threat to the general population and/or built environment. The potential for damage is widespread. Hazards in this category may have occurred in the past.
- **Extremely High—**Very widespread with catastrophic impact.

Earthquake

Likelihood of Future Occurrence–Occasional
Vulnerability–Medium

Hazard Profile and Problem Description

Earthquake vulnerability is primarily based on population and the built environment. Urban areas in high seismic hazard zones are the most vulnerable, while uninhabited areas are less vulnerable.

Ground shaking is the primary earthquake hazard. Many factors affect the survivability of structures and systems from earthquake-caused ground motions. These factors include proximity to the fault, direction of rupture, epicenter location and depth, magnitude, local geologic and soils conditions, types and quality of construction, building configurations and heights, and comparable factors that relate to utility, transportation, and other network systems. Ground motions become structurally damaging when average peak accelerations reach 10 to 15 percent of gravity, average peak velocities reach 8 to 12 centimeters per

second, and when the Modified Mercalli Intensity Scale is about VII (18-34 percent peak ground acceleration), which is considered to be very strong (general alarm; walls crack; plaster falls).

Past Occurrences

After the most recent Napa Earthquake the District performed levee inspections and verified the continued operation of the pump stations around the island to check the levee integrity and ensure there was no damage to District assets as a result of the earthquake.

Vulnerability to Earthquake

Assets/Critical Facilities at Risk

The District Planning Team noted that the levees structures, pump stations and drainage conveyances are potentially at risk to an earthquake

Natural Resources at Risk

The District Planning Team noted that All natural resources could be affected by an earthquake causing damage to the levee structure should the island flood due to an earthquake.

Historic and Cultural Resources at Risk

The District Planning Team noted that there are no known historic and or cultural resources at risk on the island.

Future Development

While future development may occur in the areas protected by levees, which may be compromised by an earthquake event the District does not control this development. The District only can control whether the levees meet certification standards.

Earthquake: Liquefaction

Likelihood of Future Occurrence–Occasional
Vulnerability–Medium

Hazard Profile and Problem Description

Earthquake is discussed in the section above, but is primarily focused on the vulnerability of buildings and people from earthquake shaking. This section deals with a secondary hazard associated with earthquake – the possible collapse of structural integrity and the possible collapse of delta levees, due to liquefaction.

Past Occurrences

The District Planning Team noted that there are no known past occurrences of liquefaction to have affected the District.

Vulnerability to Liquefaction

Assets/Critical Facilities at Risk

The U.S. Geological Survey estimates that an earthquake of magnitude 6.7 or greater has a 62 percent probability of occurring in the San Francisco Bay Area between 2003 and 2032. Such an earthquake is capable of causing multiple levee failures in the Distict which could result in fatalities, extensive property damage and the interruption of water exports from the Delta for an extended period of time. Potential earthquakes on the Hayward, Calaveras or San Andreas faults pose the highest risk to Delta Region levees. All assets in the District are at risk to the effects of liquefaction.

Natural Resources at Risk

All natural resources in the District would be at risk to liquefaction of the levee foundations and associated levee failures.

Historic and Cultural Resources at Risk

The District Planning Team noted that there are no known historic and or cultural resources at risk on the island.

Future Development

While future development may occur in the areas protected by levees, which may be compromised by an earthquake event the District does not control this development. The District only can control whether the levees meet certification standards.

Flood: 100/200/500-year

Likelihood of Future Occurrence–Occasional
Vulnerability–High

Hazard Profile and Problem Description

The District is bordered by Sevenmile Slough, Threemile Slough and the San Joaquin River. Flooding on any of these waterways could cause problems for RD 1601.

Past Occurrences

The 5-Year Plan for RD 1601 included a history of flooding in the District.

