Delta Annex Chapter 12 Reclamation District 1601

12.1 Introduction

This Annex details the hazard mitigation planning elements specific to Reclamation District 1601 (RD 1601 or District), a previously participating jurisdiction to the 2016 Sacramento County Local Hazard Mitigation Plan (LHMP) Update. This 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 the District. This Annex provides additional information specific to RD 1601, with a focus on providing additional details on the risk assessment and mitigation strategy for this District.

12.2 Planning Process

As described above, the District followed the planning process detailed in Chapter 3 of the Base Plan. In addition to providing representation on the Sacramento County Hazard Mitigation Planning Committee (HMPC), the District formulated their 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 12-1. Additional details on plan participation and District representatives are included in Appendix A.

Table 12-1 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
Elizabeth Ramos, KSN, Inc.	Project Engineer	Attended meetings, collected data, drafted text, reviewed draft docs
Megan LeRoy, KSN, Inc.	Project Engineer	Attended meetings, collected data, drafted text, reviewed draft docs

Coordination with other community planning efforts is paramount to the successful implementation of this LHMP Update. This section provides information on how the District integrated the previously approved 2016 Plan into existing planning mechanisms and programs. Specifically, the District incorporated into or implemented the 2016 LHMP through other plans and programs shown in Table 12-2.

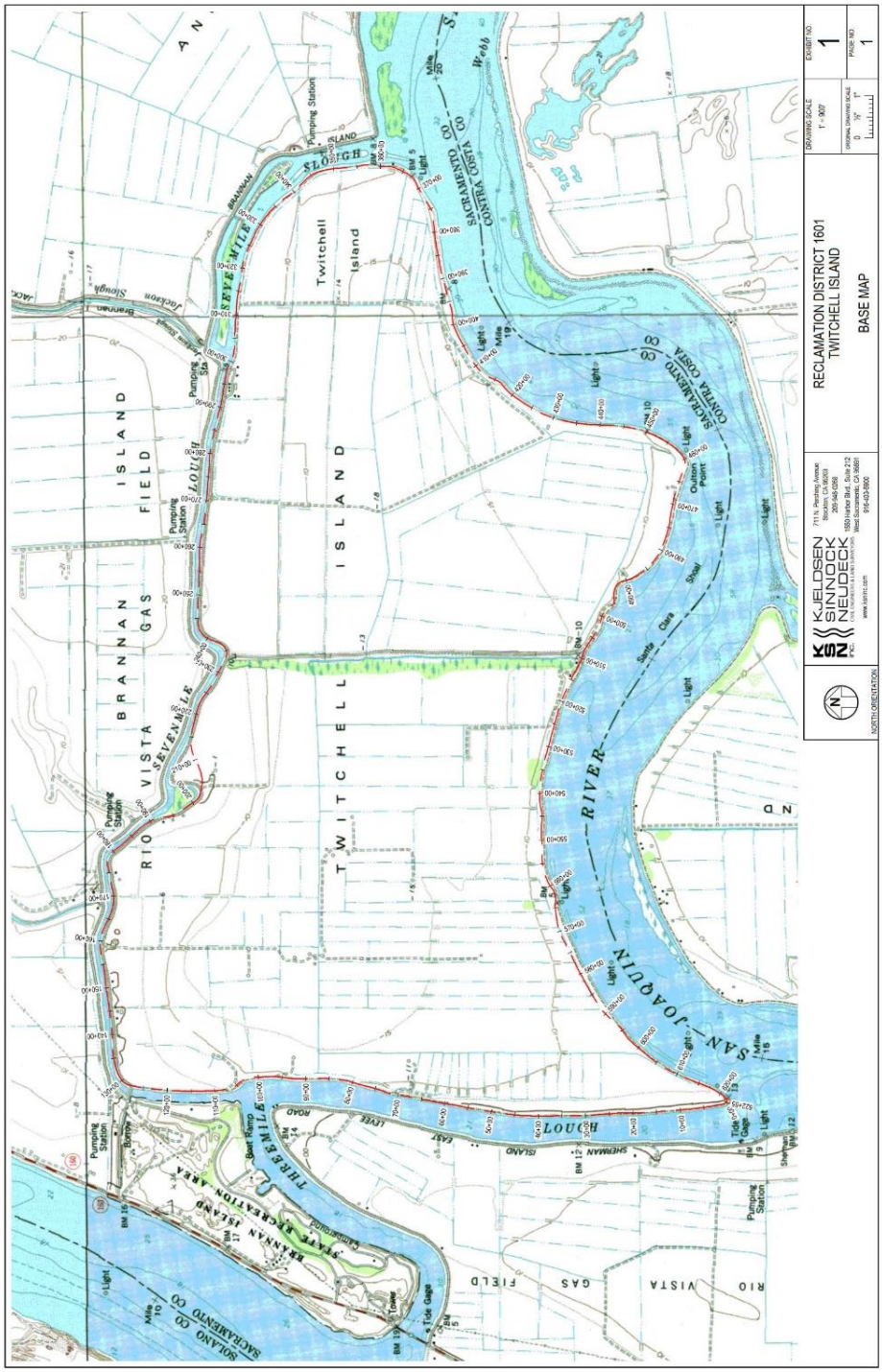
Table 12-2 2016 LHMP Incorporation

Planning Mechanism 2016 LHMP Was Incorporated/Implemented In.	Details: How was it incorporated?
Development of RD 1601 Flood EOP	Elements in the Hazard Assessment used in the development of the Flood EOP

12.3 District Profile

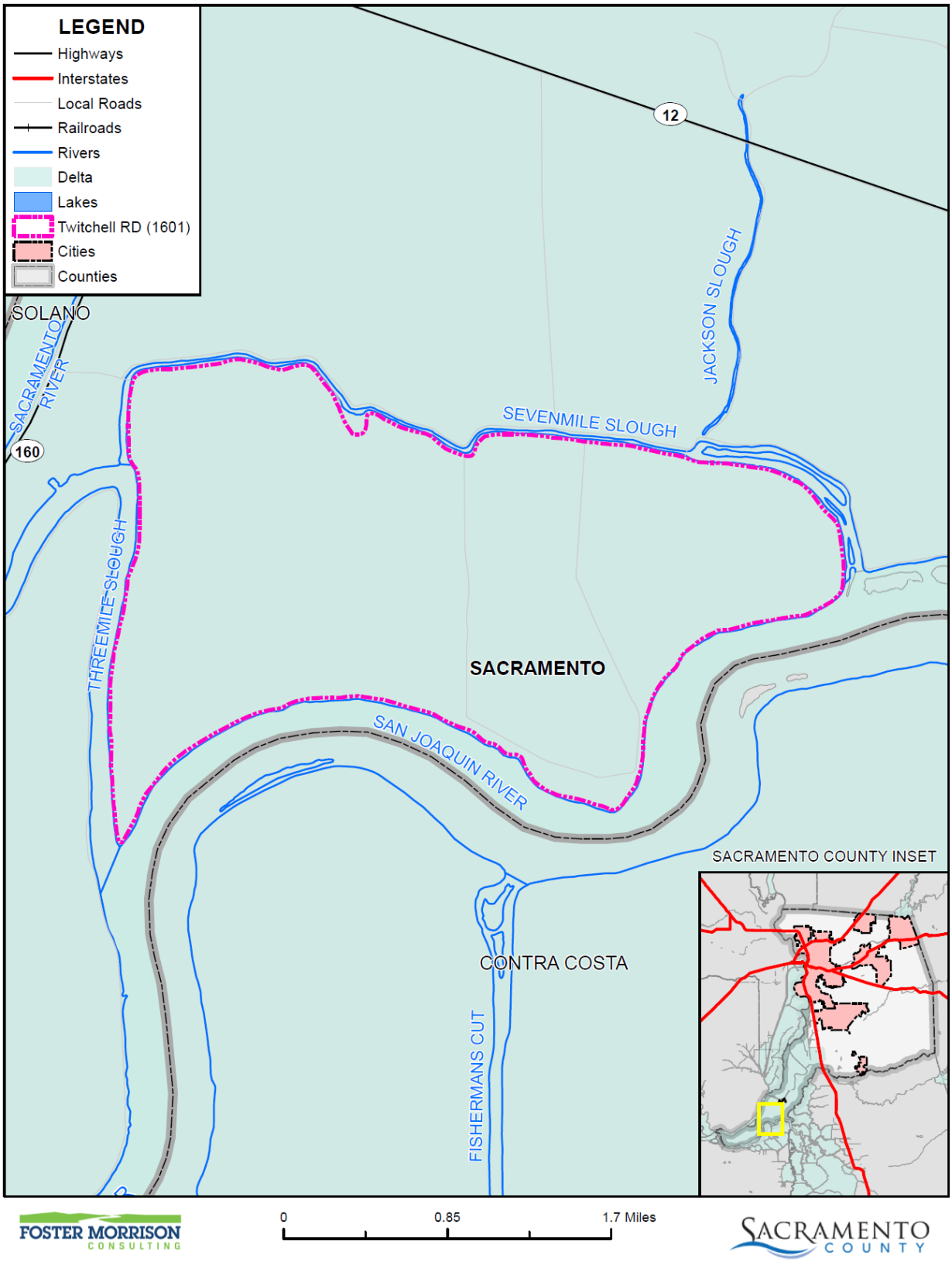
The District profile for RD 1601 is detailed in the following sections. Figure 12-1 and Figure 12-2 displays a map and the location of the District within Sacramento County.

Figure 12-1 RD 1601



Source: RD 1601 2010 5 Year Plan

Figure 12-2 RD 1601



Data Source: Twitchell Reclamation District, Sacramento County GIS, Cal-Atlas; Map Date: 09/2020.

12.3.1. Overview and Background

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 access and emergency evacuation to the East via Brannan-Andrus Island and State Highway 12 or to the West via State Highway 160.

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.

12.4 Hazard Identification

RD 1601 identified the hazards that affect the District and summarized their location, extent, frequency of occurrence, potential magnitude, and significance specific to District (see Table 12-3).