- 1986 Flood event. Poor levee performance, with several instances of boils that were treated with sandbag coffer dams. Individual boils were sandbagged on the landward levee slope at Stations 361+81, 365+50, 373+98, 405+87, 406+39, 408+49, 414+83, and 502+22, and groups of boils were sandbagged on the landward levee slope at Stations 500+64 to 501+69 and 534+94 to 536+52. Dredged fill material was placed on the waterward levee slope and the bottom of the slough in an attempt to seal a boil at Station 363+39 to 366+56. The State of California updated its flood Hazard Mitigation Plan (HMP), establishing both short-term and long-term guidelines for levee rehabilitation, including

minimum requirements for levee geometry that were required to be met by 1991 in order to receive future federal disaster assistance.

- 1997 Flood Event. USACE made emergency repairs by placing a 250 foot long gravel blanket extending 60 feet past the landside levee toe at approximately Station 59+00. Further emergency repairs were made by the District by pulling rock up from the waterside toe of the levee to form two berms on the levee crown at the juncture of Sevenmile Slough and the San Joaquin River, and on the PL 84-99 levee along Threemile Slough, approximately Station 380+00 to 385+00.
- 1998 Flood Event. During the flood event of 1998, riprap was placed on waterside slopes to mitigate damage by high water and high winds,
- 2005 to 2006 Flood Event. A storm event starting on December 30, 2005 required emergency action beginning on January 1, 2006. Four long reach excavators were used to restore the rock slope protection at Stations 363+74 to 565+00 and 580+00 to 628+74 that was lost as a result of the extreme high water and winds along the San Joaquin River. The construction involved pulling the slipped rock up along the waterside slope from the waterside levee toe. Two angle blade bulldozers were used to clear debris on the levee crown and restore eroded sections of levee due to the high water and wind-generated waves splashing over the levee to the landside slope, including portions of the levee road that were no longer passable. The San Joaquin reach of the Twitchell Island levee was nearly overtopped. 25,000 feet of existing riprap was repositioned to form a break wall by Dutra Construction in 40 consecutive hours to protect the levee from extreme wind and wave wash.

Vulnerability to Flood

Assets/Critical Facilities at Risk

Flooding of Delta islands has the potential to negatively impact water quality both locally and statewide. The largest of California's drinking water sources is the Sacramento-San Joaquin Delta and its tributaries. The Delta provides water throughout the state via the State and Federal water projects. During a flood, there is a higher potential for the waters in the Delta to be exposed to chemicals, fuel, oil, and multiple other constituents of concern that can quickly degrade water quality. Flooding can also disturb soil and soil-borne materials such as mercury and organic matter that can degrade water quality.

Additionally, maintaining the current configuration of Delta levees and channels is critical to insure Delta salinity standards are met and salt water intrusion from the bay into the Delta does not occur. Twitchell Island is one of the eight western islands, which collectively form a crucial group of islands which, if breached, could each individually greatly degrade water quality in the Delta from the transportation of tidal salt water through the major Delta channels where fresh and salt waters mix. Additionally, if the island did flood, the evaporative losses from the flooded island would have an additional detrimental impact to the overall water quality in the surrounding Delta waterways.

Should a flood breach the levees, the entirety of the assets of RD 1601 would be at risk. Levee failure is discussed later in this section. Flooding also causes erosion, which is discussed later in this section.

Natural Resources at Risk

Flooding of Delta islands destroys habitat, kills most species present, and can entrain and strand large populations of native and non-native fish species.

Historic and Cultural Resources at Risk

The District Planning Team noted that there are no known historic and or cultural resources at risk on the island.

Future Development

While future development may occur in the areas protected by levees, the District does not control this development. The District only can control whether the levees meet certification standards.

Flood: Localized Stormwater Flooding

Likelihood of Future Occurrence–Occasional
Vulnerability–High

Hazard Profile and Problem Description

Historically, RD 1601 has been at risk to flooding primarily during the spring months when river systems in the County swell with heavy rainfall. Localized flooding also occurs throughout the Planning Area at various times throughout the year with several areas of primary concern unique to the District. The District has a drainage system set up deal with localized flooding. This is shown on Figure 11-2.

Figure 11-2 RD 1601 Drainage System

Source: RD 1601 2010 5-Year Plan

Past Occurrences

The District Planning Team noted that in the last planning period there were no past occurrences.

Vulnerability to Localized Flood

Assets/Critical Facilities at Risk

The District Planning Team noted that all District assets are at risk to localized flooding; however, this flooding is likely to be a nuisance-type of flood, and would not have lasting impacts on the District.

Natural Resources at Risk

Flooding of Delta islands destroys habitat, kills most species present, and can entrain and strand large populations of native and non-native fish species.

Historic and Cultural Resources at Risk

The District Planning Team noted that there are no known historic and or cultural resources at risk on the island.

Future Development

While future development may occur in the areas protected by levees, the District does not control this development. The District only can control whether the levees meet certification standards.

Levee Failure

Likelihood of Future Occurrence–Occasional
Vulnerability–High

Hazard Profile and Problem Description

Floods can threaten the District from several sources. Usually, the possibility of flooding can be anticipated from eight to twenty hours before the "Emergency Period" is reached. However, as demonstrated in Linda, California, in February 1986, it is possible for a levee to collapse with little or no warning when there are still four or more feet of freeboard available.

Generally, levees fail due to overtopping or collapse. A catastrophic levee failure resulting from collapse probably will occur very quickly with relatively little warning. Such a failure would occur where the levee is saturated and the high hydrostatic water pressure on the river side, coupled with erosion of the levee from high water flows or an inherent defect in the levee, causes an almost instant collapse of a portion of the levee. Under such circumstances, structures located relatively near the break will suffer immediate and extensive damage. Several hundred yards away from the break the energy of the flood waters will be dispersed sufficiently to reduce, but not eliminate, flooding damage to structures in its path. The flood water will flow in a relatively shallow path toward any low point in the affected area. Flood water will

collect in these low areas and the levels will rise as the flow continues. When the rivers are high, it is not possible to close or repair a levee break until the water surface in the river and the flooded area equalize.

A major overtopping of a levee, if flow persists, will result in severe erosion of the levee crowns on the landward side and cause levee failure over a period of minutes to several hours. A severe levee overtopping can, therefore, be considered as a levee break for the purpose of determining the extent of flooding that any area will suffer. Generally, overtopping can be predicted based on river stages and the warning given depending on the source of the flood waters

Past Occurrences

The 5-Year Plan documented the history of levee failures in RD 1601.

- 1906, 1907 & 1909: Flooding of entire island occurred from levee failure or overtopping.
- 1964: Levee at approximately Station 390+00 cracked and/or dropped in December 1964, requiring immediate repair.
- 1980: A large settlement crack occurred in the levee crown at Station 376+00 to 380+00, arcing from the landward to the center of the crown and back to the landward. Crack width was from 1 to 4 inches, with a vertical settlement of 3 to 6 inches. Rock revetment was added to the waterward levee slope. Dredged material was placed on the landward levee slope as the crack gradually opened further and settlement increased. The dredge material was moved off the slope to create a 25 foot wide by 1.5 foot high stability berm at the landward toe of the levee. A core trench was constructed at Station 415+00 to 421+00 to cut off seepage. Riprap placement and dredging occurred in response to a high water and wind event, and was funded by the Federal Disaster Assistance Administration (FDAA) in the amount of $100,550. The levee crown in was low at Station 530+00 to 532+00, and required sandbags to be placed along the waterward shoulder during high tides and high winds from the south in February. A crack occurred near the landward toe of the levee, with a width of 3 inches and length of 150 feet. Dredged material was placed in the low areas on the landside of the levee, on the landward slope, and in limited amounts on the levee crown. Boils occurred on the landward levee slope at Station 415+00 to 421+00, located 5 to 6 feet below the crown. High tides at this time were 5 feet below the levee crown. A backhoe was brought in to dig a core trench in the levee crown between 6 and 7 feet deep and 18 inches wide. The trench was dug in 8 to 10 foot segments, with each segment being inspected, backfilled in layers, and tamped with the backhoe bucket before digging the next trench segment. A crack approximately 5 feet below the levee crown was discovered opposite two of the boils, and appeared to extend through the levee on a diagonal. The crack was 6 to 8 inches wide, and 1/2 inch high.
- 2006: Seepage at Stations 445+00 to 450+00, 480+00, 500+00 to 510+00, 530+00 to 540+00, and 600+00 was stopped by coring and sealing the levee with a Bentonite mix after a failed attempt at Stations 535+00 to 540+00 to stop seepage using a vibratory wall by DWR.