Table 12-3 RD 1601—Hazard Identification Assessment

Hazard	Geographic Extent	Likelihood of Future Occurrences	Magnitude/ Severity	Significance	Climate Change Influence
Climate Change	Extensive	Occasional	Limited	Low	-
Dam Failure	Limited	Unlikely	Negligible	Low	Medium
Drought & Water Shortage	Extensive	Occasional	Critical	Low	High
Earthquake	Extensive	Occasional	Limited	Medium	Low
Earthquake Liquefaction	Significant	Unlikely	Limited	Medium	Low
Floods: 1%/0.2% annual chance	Extensive	Unlikely	Catastrophic	High	Medium
Floods: Localized Stormwater	Extensive	Occasional	Critical	High	Medium
Landslides, Mudslides, and Debris Flow	Limited	Unlikely	Negligible	Low	Medium
Levee Failure	Extensive	Occasional	Catastrophic	High	Medium
Pandemic	Extensive	Likely	Limited	Low	Medium
Severe Weather: Extreme Cold and Freeze	Limited	Unlikely	Limited	Low	Medium
Severe Weather: Extreme Heat	Extensive	Likely	Limited	Low	High
Severe Weather: Heavy Rains and Storms	Extensive	Likely	Critical	High	Medium
Severe Weather: Wind and Tornado	Extensive	Likely	Critical	High	Low
Subsidence	Extensive	Likely	Critical	Medium	Medium
Volcano	Limited	Unlikely	Negligible	Low	Low
Wildfire	Limited	Unlikely	Negligible	Low	High

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

Likelihood 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

Climate Change Influence
Low: minimal potential impact
Medium: moderate potential impact
High: widespread potential impact

12.5 Hazard Profile and Vulnerability Assessment

The intent of this section is to profile the District's hazards and assess the District's vulnerability separate from that of the Sacramento County Planning Area as a whole, which has already been assessed in Section 4.3 Hazard Profiles and Vulnerability Assessment in the Base Plan. The hazard profiles in the Base Plan discuss overall impacts to the Sacramento County Planning Area and describes the hazard problem description, hazard location and extent, magnitude/severity, previous occurrences of hazard events and the likelihood of future occurrences. Hazard profile information specific to the District is included in this Annex. This vulnerability assessment analyzes the property 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 Base Plan.

12.5.1. Hazard Profiles

Each hazard vulnerability assessment in Section 12.5.3, includes a hazard profile/problem description as to how each medium or high significant hazard (as shown in Table 12-3) affects the District and includes information on past hazard occurrences and the likelihood of future hazard occurrence. The intent of this section is to provide jurisdictional specific information on hazards and further describes how the hazards and risks differ across the Sacramento County Planning Area.

12.5.2. Vulnerability Assessment and Assets at Risk

This section identifies the District's total assets at risk, including values at risk, populations at risk, critical facilities and infrastructure, natural resources, and historic and cultural resources. Growth and development trends are also presented for the District. This data is not hazard specific, but is representative of total assets at risk within the District.

Assets at Risk and Critical Facilities

This section considers RD 1601'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 LHMP. Critical facilities are defined for this Plan as:

> ***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, (3) Hazardous Materials Facilities.***

Table 12-4 lists critical facilities and other District assets identified by the District Planning Team as important to protect in the event of a disaster. RD 1601's physical assets, valued at over $2.7 million, consist of the buildings and infrastructure to support the District's operations.

Table 12-4 RD 1601 Critical Facilities, Infrastructure, and Other District Assets

Name of Asset	Facility Type	Replacement Value	Which Hazards Pose Risk
Pump Station #1 (including all station components)	Essential Services	$2,000,000l	Flood, Levee Failure, Liquefaction
Pump Station #2 (including all station components)	Essential Services	$2,000,000l	Flood, Levee Failure, Liquefaction
Drainage Conveyances	Essential Services	$350,000	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
Total		**$2,700,000**	

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 2020 5-year plan noted that the total estimated value of the 3,634.88 acres of land within the District is $16,338,771.

There are several levee geometry standards and criteria that are recognized within the Delta. Twitchell Island uses the Hazard Mitigation Plan (HMP) Criteria and the Bulletin 192-82 Standard. HMP level is the 100-year Base Flood Elevation plus an additional foot of freeboard for agricultural Districts. The goal is to reach the 192-82 level of flood protection, which is the 300-year surface elevation plus 1.5-ft freeboard for agricultural Districts.

The Level of Protection assessment below is based on the DWR 2017 Light Detection and Ranging (LiDAR) Survey. It should be noted that LiDAR survey data is generally suitable for high-level assessments and planning efforts such as this Plan, but it has limitations for more refined analyses due to accuracy thresholds, data gaps underneath vegetation and/or structure cover, and lack of identification of planimetric surface features.

The DWR 2017 LiDAR survey data indicates that the District's levee meets the following standards and criteria as shown in Table 12-5**.**

Table 12-5 - Current Levee Assessment

Delta Agricultural Levee Standard/Criteria	Length of Levee that Meets Standard/Criteria	Percentage of Levee that Meets Standard/Criteria
Total Levee Length	62,255 feet	---

Delta Agricultural Levee Standard/Criteria	Length of Levee that Meets Standard/Criteria	Percentage of Levee that Meets Standard/Criteria
HMP Criteria	38,016 feet	61.1 %
Bulletin 192-82	7,000 feet	11.2 %

Costs Due to a Levee Failure or Breach

A failure or breach of the District's levee system could result in flooding of the District to depths of approximately 20 feet on average. Projected costs associated with such an event have been calculated using actual costs from the 2004 Jones Tract flood event. All information used was gathered from the final FEMA Project Worksheets used to close out the claims for all of the public agencies involved in the disaster event (FEMA 1529-DR). Additional costs for work not claimed to FEMA included work performed by the United States Army Corps of Engineers; these costs were established from the invoiced amount provided by the Contractor.

In order to establish the unit costs for an anticipated flood cost model for Delta reclamation districts, the costs from the 2004 Jones Tract flood event were broken into component costs that can be applied to other districts using characteristic data for each district. The data used for the District includes the following:

- 3,560 acres of land
- 11.8 levee miles
- 20 feet average depth of District relative to BFE
- 82,600 linear feet of District maintained canals
- 71,200 acre-feet of floodwater to be evacuated from District

For the District, the estimated cost of a flood event resulting from a single levee failure would be approximately $32.1 million based on the costs from the 2004 Jones Tract flood event.

The cost analysis does not include damage to privately owned property and improvements. The actual financial impact to those properties and facilities would depend greatly on the replacement costs, the amount of insurance those properties might have, and where they are located relative to the location of the levee breach and depth of water at those locations. It should also be noted that a flood could potentially eliminate a cropping season.

Reclamation District Structures, Pumps, and Pipelines

Water for irrigation is supplied from the surrounding waterways via landowner and District owned siphons, and is routed through irrigation ditches located on the high end of the fields. Drainage of irrigation tail-water, storm drainage runoff, and subsurface seepage occurs through earth-lined drainage canals through the farmed portion of the island, draining toward the District pump station. The drainage canals are maintained regularly to remove accumulated debris and vegetation from the channels.

Excess water from the canal drainage collection system is conveyed to the District pump station located at Station 510+00. This pump station discharges into the San Joaquin River and has three 100-horsepower pumps that have a combined flow rate of approximately 22,000 gallons per minute.

The flow rates listed above are based on pump performance during conditions at the time of the pump test. These conditions are assumed to be indicative of normal operations of the pump stations. Pump capacities for any pump with a given motor vary, depending on the total dynamic head, impeller size, and efficiency.

The District's pump station is powered by electricity provided by Pacific Gas and Electric (PG&E). If the power supply to the island is disrupted, there is no backup power supply immediately available to the pumps, and it would be necessary to bring in backup generators to operate the pumps.

General Infrastructure

Approximately 35 producing gas wells are located within the District. Gas wells come in and out of production regularly, so to establish a firm number at any given time is difficult. The estimated value of these wells is $27,074,352, as of June 10, 2010. A network of collection pipelines connects the wells throughout the island, and two gas transmission pipelines transport gas off the island, transecting the District's levee at approximately Station 161+00 and Station 265+00. The 8-inch high-pressure pipeline crossing at Station 161+00 was installed in 2002 using horizontal directional drilling, and is located at a depth of 60 feet below the levee crown. The crossing at Station 265+00 utilizes a previously abandoned 8-inch PG&E pipeline that was capped in 2000. The capped 8-inch PG&E pipeline is located approximately 2 to 3 feet below the levee crown, as shown in the historic drawings produced by PG&E in 1953. Currently, the pipeline is approximately 4 feet below the levee crown. In 2002, PG&E abandoned the pipeline by cutting and capping the lines in the concrete containment bulkhead located on the landside levee slope. In 2007, Rosetta Resources reconnected a new 6-inch line to a sleeve that was installed inside the previously abandoned 8-inch pipeline running through the levee. All of the pipeline crossings were permitted by the District.

Local Assets

The total estimated value of the 3634.88 acres of land within the District is $16,338,771. The value is derived from the price per acre of $4,500 as stated in the Appraisal performed by Sean Hardin, California Department of Water Resources, Division of Engineering titled "Twitchell Island, West Delta Wildlife Management Plan, Parcel No. ND-1, Sacramento County," dated April 17, 2008, included in the appendices of this Plan.

The DRMS study values the assets on the island protected by the levees, at $12,106,000.

For the purposes of this report, no economic value has been placed on the environmental benefits provided by the interior lands within the island and protected by the levees. The costs of replacing these environmental benefits are likely substantial, and the costs to mitigate for environmental or habitat losses currently range from $65,000 to $145,000 per acre.

Natural Resources

RD 1601 has a variety of natural resources of value to the District. These natural resources parallels that of Sacramento County as a whole. Information can be found in Section 4.3.1 of the Base Plan.

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 freshwater 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

General growth in the District parallels that of the Sacramento County Planning Area as a whole. Information can be found in Section 4.3.1 of the Base Plan.

Development since 2016

The District Planning Team noted that there has been no growth and development in the District since the last planning period. No District facilities have been constructed since 2016.

Future Development

More general information on growth and development in Sacramento County as a whole can be found in "Growth and Development Trends" in Section 4.3.1 Sacramento County Vulnerability and Assets at Risk of the Base Plan.

Proposed Rock Slope Protection Project

The District plans to ensure the protection of the existing levee by adding quarry stone riprap above the existing riprap to any portions of the waterside slope of the levee requiring additional rock slope protection. This will prevent erosion and reduce future erosion repairs. Prior to submitting a project proposal, a thorough riprap inventory of the District must be completed to determine where additional riprap may be necessary and determine more definitive quantities and costs required to complete the project. The quantities and costs provided in this Plan are planning level estimates based on input from the District and from the District's most recent survey.