Vulnerability to Levee Failure

The two primary vulnerabilities that threaten the levee system on Twitchell Island involve levee stability and levee geometry.

The Twitchell Island levee system has a long history of levee stability problems including settlement, movement, seepage, and slope failure. Documentation of the levee's performance is extensive. GEI Consultants, a geotechnical, environmental and water resources engineering firm, obtained information from the California Department of Water Resources documenting these problems as far back as 1955 during

the course of research for the January 2009 "Geotechnical Investigation and Evaluation Report" performed for the San Joaquin River portion of the levees. The San Joaquin river levee reach has historically shown more problems relative to Stability. Deep organic soils and sands in conjunction with deep water and high winds cause this reach of levee to be extremely vulnerable to failure during high water and storm events. It should also be noted that the investigations did not locate an acceptable on-island borrow material suitable for levee projects As of the last complete profile survey of the island in 2008, and taking into account completed projects through fiscal year ending June 30, 2010, there remain several locations along Sevenmile Slough that do not meet the Hazard Mitigation Plan (HMP) standard for geometry.

This standard requires the levee to be one foot above base flood elevation, and 1.5:1 waterside and 2:1 Landside slopes. There is approximately 3000' (5%) of District levee below the HMP Standard and approximately 28,000' (45%) below the PL84 Standard. These values were calculated by analyzing a combination of the most current District surveys, including the 2009 District Aerial Survey for the San Joaquin River levee and the 2006 KSN GPS Survey for the Threemile Slough and Sevenmile Slough levees. Levee centerline profiles were cut through each of the modeled survey surfaces and compared to water surface elevation profiles from the US Army Corps of Engineers' 1992 Sacramento-San Joaquin Delta Special Hydrology Study.

Sevenmile Slough is isolated from tidal waters by water control structures that, along with the balance of the levee system, meet the HMP standard. Up until 2006, the District was considered to have met the HMP standard; however, in 2006 the Federal Emergency Management Agency determined that because the entire Sevenmile slough levee did not meet the geometry required in HMP, that the District was not eligible for Federal Disaster Assistance. Thus, the vulnerability to the District is both a flood threat due to overtopping caused by low levee crown elevations and a financial threat because no Federal Disaster Assistance would be available for damages resulting from a declared disaster event.

Assets/Critical Facilities at Risk

Should the levees fail, all District assets would be at risk.

Natural Resources at Risk

Flooding of Delta islands destroys habitat, kills most species present, and can entrain and strand large populations of native and non-native fish species.

Historic and Cultural Resources at Risk

The District Planning Team noted that there are no known historic and or cultural resources at risk on the island.

Future Development

While future development may occur in the areas protected by levees, the District does not control this development. The District only can control whether the levees meet certification standards.

River/Stream/Creek Bank Erosion

Likelihood of Future Occurrence–Likely
Vulnerability–Medium

Hazard Profile and Problem Description

Stream bank erosion is a natural process, but acceleration of this natural process leads to a disproportionate sediment supply, stream channel instability, land loss, habitat loss and other adverse effects. As farmers settled the valleys in the 1800s, the Gold Rush drew prospectors to the hills. As mining in the Sierra Nevada turned to the more "efficient" methods of hydraulic mining, the use of environmentally destructive high-pressure water jets washed entire mountainsides into local streams and rivers. As a result, the enormous amounts of silt deposited in the riverbeds of the Central Valley increased flood risk. As a remedy to these rising riverbeds, levees were built very close to the river channels to keep water velocity high and thereby scour away the sediment. However, the design of these narrow channels has been too successful. While the Gold Rush silt is long gone, the erosive force of the constrained river continues to eat away at the levee system and stream banks within the District.

Past Occurrences

The 5-Year Plan documented the history of erosion in RD 1601.