The anticipated planning-level costs of the Rock Slope Protection Project consisting of additional riprap as needed is $3.6 million. Costs are provided in this Plan as planning level estimates based on input from the District and from the District's most recent survey and inspection. A thorough riprap inventory of the

District must be completed prior to submitting a project proposal to determine where additional riprap may be necessary and determine more definitive quantities and costs required to complete the project.

Proposed Bulletin 192-82 Levee Project

The District will bring those portions of levee along Threemile Slough and Sevenmile Slough below the Bulletin 192-82 Standard to six inches above the Bulletin 192-82 Standard with a District minimum crown width of 24 feet to allow for future levee raises to address climate change and sea level rise. This work will likely be divided into several phases or projects, depending on the funding available. The Bulletin 192-82 Levee Project sites are proposed to be limited to the following locations as shown in Table 12-6.

Table 12-6 Bulletin 192-82 Levee Project Sites

Start Station	End Station	Length in Feet
62+60	360+00	29,740
590+00	619+05	2,905

Source: RD 1601

The cost estimate provided in this report treats all Bulletin 192-82 project sites as a single project. The anticipated planning-level costs involved with constructing a minimum 16-foot-wide crown in accordance with the Bulletin 192-82 Standard is approximately $44.6 million. Furthermore, the incremental costs involved with widening the crown to 24 feet to allow for future raises in freeboard to address climate change and sea level rise is approximately $10 million. Quantities and costs are provided in this Plan as planning level estimates based on input from the District and from the District's most recent survey and inspection. A design-level survey and inspection of the District must be completed prior to submitting a project proposal to determine more definitive quantities and costs required to complete the project.

San Joaquin River Setback Levee Project

The District will also implement the levee improvement recommendations along the San Joaquin River in accordance with the 2009 GEI geotechnical report by constructing a toe berm and setback levee. The setback levee along the San Joaquin River also includes a channel margin habitat component that will provide approximately four miles of much needed "fish friendly" levees in this part of the Delta. This work will likely be divided into several phases or projects, depending on the funding available

The San Joaquin River Setback Levee Project sites are proposed to be limited to the following locations as shown in Table 12-7.

Table 12-7 San Joaquin River Setback Levee Project Sites

Reach	Start Station	End Station	Length in Feet
1	360+00	387+00	2,700
2	387+00	408+00	2,100
3	408+00	435+00	2,700
4	435+00	462+00	2,700
5	462+00	482+00	2,000

Reach	Start Station	End Station	Length in Feet
6	482+00	508+80	2,680
7	512+00	539+50	2,750
8	539+50	567+00	2,750
9	567+00	590+00	2,300
10	---	---	2,400

The cost estimate provided in this report treats all San Joaquin River Setback Levee Project sites as a single project. The anticipated costs of the San Joaquin River Setback Levee Project are approximately $153 million. The costs provided in this Plan for the San Joaquin River Setback Levee Project take into account that all environmental, permitting, and preliminary engineering for the overall project have been completed as part of DWR Project Funding Agreement No. TW-09-1.0 through the Delta Levees Special Projects Program.

12.5.3. Vulnerability to Specific Hazards

This section provides the vulnerability assessment, including any quantifiable loss estimates, for those hazards identified above in Table 12-3 as high or medium significance hazards. Impacts of past events and vulnerability of the District 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 evaluating vulnerabilities and calculating loss estimates are the same as those described in Section 4.3 of the Base Plan.

An estimate of the vulnerability of the District to each identified priority hazard, in addition to the estimate of likelihood 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.

Depending on the hazard and availability of data for analysis, this hazard specific vulnerability assessment also includes information on values at risk, critical facilities and infrastructure, populations at risk, and future development.

Power Outage/Power Failure

An impact of almost all hazards below relates to power outage and/or power failures. The US power grid crisscrosses the country, bringing electricity to homes, offices, factories, warehouses, farms, traffic lights and even campgrounds. According to statistics gathered by the Department of Energy, major blackouts are on the upswing. Incredibly, over the past two decades, blackouts impacting at least 50,000 customers have increased 124 percent. The electric power industry does not have a universal agreement for classifying disruptions. Nevertheless, it is important to recognize that different types of outages are possible so that plans may be made to handle them effectively. In addition to blackouts, brownouts can occur. A brownout is an intentional or unintentional drop in voltage in an electrical power supply system. Intentional brownouts are used for load reduction in an emergency. Electric power disruptions can be generally grouped into two categories: intentional and unintentional. More information on types of power disruptions can be found in Section 4.3.2 of the Base Plan.

Public Safety Power Shutoff (PSPS)

A new intentional disruption type of power outage/failure event has recently occurred in California. In recent years, several wildfires have started as a result of downed power lines or electrical equipment. This was the case for the Camp Fire in 2018. As a result, California's three largest energy companies (including PG&E), at the direction of the California Public Utilities Commission (CPUC), are coordinating to prepare all Californians for the threat of wildfires and power outages during times of extreme weather. To help protect customers and communities during extreme weather events, electric power may be shut off for public safety in an effort to prevent a wildfire. This is called a PSPS. More information on PSPS criteria can be found in Section 4.3.2 of the Base Plan.

The District Planning Team noted that the pump stations and drainage conveyances are potentially at risk to power outages and/ or power failure. In the absence of power, localized flooding can occur because existing pump stations do not have backup power. In addition, if power outages occur near the end of the flood, it will be a challenge to dewater the District.

Earthquake

Likelihood of Future Occurrence–Unlikely
Vulnerability–Medium

Hazard Profile and Problem Description

An earthquake is caused by a sudden slip on a fault. Stresses in the earth's outer layer push the sides of the fault together. Stress builds up, and the rocks slip suddenly, releasing energy in waves that travel through the earth's crust and cause the shaking that is felt during an earthquake. Earthquakes can cause structural damage, injury, and loss of life, as well as damage to infrastructure networks, such as water, power, gas, communication, and transportation. Earthquakes may also cause collateral emergencies including dam and levee failures, seiches, hazmat incidents, fires, avalanches, and landslides. The degree of damage depends on many interrelated factors. Among these are: the magnitude, focal depth, distance from the causative fault, source mechanism, duration of shaking, high rock accelerations, type of surface deposits or bedrock,

degree of consolidation of surface deposits, presence of high groundwater, topography, and the design, type, and quality of building construction.

Location and Extent

The amount of energy released during an earthquake is usually expressed as a magnitude and is measured directly from the earthquake as recorded on seismographs. An earthquake's magnitude is expressed in whole numbers and decimals (e.g., 6.8). Seismologists have developed several magnitude scales, as discussed in Section 4.3.9 of the Base Plan. Geological literature indicates that no major active faults transect the County; however, there are several subsurface faults in the Delta. The Midland fault, buried under alluvium, extends north of Bethel Island in the Delta to the east of Lake Berryessa and is considered inactive but possibly capable of generating a near 7.0 (Richter Scale) earthquake. This magnitude figure is speculative based on an 1895 earthquake measuring 6.9 on the Richter Scale with an epicenter possibly in the Midland Fault vicinity. However, oil and gas companies exploring the area's energy potential have identified several subsurface faults, none of which show any recent surface rupture. A second, presumably inactive, fault is in the vicinity of Citrus Heights near Antelope Road. This fault's only exposure is along a railroad cut where offsetting geologic beds can be seen. Neither the lateral extent of the trace, the magnitude of the offset, nor the age of faulting has been determined. To the east, the Bear Mountain fault zone trends northwest-southeast through Amador and El Dorado Counties. Geologists believe this series of faults has not been active in historic time. Potential earthquakes on the Hayward, Calaveras, and San Andreas fault could also affect the Delta area.

Another measure of earthquake severity is intensity. Intensity is an expression of the amount of shaking at any given location on the ground surface. Seismic shaking is typically the greatest cause of losses to structures during earthquakes. Seismic shaking maps for the area show Sacramento County and the District fall within a low to moderate shake risk, with most of the moderate risk in the Delta area of the County.

Past Occurrences

There have be no past federal or state disaster declarations from this hazard. After the 2014 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 and Impacts from Earthquake

The combination of plate tectonics and associated California coastal mountain range building geology generates earthquake as a result of the periodic release of tectonic stresses. Sacramento County lies in the center of the North American and Pacific tectonic plate activity. There have been earthquakes as a result of this activity in the historic past, and there will continue to be earthquakes in the future of the California north coastal mountain region.

Fault ruptures itself contributes very little to damage unless the structure or system element crosses the active fault; however, liquefaction can occur further from the source of the earthquake. In general, newer construction is more earthquake resistant than older construction due to enforcement of improved building codes. Manufactured buildings can be very susceptible to damage because their foundation systems are

rarely braced for earthquake motions. Locally generated earthquake motions and associated liquefaction, even from very moderate events, tend to be more damaging to smaller buildings, especially those constructed of unreinforced masonry (URM) and soft story buildings.

The Uniform Building Code (UBC) identifies four seismic zones in the United States. The zones are numbered one through four, with Zone 4 representing the highest level of seismic hazard. The UBC establishes more stringent construction standards for areas within Zones 3 and 4. All of California lies within either Zone 3 or Zone 4. RD 1601 is within the less hazardous Zone 3.

Impacts from earthquake in the District will vary depending on the fault that the earthquake occurs on, the depth of the earthquake strike, and the intensity of shaking. Large events could cause damages to levees, infrastructure, critical facilities, residential and commercial properties, and possible injuries or loss of life. 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 a damaging earthquake.

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.

Assets at Risk

The District Planning Team noted that the levees structures, pump stations and drainage conveyances are potentially at risk to an earthquake, though no evidence of damage has been observed to date

Earthquake: Liquefaction

Likelihood of Future Occurrence–Unlikely
Vulnerability–Medium

Hazard Profile and Problem Description

Liquefaction can be defined as the loss of soil strength or stiffness due to a buildup of pore-water pressure during a seismic event and is associated primarily with relatively loose, saturated fine- to medium-grained unconsolidated soils. Seismic ground shaking of relatively loose, granular soils that are saturated or submerged can cause the soils to liquefy and temporarily behave as a dense fluid. If this layer is at the surface, its effect is much like that of quicksand for any structure located on it. If the liquefied layer is in the subsurface, the material above it may slide laterally depending on the confinement of the unstable mass. Liquefaction is caused by a sudden temporary increase in pore-water pressure due to seismic densification or other displacement of submerged granular soils. Liquefiable soil conditions are not uncommon in alluvial deposits in moderate to large canyons and could also be present in other areas of alluvial soils where the groundwater level is shallow (i.e., 50 feet below the surface). Bedrock units, due to their dense nature, are unlikely to present a liquefaction hazard.