- 1981: Erosion on the waterward side of the levee was repaired and protected with riprap revetment at Station 625+00 to 628+74
- 1982-1983: The flood event FEMA 677 DR caused waterside erosion, multiple cracks on the landside slope along with sinkholes, subsidence areas, and seepage areas. Disaster claims totaled $1,818,160 $1,818,160 for construction of landside berms, raising levee crown, and riprap erosion protection.
- 2009: Riprap was installed on the levee waterside slope and crown on the setback levee at Stations 570+00 to 595+00 to mitigate erosion that had occurred in past years.

Vulnerability to Erosion

Assets/Critical Facilities at Risk

The entirety of the levee system in RD 1601 is at risk to erosion.

Natural Resources at Risk

The District Planning Team noted that stream bank erosion in the Delta islands can possibly destroy habitat, kill species present, and can entrain and strand large populations of native and non-native fish species.

Historic and Cultural Resources at Risk

The District Planning Team noted that there are no known historic and or cultural resources at risk on the island.

Future Development

While future development may occur in the areas protected by levees, which can be compromised by severe erosion, the District does not control this development. The District only can control whether the levees meet certification standards.

Severe Weather: Heavy Rains and Storms (Thunderstorms/Hail, Lightning)

Likelihood of Future Occurrence–Likely
Vulnerability–Medium

Hazard Profile and Problem Description

According to historical hazard data, severe weather is an annual occurrence in the District. Damage and disaster declarations related to severe weather have occurred and will continue to occur in the future.

Past Occurrences

The 5-Year Plan for RD 1601 included a history of heavy rains in the District.

- 2005 to 2006. A storm event starting on December 30, 2005 required emergency action beginning on January 1, 2006. Four long reach excavators were used to restore the rock slope protection at Stations 363+74 to 565+00 and 580+00 to 628+74 that was lost as a result of the extreme high water and winds along the San Joaquin River. The construction involved pulling the slipped rock up along the waterside slope from the waterside levee toe. Two angle blade bulldozers were used to clear debris on the levee crown and restore eroded sections of levee due to the high water and wind-generated waves splashing over the levee to the landside slope, including portions of the levee road that were no longer passable. The San Joaquin reach of the Twitchell Island levee was nearly overtopped. 25,000 feet of existing riprap was repositioned to form a break wall by Dutra Construction in 40 consecutive hours to protect the levee from extreme wind and wave wash.

Vulnerability to Heavy Rains and Storms

Assets/Critical Facilities at Risk

Heavy rain and thunderstorms are the most frequent type of severe weather occurrence in the area. Wind and lightning often accompany these storms and have caused damage in the past. Problems associated with the primary effects of severe weather include flooding, pavement deterioration, washouts, high water crossings, landslide/mudslides, debris flows, and downed trees. However, it is the secondary effects of heavy rain and storms that are of concern to RD 1601. Heavy rains can cause flooding, levee failure, and stream bank erosion. Flooding, levee failure, and stream bank erosion can cost RD 1601 millions in damages.

Natural Resources at Risk

The District Planning Team noted that all natural resources could be at risk from heavy rains on the district.

Historic and Cultural Resources at Risk

The District Planning Team noted that there are no known historic and or cultural resources at risk on the island.

Future Development

While future development may occur in the areas protected by levees, which can be compromised by severe weather events, the District does not control this development. The District only can control whether the levees meet certification standards.

Severe Weather: Wind and Tornadoes

Likelihood of Future Occurrence–Likely
Vulnerability–High

Hazard Profile and Problem Description

According to historical hazard data, severe weather (including high winds) is an annual occurrence in the District. Tornadoes occur much less frequently. Damage and disaster declarations related to severe weather have occurred and will continue to occur in the future.

Past Occurrences

The 5-Year Plan for RD 1601 included a history of wind and tornadoes in the District.

- 1998 Flood Event. During the flood event of 1998, riprap was placed on waterside slopes to mitigate damage by high water and high winds.
- 2006 Flood Event. Rip rap was placed on waterside slopes to mitigate damage caused from high winds.

Vulnerability to Wind and Tornadoes

Assets/Critical Facilities at Risk

The District Planning Team noted that the entirety of the levee structures are at risk from wind.

Natural Resources at Risk

The District Planning Team noted that all natural resources in the District are at risk if winds caused a levee failure in the District.

Historic and Cultural Resources at Risk

The District Planning Team noted that there are no known historic and or cultural resources at risk on the island.

Future Development

While future development may occur in the areas protected by levees, which can be compromised by high wind events, the District does not control this development. The District only can control whether the levees meet certification standards.

Subsidence

Likelihood of Future Occurrence–Likely
Vulnerability–Medium

Hazard Profile and Problem Description

For over a century, subsidence of the organic soils in portions of the Delta has led to an increasing need for subsurface drainage. Aerobic oxidation of organic carbon, the primary cause of subsidence, began in the late 1800s as the nutrient-rich organic soils were cleared and farming began. Peat fires, lit to level agricultural fields prior to 1950, and wind erosion are also significant causes of subsidence throughout the Delta. Since reclamation of the island began, elevations have fallen to as much as 20 feet below sea level, requiring protection by over 1,125 miles of man-made levees throughout the Delta. Drainage is provided by a network of ditches that collect and transport shallow groundwater, irrigation runoff, and levee seepage to pump stations that discharge back into the Delta waterways. These ditches create an unsaturated root zone for crops, and provide a more stable levee foundation.

Past Occurrences

The 5-Year Plan documented the history of subsidence in RD 1601.

- 1982-1983: The flood event FEMA 677 DR caused waterside erosion, multiple cracks on the landside slope along with sinkholes, subsidence areas, and seepage areas. The levee was found to have problems with subsidence and seepage, and had cracks in the landward slope at Stations 374+00 to 378+00, 384+00 to 387+00, 405+00 to 409+00, 419+00 to 436+00, 526+00 to 530+00, 550+00 to 554+00, and 567+00 to 569+50. Import fill material was placed on the landward levee slope to flatten the slope, and a landside berm fill was constructed, with Mirafi fabric placed under the berm fill, except at Stations 384+00 to 387+00, 534+00 to 536+25, and 567+00 to 569+50. Sink holes were located at the landward toe of the levee at Stations 448+00, 550+00, and were filled with import fill material.
- 1985 to 1986: The levee was found to have problems with subsidence and seepage, and had cracks in the landward slope at Stations 363+39 to 367+00 and 582+00 to 588+34.

The District Planning Team noted that, in addition to the 5-Year Plan history, a 2006 storm event caused subsidence in the District. An area on the west side of Pump Station #1 suffered from subsidence.

Vulnerability to Subsidence

Assets/Critical Facilities at Risk

The management issues raised by land subsidence range in scale from those faced by individual farmers to the possible global-scale issue posed by the carbon-dioxide flux, with its possible link to climate change. At the most local level, individual farmers or reclamation districts must maintain drainage networks on the

islands and pump the agricultural drainage back into waterways. These costs increase gradually as subsidence progresses. The District Planning Team noted that all levee structures in the District are at risk to subsidence.

Natural Resources at Risk

The District Planning Team noted that all natural resources in the District are at risk to subsidence.

Historic and Cultural Resources at Risk

The District Planning Team noted that there are no known historic and or cultural resources at risk on the island.

Future Development

While future development may occur in the areas protected by levees, which can be compromised by subsidence activity, the District does not control this development. The District only can control whether the levees meet certification standards.

11.6 Capability Assessment

Capabilities are the programs and policies currently in use to reduce hazard impacts or that could be used to implement hazard mitigation activities. This capabilities assessment is divided into five sections: regulatory mitigation capabilities, administrative and technical mitigation capabilities, fiscal mitigation capabilities, mitigation education, outreach, and partnerships, and other mitigation efforts.

11.6.1. Regulatory Mitigation Capabilities

Table 11-4 lists regulatory mitigation capabilities, including planning and land management tools, typically used by local jurisdictions to implement hazard mitigation activities and indicates those that are in place in the RD 1601.