Location and Extent

There is no scientific scale for earthquake related liquefaction. The speed of onset is short, as is the duration. The effects from liquefaction can last for days, weeks, months or even years as areas of the County are

rebuilt or leveed areas are dewatered, and the levees rebuilt. In Sacramento County, the Delta and areas of downtown Sacramento are at risk to liquefaction. The Delta sits atop a blind fault system on the western edge of the Central Valley. Moderate earthquakes in 1892 near Vacaville and in 1983 near Coalinga demonstrate the seismic potential of this structural belt. The increasing height of the levee system has prompted growing concern about the seismic stability of the levees. The concern is based on the proximity of faulting, the nature of the levee foundations, and the materials used to build the levees. Many levees consist of uncompacted weak local soils that may be unstable under seismic loading. The presence of sand and silt in the levees and their foundations indicates that liquefaction is also a possibility.

Past Occurrences

There have be no past federal or state disaster declarations from this hazard. The District noted no past occurrences of earthquake liquefaction or that affected the District in any meaningful way. The seismic events of 1989 and 2014 did not induce liquefaction on the Delta Levees. Delta levees are composed of material that contain pockets, rather than long continuous lenses, of sand. Though it has a low likelihood of future occurrence, liquefaction is a recognized potential risk.

Vulnerability to and Impacts from Liquefaction

Earthquake is discussed 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 of the ground underneath liquefaction prone areas. In Sacramento County, two of these areas have been identified: downtown Sacramento and the Delta area, which could lead to a possible collapse of delta levees and any above ground structures. While this levee failure differs from the levee failure discussion below which generally focuses on levee failure due to high water conditions or other types of structural failure, the resulting impacts would be similar and include those related to a large flood event. 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.

Assets at Risk

The District Planning Team noted that the levees structures, pump stations and drainage conveyances are potentially at risk to liquefaction resulting from seismic activity. Additionally, all-natural resources in the District would be at risk to liquefaction of the levee foundations and associated levee failures.

Flood: 1%/0.2% Annual Chance

Likelihood of Future Occurrence–Occasional
Vulnerability–High

Hazard Profile and Problem Description

This hazard analyzes the FEMA DFIRM 1% and 0.2% annual chance floods. These tend to be the larger floods that can occur in the County or in the District, and have caused damages in the past. Flooding is a significant problem in Sacramento County and the District. Historically, the District has been at risk to flooding primarily during the winter and spring months when river systems in the County swell with heavy

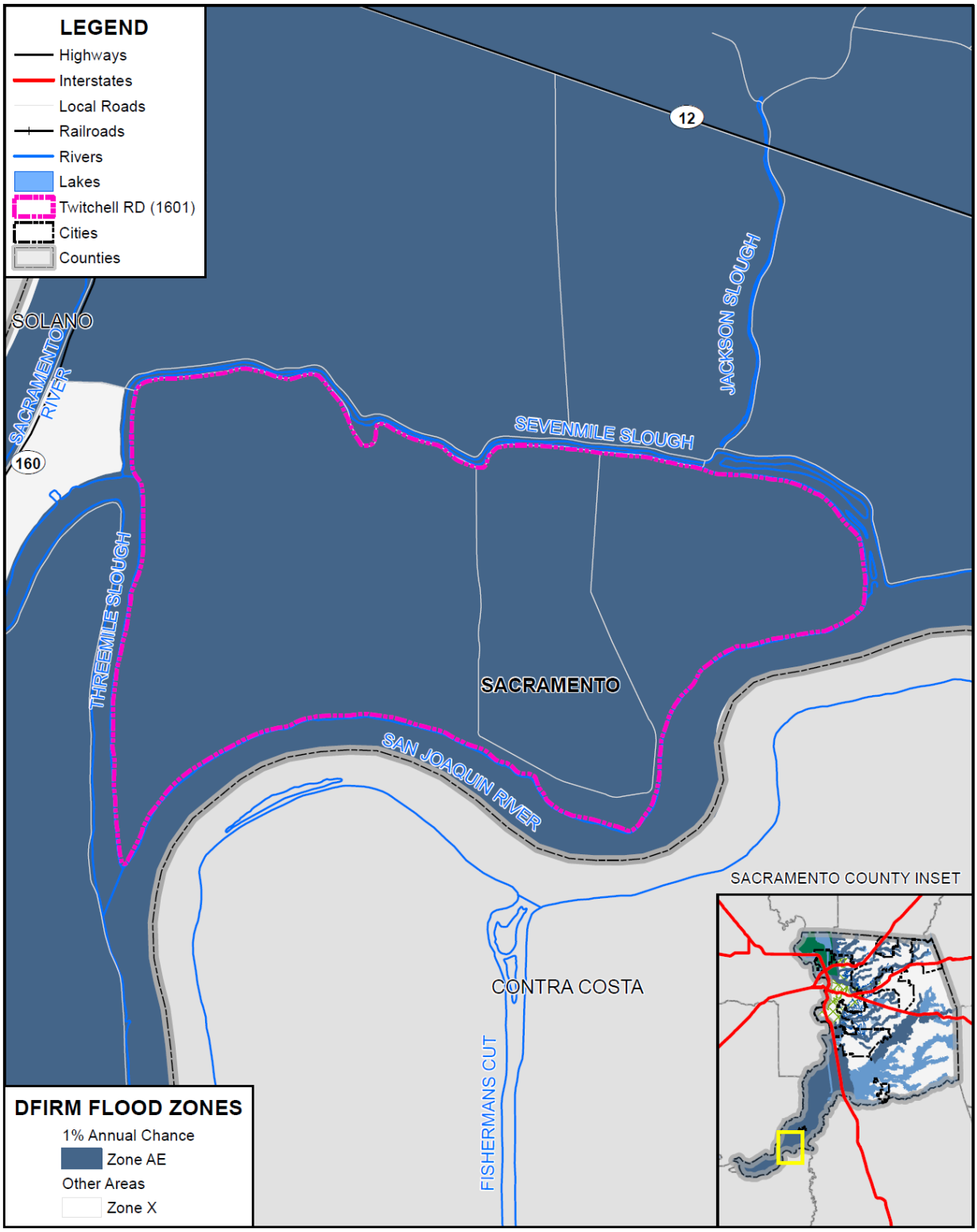
rainfall and snowmelt runoff. Normally, storm floodwaters are kept within defined limits by a variety of storm drainage and flood control measures. Occasionally, extended heavy rains result in floodwaters that exceed normal high-water boundaries and cause damage.

As previously described in Section 4.3.11 of the Base Plan, the Sacramento County Planning Area and RD 1601 have been subject to historical flooding.

Location and Extent

RD 1601 has areas located in the 1% annual chance floodplain. This is seen in Figure 12-3.

Figure 12-3 RD 1601 – FEMA DFIRM Flood Zones



Data Source: FEMA NFHL 07/19/2018, Twitchell Reclamation District, Sacramento County GIS, Cal-Atlas; Map Date: 09/2020.

Table 12-8 details the DFIRM mapped flood zones within the 1% annual chance flood zone as well as other flood zones located within the District.

Table 12-8 RD 1601– DFIRM Flood Hazard Zones

Flood Zone	Description	Flood Zone Present in the District
A	100-year Flood: No base flood elevations provided	
AE	100-year Flood: Base flood elevations provided	X
AH	An area inundated by 1% annual chance flooding (usually an area of ponding), for which BFEs have been determined; flood depths range from 1 to 3 feet	
AO	Areas subject to inundation by 100-year shallow flooding (usually sheet flow on sloping terrain) where average depths are between one and three feet	
A99	Areas with a 1% annual chance of flooding that will be protected by a Federal flood control system where construction has reached specified legal requirements. No depths or base flood elevations are shown within these zones	
Shaded X	500-year flood the areas between the limits of the 1% annual chance flood and the 0.2-percent-annual-chance (or 500-year) flood	
X Protected by Levee	An area determined to be outside the 500-year flood and protected by levee from 100-year flood	

Source: FEMA

Additionally, flood extents can generally be measured in volume, velocity, and depths of flooding. Expected flood depths in the District vary, depending on the nature and extent of a flood event; specific depths are unknown. Flood durations in the District tend to be short to medium term, or until either the storm drainage system can catch up or flood waters move downstream. Flooding in the District tends to have a shorter speed of onset, due to the amount of water that flows through the District. Flooding can occur with compound effects of a storm, high releases from upstream dams, snowmelt, and is influenced by tidal movement.

Past Occurrences

A list of state and federal disaster declarations for Sacramento County from flooding is shown on Table 12-9. These events also likely affected the District to some degree.

Table 12-9 Sacramento County – State and Federal Disaster Declarations from Flood 1950-2020

Disaster Type	Federal Declarations		State Declarations	
	Count	Years	Count	Years
Flood (including heavy rains and storms)	19	1950, 1955, 1958 (twice), 1963, 1969, 1982 (twice), 1983, 1986, 1995 (twice), 1996, 1997, 1998, 2008, 2017 (three times)	14	1955, 1958, 1964, 1969, 1983, 1986, 1995 (twice), 1997, 1998, 2006, 2017 (three times)

Source: Cal OES, FEMA

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.
- 2017 Flood Event. A large series of storm events generating high winds and heavy rain caused rivers to rise above flood stage. Emergency floodfight and repairs, rodent hole repairs, and emergency response patrols and labor occurred during the event. The District had well organized floodfight response, and was able to immediately address problems. The District's levees and sustained only minor damage and performed well. The total 2017 Event claims to FEMA was $118,691.

Vulnerability to and Impacts from Flood

Floods have been a part of the District's historical past and will continue to be so in the future. During winter months, long periods of precipitation and the timing of that precipitation are critical in determining the threat of flood, and these characteristics further dictate the potential for widespread structural and property damages. Predominantly, the effects of flooding are generally confined to areas near the waterways of the County. As waterways grow in size from local drainages, so grows the threat of flood and dimensions of the threat. This threatens structures in the floodplain. Structures can also be damaged from trees falling as a result of water-saturated soils. Electrical power outages happen, and the interruption of power causes major problems. Roads can be damaged and closed, causing safety and evacuation issues. People may be swept away in floodwaters, causing injuries or deaths.