Table 11-4 RD 1601's Regulatory Mitigation Capabilities

Plans	Y/N Year	Does the plan/program address hazards? Does the plan identify projects to include in the mitigation strategy? Can the plan be used to implement mitigation actions?
Comprehensive/Master Plan	Y 2010	5 Year Plan identifies hazards that may affect RD 1601. Some mitigation strategies are proposed. An Evacuation Plan is detailed, as well as an Emergency Response Plan.
Capital Improvements Plan	N	
Economic Development Plan	N	
Local Emergency Operations Plan	Y	In progress at the time of the development of this plan will be completed by December 2016
Continuity of Operations Plan	N	

Transportation Plan	N	
Stormwater Management Plan/Program	N	
Engineering Studies for Streams	N	
Community Wildfire Protection Plan	N	
Other special plans (e.g., brownfields redevelopment, disaster recovery, coastal zone management, climate change adaptation)		
Building Code, Permitting, and Inspections	**Y/N**	**Are codes adequately enforced?**
Building Code	N	Version/Year:
Building Code Effectiveness Grading Schedule (BCEGS) Score	N	Score:
Fire department ISO rating:	N	Rating:
Site plan review requirements	N	
Land Use Planning and Ordinances	**Y/N**	**Is the ordinance an effective measure for reducing hazard impacts? Is the ordinance adequately administered and enforced?**
Zoning ordinance	N	
Subdivision ordinance	N	
Floodplain ordinance	N	
Natural hazard specific ordinance (stormwater, steep slope, wildfire)	N	
Flood insurance rate maps	N	
Elevation Certificates	N	
Acquisition of land for open space and public recreation uses	N	
Erosion or sediment control program	N	
Other	N	
How can these capabilities be expanded and improved to reduce risk?		

Source: RD 1601

11.6.2. Administrative/Technical Mitigation Capabilities

Table 11-5 identifies the department(s) responsible for activities related to mitigation and loss prevention for RD 1601.

Table 11-5 RD 1601's Administrative and Technical Mitigation Capabilities

Administration	Y/N	Describe capability Is coordination effective?
Planning Commission	N	

Mitigation Planning Committee	Y	RD 1601 staff and KSN, Inc. staff
Maintenance programs to reduce risk (e.g., tree trimming, clearing drainage systems)	Y	
Mutual aid agreements	Y	
Other		
Staff	**Y/N FT/PT**	**Is staffing adequate to enforce regulations? Is staff trained on hazards and mitigation? Is coordination between agencies and staff effective?**
Chief Building Official	N	
Floodplain Administrator	N	
Emergency Manager	Y	KSN, Inc.
Community Planner	N	
Civil Engineer	Y	KSN, Inc.
GIS Coordinator	Y	KSN, Inc.
Other		
Technical		
Warning systems/services (Reverse 911, outdoor warning signals)	N	
Hazard data and information	Y	KSN, Inc.
Grant writing	Y	KSN, Inc.
Hazus analysis	N	
Other		
How can these capabilities be expanded and improved to reduce risk?		

Source: RD 1601

11.6.3. Fiscal Mitigation Capabilities

Table 11-6 identifies financial tools or resources that the RD 1601 could potentially use to help fund mitigation activities.

Table 11-6 RD 1601's Fiscal Mitigation Capabilities

Funding Resource	Access/ Eligibility (Y/N)	Has the funding resource been used in past and for what type of activities? Could the resource be used to fund future mitigation actions?
Capital improvements project funding	Y	
Authority to levy taxes for specific purposes	Y	Levy Assessment Program but not taxes
Fees for water, sewer, gas, or electric services	N	
Impact fees for new development	N	

Funding Resource	Access/ Eligibility (Y/N)	Has the funding resource been used in past and for what type of activities? Could the resource be used to fund future mitigation actions?
Storm water utility fee	Y	Part of our Levy Assessment Program
Incur debt through general obligation bonds and/or special tax bonds	Y	
Incur debt through private activities	N	
Community Development Block Grant	N	
Other federal funding programs	Y	USACE PL84-99
State funding programs	Y	DWR Levee Subventions and Special Projects Program
Other		
How can these capabilities be expanded and improved to reduce risk?		