Floods are among the costliest natural disasters in terms of human hardship and economic loss nationwide. Floods can cause substantial damage to structures, landscapes, and utilities as well as life safety issues. Floods can be extremely dangerous, and even six inches of moving water can knock over a person given a strong current. During a flood, people can also suffer heart attacks or electrocution due to electrical equipment short outs. Floodwaters can transport large objects downstream which can damage or remove stationary structures. Ground saturation can result in instability, collapse, or other damage. Objects can also be buried or destroyed through sediment deposition. Floodwaters can also break utility lines and interrupt services. Standing water can cause damage to crops, roads, foundations, and electrical circuits. Direct impacts, such as drowning, can be limited with adequate warning and public education about what to do during floods. Other problems connected with flooding and stormwater runoff include erosion, sedimentation, degradation of water quality, loss of environmental resources, and economic impacts.

RD 1601 (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.

Assets at Risk

Should a flood breach the levees, the entirety of the assets of RD 1601 would be at risk. Additionally, flooding of Delta islands destroys habitat, kills most species present, and can entrain and strand large populations of native and non-native fish species.

Flood: Localized Stormwater Flooding

Likelihood of Future Occurrence–Occasional
Vulnerability–High

Hazard Profile and Problem Description

Flooding occurs in areas other than the FEMA mapped 1% and 0.2% annual chance floodplains. Flooding may be from drainages not studied by FEMA, lack of or inadequate drainage infrastructure, or inadequate

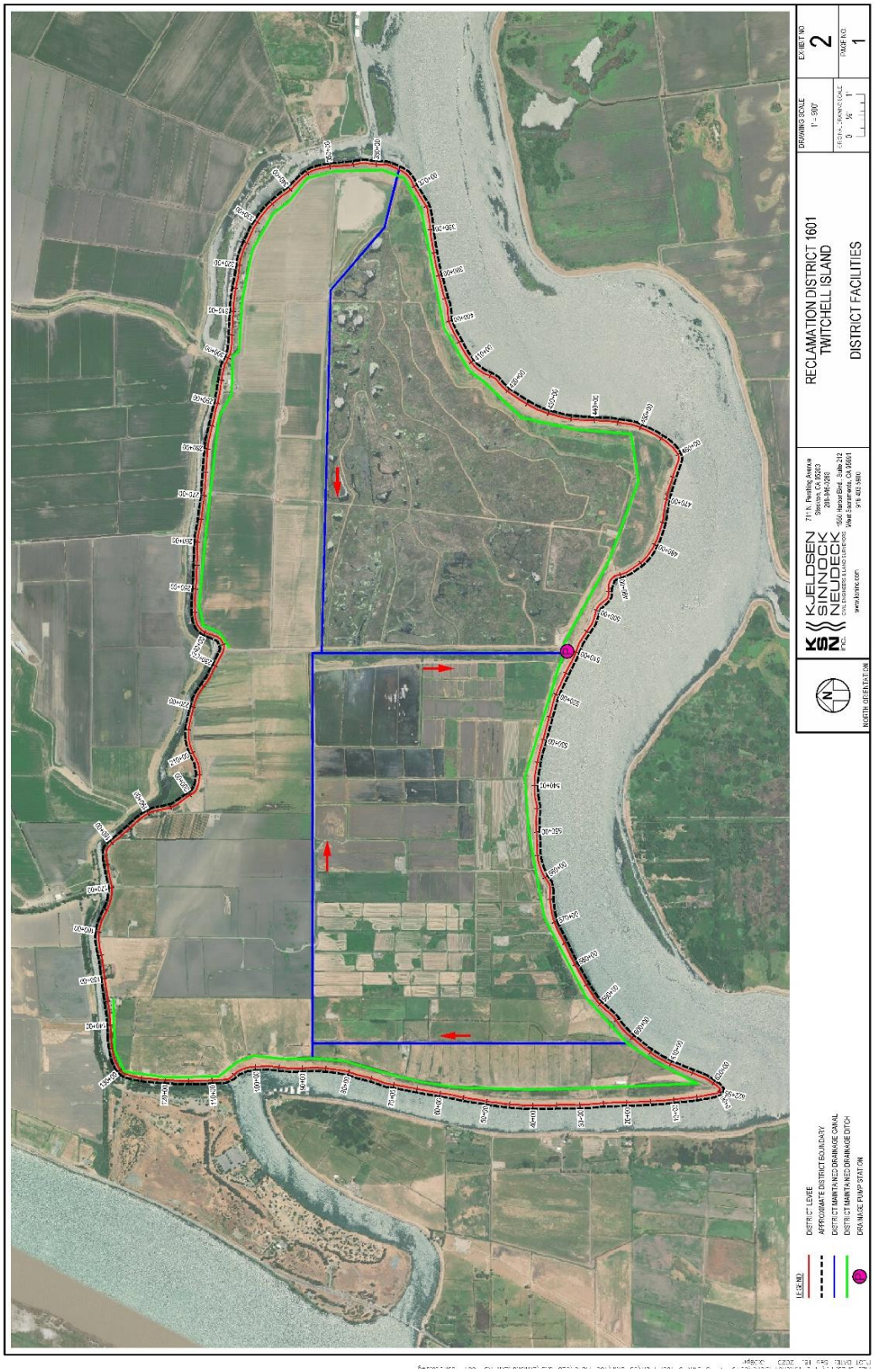
maintenance. Localized, stormwater flooding occurs throughout the County during the rainy season from November through April. Prolonged heavy rainfall contributes to a large volume of runoff resulting in high

Location and Extent

RD 1601 is subject to localized flooding throughout the District. Flood extents are usually measured in areas affected, velocity of flooding, and depths of flooding. Expected flood depths in the District vary by location. Flood durations in the District tend to be short to medium term, or until either the storm drainage system can catch up or flood waters move downstream. Localized flooding in the District tends to have a shorter speed of onset, especially when antecedent rainfall has soaked the ground and reduced its capacity to absorb additional moisture.

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. A map of this system can be seen on Figure 12-4

Figure 12-4 RD 1601 Drainage System



Source: RD 1601

The District has localized flooding areas at the District low spot in the center of the District

Past Occurrences

There have been no federal or state disaster declarations in the County due to localized flooding. The District has not identified past events.

Vulnerability to and Impacts from Localized Flooding

Historically, much of the growth in the District and County has occurred adjacent to streams, resulting in significant damages to property, and losses from disruption of community activities when the streams overflow. Additional development in the watersheds of these streams affects both the frequency and duration of damaging floods through an increase in stormwater runoff.

Primary concerns associated with stormwater flooding include impacts to infrastructure that provides a means of ingress and egress throughout the community. Ground saturation can result in instability, collapse, or other damage to trees, structures, roadways and other critical infrastructure. Objects can also be buried or destroyed through sediment deposition. Floodwaters can break utility lines and interrupt services. Standing water can cause damage to crops, roads, and foundations. Other problems connected with flooding and stormwater runoff include erosion, sedimentation, degradation of water quality, losses of environmental resources, and certain health hazards.

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

Levee Failure

Likelihood of Future Occurrence–Occasional
Vulnerability–High

Hazard Profile and Problem Description

A levee is a raised area that runs along the banks of a stream or canal. Levees reinforce the banks and help prevent flooding by containing higher flow events to the main stream channel. By confining the flow to a narrower steam channel, levees can also increase the speed of the water. Levees can be natural or man-made.

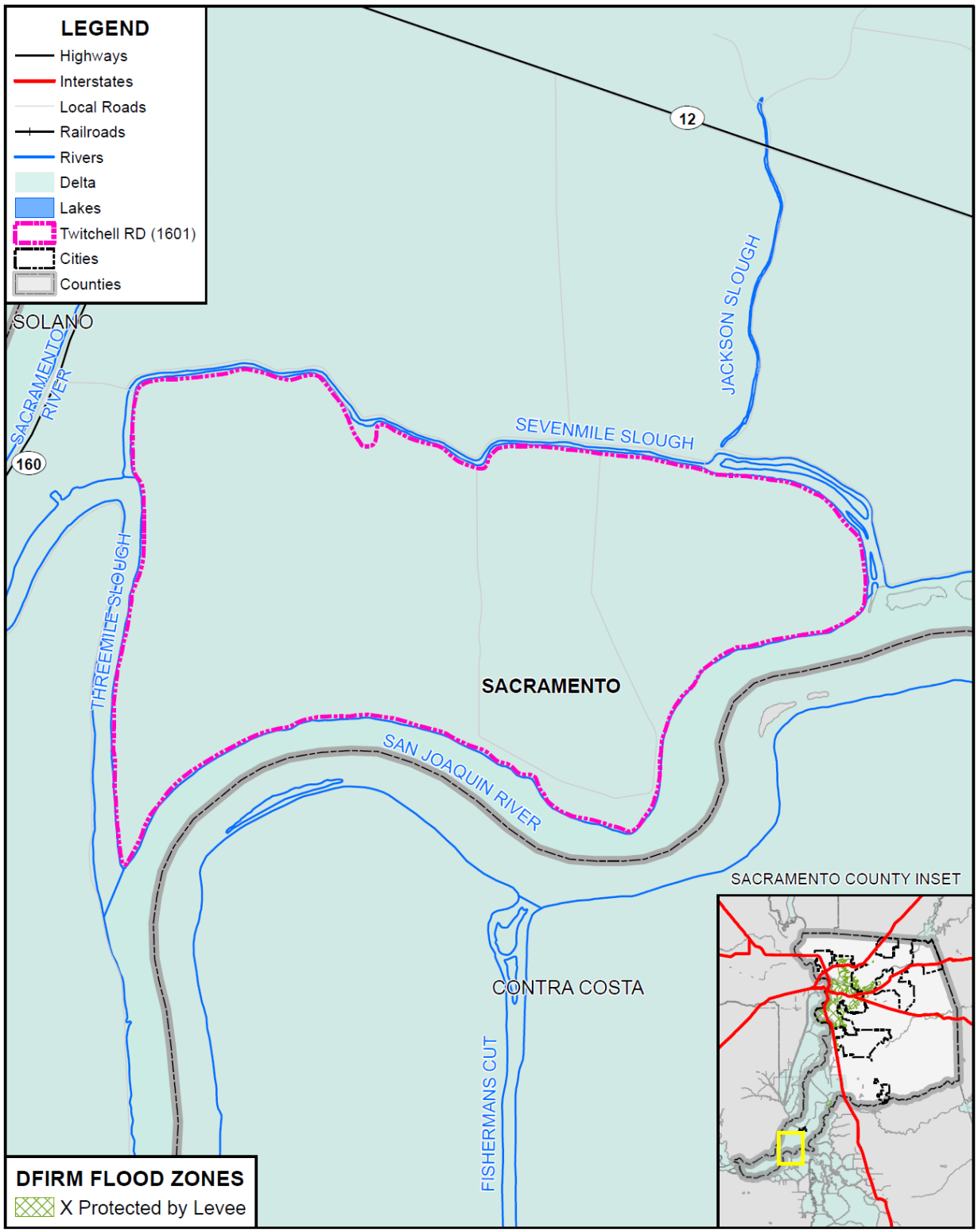
Levees provide strong flood protection, but they are not failsafe. Levees are designed to protect against a specific flood level and could be overtopped during severe weather events or dam failure. For example, levees can be certified to provide protection against the 1% annual chance flood. Levees reduce, not eliminate, the risk to individuals and structures located behind them. A levee system failure or overtopping can create severe flooding and high water velocities. Levee failure can occur through overtopping or from

seepage issues resulting from burrowing rodents, general erosion, excessive vegetation and root systems and other factors that compromise the integrity of the levee. No levee provides protection from events for which it was not designed, and proper operation and maintenance are necessary to reduce the probability of failure.

Location and Extent

There is not a scientific scale or measurement system in place for levee failure. Expected flood depths from a levee failure in the District vary by event and location. The speed of onset is slow as the river rises, but if a levee fails the warning times are generally short for those in the inundation area. The duration of levee failure risk times can be hours to weeks, depending on the river flows that the levee holds back. When northern California dams and reservoirs are nearing maximum capacity, they release water through the river systems, causing additional burdens on County levees. Levees in the District are shown on Figure 12-5.

Figure 12-5 RD 1601 – Levee Protected Areas



FOSTER MORRISON CONSULTING

SACRAMENTO COUNTY

Data Source: FEMA NFHL 07/19/2018, Twitchell Reclamation District, Sacramento County GIS, Cal-Atlas; Map Date: 09/2020.

The District is entirely protected by levees on all sides.

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.
- 2016-2014: Supplementation of existing riprap at several locations throughout the District due to erosion.
- 2017-2018: Construction of all-weather road on San Joaquin River levee toe from Station 360+00 to Station 622+55. This reach of levee is highly susceptible to extreme wave wash under high wind conditions along with seepage and landside slope deformation. Flood fighting relies heavily on access to the levee at all times by use of all-weather roads.

Vulnerability to and Impacts from Levee Failure

A levee failure can range from a small, uncontrolled release to a catastrophic failure. Levee failure flooding can occur as the result of prolonged rainfall and flooding. The primary danger associated with levee failure is the high velocity flooding of those properties outside and downstream of the breach.

Should a levee fail, some or all of the area protected by the levees would be at risk to flooding. Impacts from a levee failure include property damage, critical facility damage, and life safety issues. Business and

economic losses could be large as facilities could be flooded and services interrupted. School and road closures could occur. Road closures would impede both evacuation routes and ability of first responders to quickly respond to calls for aid. Other problems connected with levee failure flooding include erosion, sedimentation, degradation of water quality, losses of environmental resources, and certain health hazards.

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.

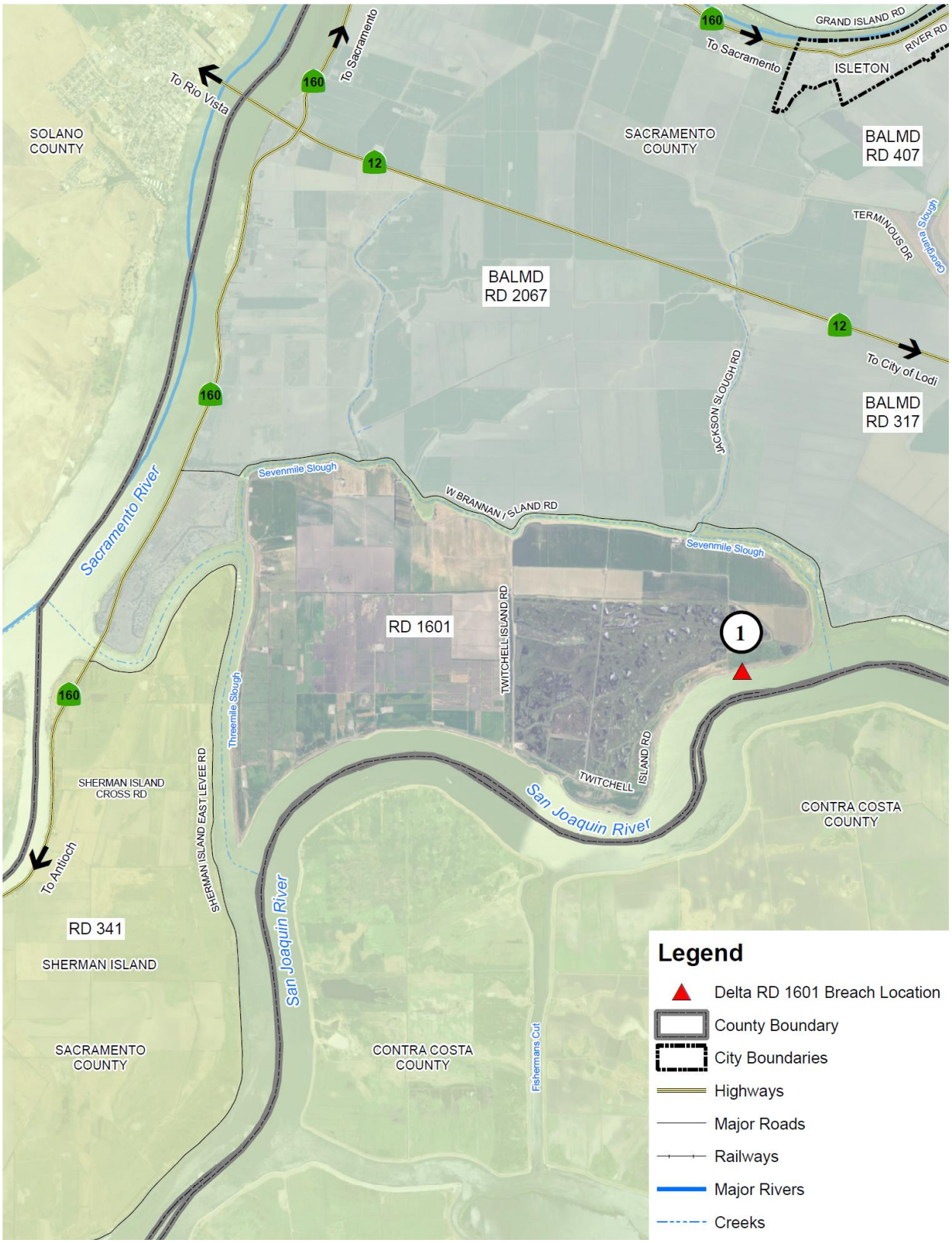
StormReady Flood Scenarios and Evacuation Routes

The County of Sacramento and the City of Sacramento have prepared various detailed maps showing hypothetical levee breaks, inundation levels and the time it would take for waters to rise in affected neighborhoods, and rescue and evacuation zones. It is important to note that these maps deal with potential scenarios. These are to help Sacramento County citizens think of how to escape before an emergency occurs. It should be noted that it would be incorrect to assume that the evacuation routes shown on the

maps will necessarily be citizens only way out in a flood. Escape routes could be affected by localized flooding, traffic accidents, and different flooding situations occurring at the time. Emergency officials will monitor roads and let the public know through radio stations and other media if alternate routes should be taken.

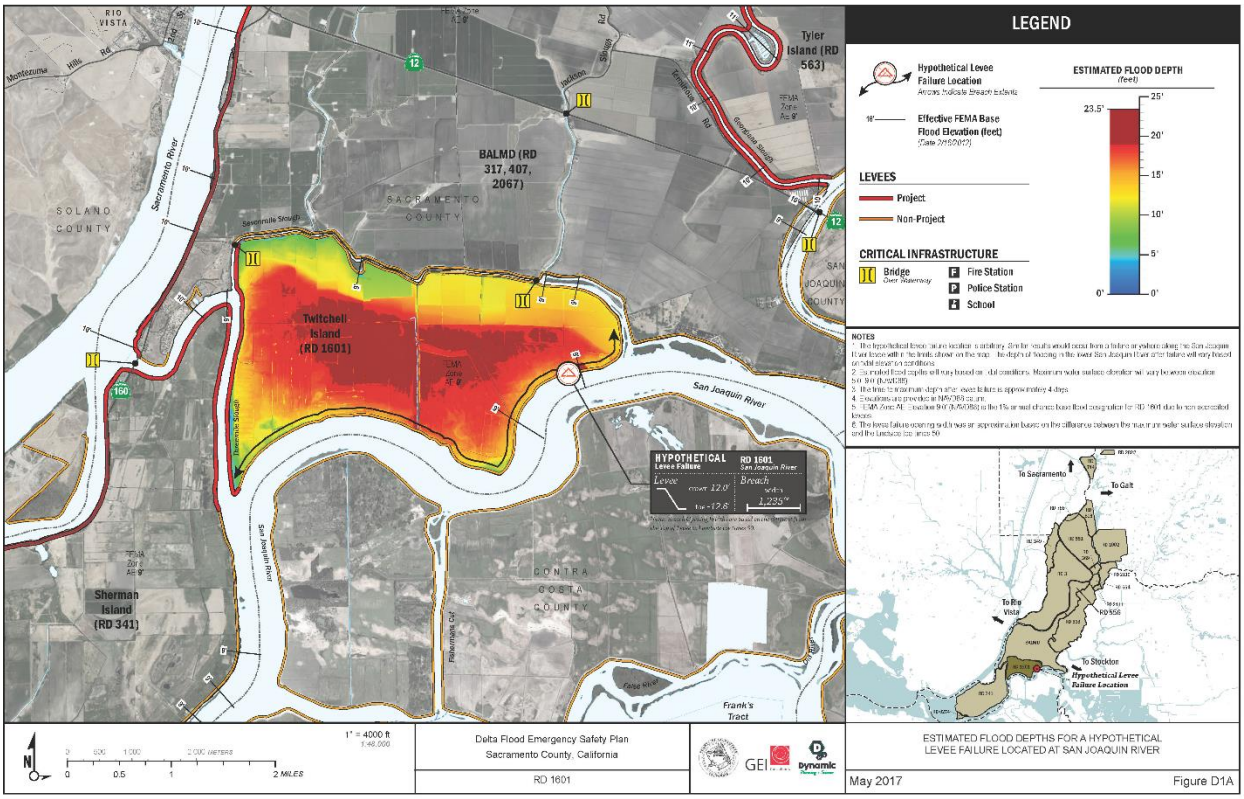
For RD 1601, Figure 12-6 details the locations in the Delta within Reclamation District 1601 where flooding could occur. The red triangles denote potential levee breach locations. RD 1601 has a hypothetical potential levee break scenario. Maps for the levee breach scenario regarding time to one foot inundation (Figure 12-7), estimated flood depths (Figure 12-8), and suggested evacuation routes (Figure 12-9) are displayed below.