Source: RD 1601

11.6.4. Mitigation Education, Outreach, and Partnerships

Table 11-7 identifies education and outreach programs and methods already in place that could be/or are used to implement mitigation activities and communicate hazard-related information.

Table 11-7 RD 1601's Mitigation Education, Outreach, and Partnerships

Program/Organization	Yes/No	Describe program/organization and how relates to disaster resilience and mitigation. Could the program/organization help implement future mitigation activities?
Local citizen groups or non-profit organizations focused on environmental protection, emergency preparedness, access and functional needs populations, etc.	N	
Ongoing public education or information program (e.g., responsible water use, fire safety, household preparedness, environmental education)	N	
Natural disaster or safety related school programs	N	
StormReady certification	N	
Firewise Communities certification	N	
Public-private partnership initiatives addressing disaster-related issues	N	
Other		
How can these capabilities be expanded and improved to reduce risk?		

11.6.5. Other Mitigation Efforts

The entire Twitchell Island levee system consists of 2.5 miles of Federal Project Levee and 9.4 miles of Non-Project levee and is inspected daily by District staff who are familiar with all aspects of its function. The District engineer typically performs an inspection once a month or more frequently when warranted. The Federal Project Levee along Threemile Slough is inspected in the Fall and Spring by the Department of Water Resources levee inspectors. Reports are compiled and submitted to the District. The District staff also inspects the Federal Project Levee in the Winter and Summer, and submits reports back to the Department of Water Resources. During high water or severe weather events, inspection frequency is increased to meet the demand. The entire levee is inspected continuously at one hour intervals.

11.7 Mitigation Strategy

11.7.1. Mitigation Goals and Objectives

RD 1601 adopts the hazard mitigation goals and objectives developed by the HMPC and described in Chapter 5 Mitigation Strategy.

11.7.2. Mitigation Actions

The planning team for RD 1601 identified and prioritized the following mitigation actions based on the risk assessment. Background information and information on how each action will be implemented and administered, such as ideas for implementation, responsible office, potential funding, estimated cost, and timeline are also included.

Action 1. Levee Improvement Project

Hazards Addressed: EQ, EQ Liquefaction, Flood: 100/200/500-year, Flood: Localized Stormwater Flooding, Levee Failure, River/Stream/Creek Bank Erosion, Severe Weather: Heavy Rains and Storms (Thunderstorms/Hail, Lightning), Severe Weather (Wind and Tornadoes), Subsidence

Goals Addressed:

Issue/Background: The goal of this Mitigation Action is to improve the Twitchell Island levees over the next five years to a level of protection that meets, or exceeds, the U.S. Army Corps of Engineers' (USACE) PL84-99 Levee Standard.

Project Description: The District would like to bring portions of the RD 1601 Twitchell Island levee currently below the HMP Criteria to six inches above the PL 84-99 Standard using 2:1 landside slopes. If sufficient funding is available, the segments of levee improved during this phase will include portions of the levee that meet the HMP Criteria, but do not meet the design template for this project, due to the many relatively short stretches of levee that do not meet the PL 84-99 Standard in close proximity to longer stretches of levee that do not meet the HMP Standard. After the entire levee meets or exceeds the HMP Criteria, the District will bring any remaining portions of levee below the PL 84-99 Standard to six inches above the PL 84-99 Standard.

Other Alternatives: none

Existing Planning Mechanism(s) through which Action Will Be Implemented: Permitting process, Finalizing the EIR, CEQA Design Process

Responsible Office/Partners: RD 1601

Cost Estimate: $90 -100 million

Project Priority: High

Benefits (Losses Avoided): Preservation of 563 levee structures, Ecosystem Restoration and Habitat Enhancement Component, Reversing Land Subsidence, Ensuring Adequate and Effective Emergency Response Plans, Benefitting Water Quality, Improving Water Supply Reliability

Potential Funding: Prop 1 and 1E, 84 Funds, HMGP Grant Programs, seeking cost sharing partners for project.

Timeline: 1-10 years depending on regulatory process and funding