Figure 12-6 RD 1601 – Potential Levee Breach Location



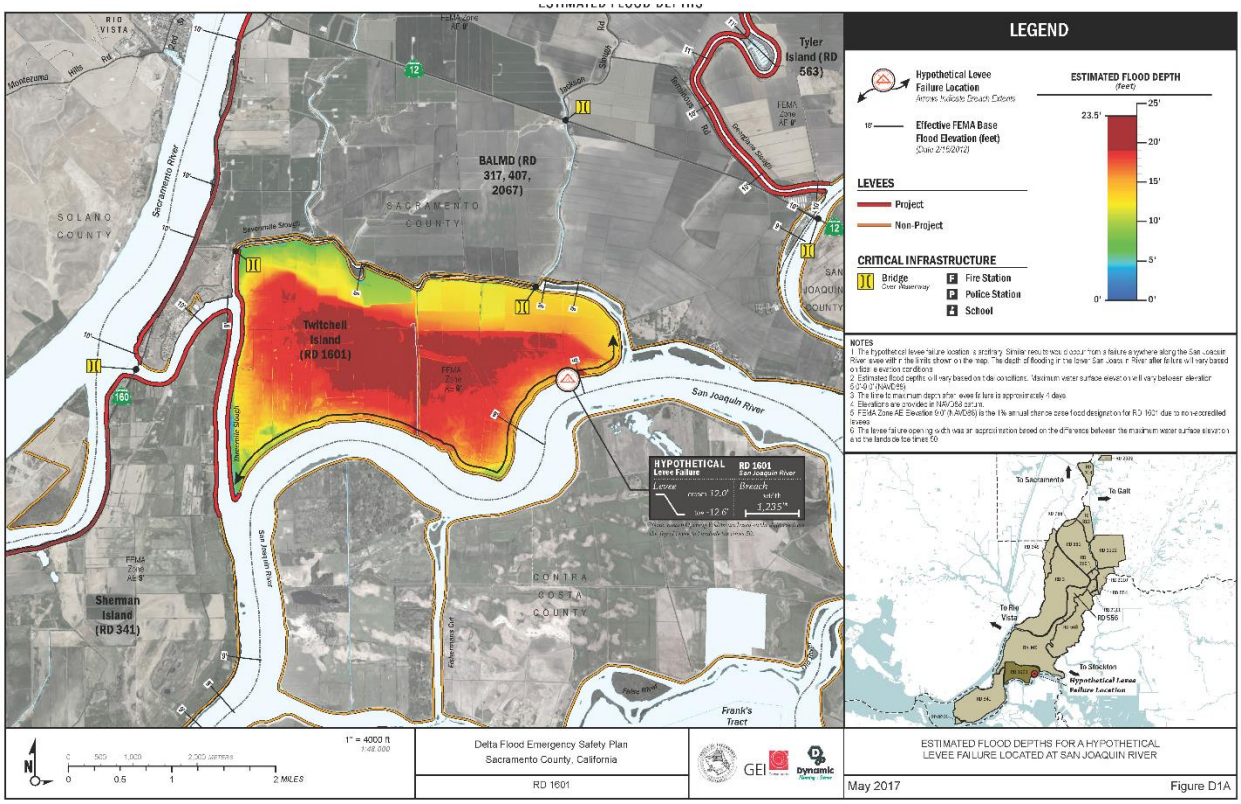
Source: Sacramento County Storm Ready – retrieved March 16, 2021

Figure 12-7 RD 1601 – Time to One Foot Inundation after Levee Breach



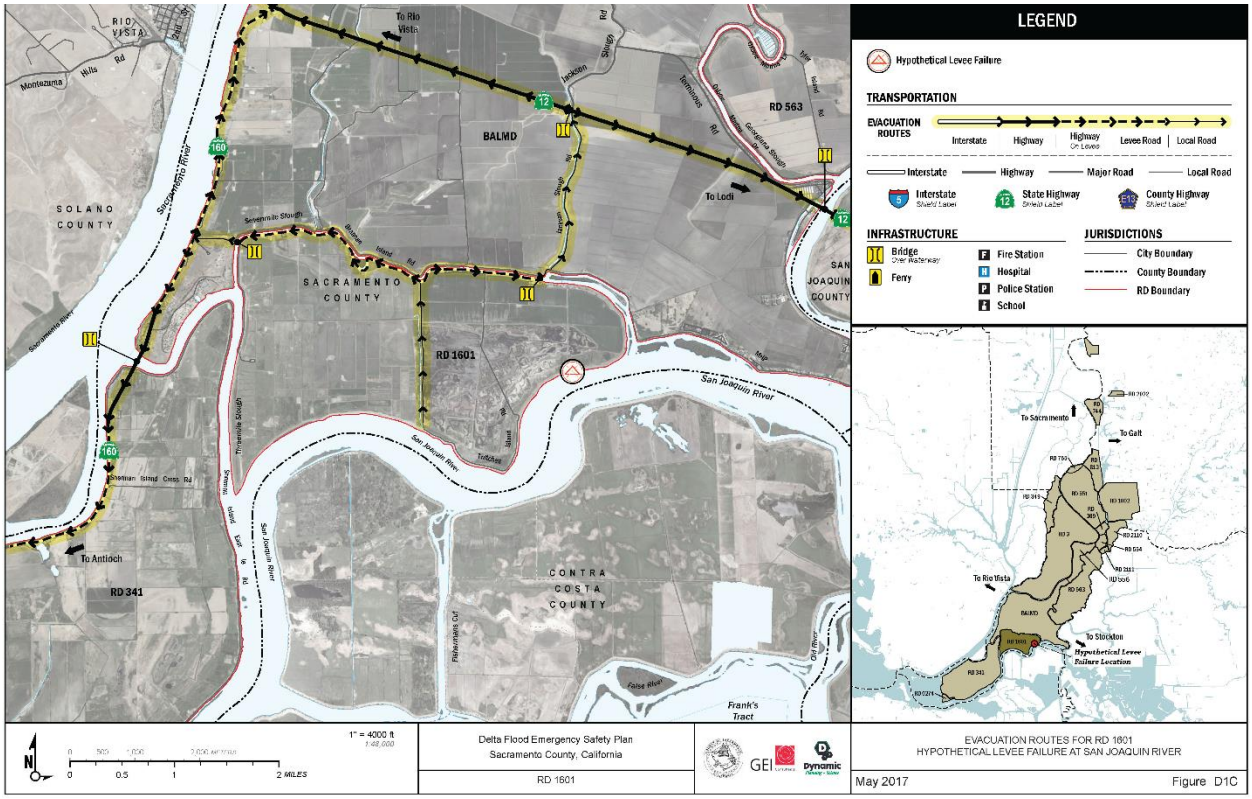
Source: Sacramento County Storm Ready – retrieved March 16, 2021

Figure 12-8 RD 1601 – Estimated Flood Depth from Levee Breach Scenario



Source: Sacramento County Storm Ready – retrieved March 16, 2021

Figure 12-9 RD 1601 – Levee Breach Scenario Evacuation Routes



Source: Sacramento County Storm Ready – retrieved March 16, 2021

Assets at Risk

Should the levees fail, all District assets would be 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.

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

Likelihood of Future Occurrence–Likely
Vulnerability–Medium

Hazard Profile and Problem Description

Storms in the District occur annually and are generally characterized by heavy rain often accompanied by strong winds and sometimes lightning and hail. Approximately 10 percent of the thunderstorms that occur each year in the United States are classified as severe. A thunderstorm is classified as severe when it contains one or more of the following phenomena: hail that is three-quarters of an inch or greater, winds in excess of 50 knots (57.5 mph), or a tornado. Heavy precipitation in the District falls mainly in the fall, winter, and spring months.

Location and Extent

Heavy rain events occur on a regional basis. Rains and storms can occur in any location of the District. All portions of the District are at risk to heavy rains. Most of the severe rains occur during the fall, winter, and spring months. There is no scale by which heavy rains and severe storms are measured. Magnitude of storms is measured often in rainfall and damages. The speed of onset of heavy rains can be short, but accurate weather prediction mechanisms often let the public know of upcoming events. Duration of severe storms in California, Sacramento County, and the District can range from minutes to hours to days. Information on precipitation extremes can be found in Section 4.3.4 of the Base Plan.

Past Occurrences

There have been past disaster declarations from heavy rains and storms, which were discussed in Past Occurrences of the flood section above. According to historical hazard data, severe weather, including heavy rains and storms, is an annual occurrence in the District. This is the cause of many of the federal disaster declarations related to flooding.

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.
- 2017 Flood Event. A large series of storm events generating high winds and heavy rain caused rivers to rise above flood stage. Emergency floodfight and repairs, rodent hole repairs, and emergency response patrols and labor occurred during the event. The District had well organized floodfight response, and was able to immediately address problems. The District's levees and sustained only minor damage and performed well. The total 2017 Event claims to FEMA was $118,691. The 2017 water year was the second wettest water year ('82-'83 being the wettest) within the San Joaquin basin as measured by the California Hydrology and Flood Operations Office. Numerous storms occurred over the '16/17 winter months with a 5 station average of 25.2 inches and 17.70 inches in January and February, respectively. Flood water stages peaked in January and spiked again in February then receded in March with prolonged elevated stages occurring over the San Joaquin Delta through to September. In the late winter early spring 2017 an area of settlement was developed. A 1-foot-deep trough, 30 ft wide by 250 LF Scarp developed parallel to the levee and centered on STA 425+00. A geotechnical investigation was conducted on the area and resulted in no unusual findings. The area was recommended for future visual observations however not additional investigations are not warranted. Construction of an All Weather Road along the toe of the south levee segment was completed as a means to be provide all weather access for levee patrol. A significant seep was found during the event. A historic siphon within the Owl Harbor Marina was discovered as the cause for the seep and was removed from the levee.

Vulnerability to and Impacts from Heavy Rain and Storms

Heavy rain and severe storms are the most frequent type of severe weather occurrences in the District. These events can cause localized flooding. Elongated events, or events that occur during times where the ground is already saturated can cause 1% and 0.2% annual chance flooding. Wind often accompanies these storms and has caused damage in the past. Hail and lightning are rare in the District.

Actual damage associated with the effects of severe weather include impacts to property, critical facilities (such as utilities), and life safety. Heavy rains and storms often result in localized flooding creating significant issues. Roads can become impassable and ground saturation can result in instability, collapse, or other damage to trees, structures, roadways and other critical infrastructure. Floodwaters and downed trees can break utilities and interrupt services.

During periods of heavy rains and storms, power outages can occur. These power outages can affect pumping stations and lift stations that help alleviate flooding. More information on power shortage and failure can be found in the Severe Weather: Extreme Heat Section above, as well as in Section 4.3.3 of the Base Plan.

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.

Assets at Risk

All assets are at risk from heavy rains and storms within the District.

Severe Weather: High Winds and Tornadoes

Likelihood of Future Occurrence–Likely
Vulnerability–High

Hazard Profile and Problem Description

High winds, as defined by the NWS glossary, are sustained wind speeds of 40 mph or greater lasting for 1 hour or longer, or winds of 58 mph or greater for any duration. High winds can cause significant property and crop damage, threaten public safety, and have adverse economic impacts from business closures and power loss. High winds can also cause PSPS events.

Tornadoes are rotating columns of air marked by a funnel-shaped downward extension of a cumulonimbus cloud whirling at destructive speeds of up to 300 mph, usually accompanying a thunderstorm. Tornadoes form when cool, dry air sits on top of warm, moist air. Tornadoes are the most powerful storms that exist. Tornadoes, though rare, are another severe weather hazard that can affect areas of the Sacramento County Planning Area, primarily during the rainy season in the late fall, winter, and early spring.

Location and Extent

The entire District is subject to significant, non-tornadic (straight-line), winds. Each area of the County is at risk to high winds. Magnitude of winds is measured often in speed and damages. These events are often part of a heavy rain and storm event, but can occur outside of storms. The speed of onset of winds can be short, but accurate weather prediction mechanisms often let the public know of upcoming events. Duration of winds in California is often short, ranging from minutes to hours. The Beaufort scale is an empirical 12 category scale that relates wind speed to observed conditions at sea or on land. Its full name is the Beaufort Wind Force Scale. The Beaufort Scale was shown in Section 4.3.5 of the Base Plan.

Tornadoes, while rare, can occur at any location in the County and District. Prior to February 1, 2007, tornado intensity was measured by the Fujita (F) scale. This scale was revised and is now the Enhanced Fujita scale. Both scales are sets of wind estimates (not measurements) based on damage. The new scale (EF) provides more damage indicators (28) and associated degrees of damage, allowing for more detailed analysis and better correlation between damage and wind speed. It is also more precise because it considers the materials affected and the construction of structures damaged by a tornado. The F Scale and EF Scale are shown in Section 4.3.5 of the Base Plan.

Past Occurrences

There has been no federal or state disaster declarations in the County for winds and tornadoes. The District noted that since high winds is a regional phenomenon, events that affected the lower elevations of the County also affected the District. Those past occurrences were shown in the Base Plan in Section 4.3.5.

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.
- 2017 Flood Event. A large series of storm events generating high winds and heavy rain caused rivers to rise above flood stage. Emergency floodfight and repairs, rodent hole repairs, and emergency response patrols and labor occurred during the event. The District had well organized floodfight response, and was able to immediately address problems. The District's levees and sustained only minor damage and performed well. The total 2017 Event claims to FEMA was $118,691

Vulnerability to and Impacts from Severe Weather: Wind and Tornado

High winds are common occurrences in the District throughout the entire year. Straight line winds are primarily a public safety and economic concern. Windstorm can cause damage to structures and power lines which in turn can create hazardous conditions for people. Debris flying from high wind events can shatter windows in structures and vehicles and can harm people that are not adequately sheltered. High winds can impact critical facilities and infrastructure and can lead to power outages. Wind can also drive wildfire flames, spreading wildfires quickly During periods of high winds and dry vegetation, wildfire risk increases. High winds that occur during periods of extreme heat can cause PSPS events to be declared in the County. More information on power shortage and failure can be found at the beginning of Section 12.5.3 above, as well as in Section 4.3.3 of the Base Plan.

Impacts from high winds in the District will vary. Future losses from straight line winds include:

- Downed trees
- Power line impacts and economic losses from power outages
- Occasional structure damage
- Erosion of levees and other areas

When paired with highwater, heavy runoff, high tide, and high wind, impacts to District levees, as well as the entire Sacramento – San Joaquin Delta region, include serious levee erosion that could result in overtopping that possibly lead to failure.

Assets at Risk

The District Planning Team noted that the entirety of the levee structures is at risk from wind. The District Planning Team noted that all natural resources in the District are at risk if winds caused a levee failure in the District.

Subsidence

Likelihood of Future Occurrence–Likely
Vulnerability–Medium

Hazard Profile and Problem Description

Subsidence is the gradual settling or sinking of the earth's surface over manmade or natural underground voids with little or no horizontal motion. Subsidence occurs naturally and also through man-driven or technologically exacerbated circumstances. Subsidence is worsened when groundwater drawdown exceeds the ability of the ground to naturally recharge. This is more common during periods of drought.

Location and Extent

There is no scientific scale to measure subsidence. Subsidence is measured in inches or feet of elevation change over time. Subsidence has a long speed of onset, as it occurs over many years. The duration of subsidence is long, as it is rare for subsidence to be reversed. In Sacramento County, the Delta in the southeast portion of the County is highly at risk to subsidence. In the Delta, subsidence affects the islands as well as the levees.

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. No events have occurred since 2016.

Vulnerability to and Impacts from Subsidence

Historically, the County has been at risk from subsidence. Vulnerability in the County from subsidence comes from several different causes:

- Compaction of Unconsolidated Soils by Earthquake Shaking (Liquefaction)
- Compaction by Heavy Structures
- The Erosion of Peat Soils
- Fluid Withdrawal

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.

These were discussed in detail in Section 4.3.16 of the Base Plan.

Assets at Risk

The District Planning Team noted that all levee structures in the District are at risk to subsidence.

12.6 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.

12.6.1. Regulatory Mitigation Capabilities

Table 12-10 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 12-10 RD 1601 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/General Plan	Y 2020	5 Year Plan identifies hazards that may affect RD 1601. Some mitigation strategies are proposed. Yes, the plan can be used to implement mitigation actions.
Capital Improvements Plan	N	
Economic Development Plan	N	
Local Emergency Operations Plan	Y	A District-specific Flood Safety Plan, composed of an Emergency Operations Plan and an Annex – A Flood (the Flood Contingency Map) was completed in 2019 for RD1601.
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		
How can these capabilities be expanded and improved to reduce risk?		

The Emergency Operations Plan development process alone helps to increase the capabilities of the District to respond to emergencies and disasters. Continued funding available to maintain these plans would be helpful.

Source: RD 1601

12.6.2. Administrative/Technical Mitigation Capabilities

Table 12-11 identifies the District department(s) responsible for activities related to mitigation and loss prevention in RD 1601.

Table 12-11 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 together with KSN (engineering firm) staff support this committee.
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)	Y	Sacramento County has an alert and warning system that covers the District.
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?		
These capabilities can be expanded by utilization of additional funding opportunities to pay for the services provided by KSN, Inc. so the District can use the General Fund dollars to fund additional District priorities.		

Source: RD 1601

12.6.3. Fiscal Mitigation Capabilities

Table 12-12 identifies financial tools or resources that the District could potentially use to help fund mitigation activities.

Table 12-12 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	
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	HMGP, FEMA Post-Disaster Assistance
State funding programs	Y	DWR Levee Subventions and Special Projects Program, DWR's Deferred Maintenance Program, Flood System Repair Program
Other		
How can these capabilities be expanded and improved to reduce risk?		
Continued funding from the Delta Levees Program is crucial. Federal funding programs are difficult to pursue because of the local cost share; if state or other partners could help the local cost share then small, rural communities it would gain more access to federal grants.		

Source: RD 1601

12.6.4. Mitigation Education, Outreach, and Partnerships

Table 12-13 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 12-13 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	

Program/Organization	Yes/No	Describe program/organization and how relates to disaster resilience and mitigation. Could the program/organization help implement future mitigation activities?
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	Y	DWR Flood Methods Course and Just In Time Training Program, and SEMS/NIMS. Training Policy is outlined in Attachment 1 of RD1601's Emergency Operations Plan (EOP), which includes SEMS/NIMS courses (SEMS 100, 200, 700; or can be covered through G0402).
How can these capabilities be expanded and improved to reduce risk?		
Additional Funding to provide these types of programs. The District will seek grants from Cal OES, CA DWR, FEMA and others to increase its mitigation capabilities.		

Source: RD 1601

12.6.5. Other Mitigation Efforts

The District has many other completed or ongoing mitigation efforts that include the following:

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.

12.7 Mitigation Strategy

12.7.1. Mitigation Goals and Objectives

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

12.7.2. 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. The following hazards were considered a priority for purposes of mitigation action planning:

- Earthquake
- Earthquake Liquefaction
- Floods: 1%/0.2% annual chance
- Floods: Localized Stormwater
- Levee Failure
- Severe Weather: Heavy Rains and Storms
- Severe Weather: Wind and Tornado

It should be noted that many of the projects submitted by each jurisdiction in Table 5-4 in the Base Plan benefit all jurisdictions whether or not they are the lead agency. Further, many of these mitigation efforts are collaborative efforts among multiple local, state, and federal agencies. In addition, the countywide public outreach action, as well as many of the emergency services actions, apply to all hazards regardless of hazard priority. Collectively, this multi-jurisdictional mitigation strategy includes only those actions and projects which reflect the actual priorities and capacity of each jurisdiction to implement over the next 5-years covered by this plan. It should further be noted, that although a jurisdiction may not have specific projects identified for each priority hazard for the five year coverage of this planning process, each jurisdiction has focused on identifying those projects which are realistic and reasonable for them to implement and would like to preserve their hazard priorities should future projects be identified where the implementing jurisdiction has the future capacity to implement.

Multi-Hazard Actions

Action 1. Levee Improvement Project

Hazards Addressed: Earthquake, Earthquake: Liquefaction, Flood: 100/200/500-year, Flood: Localized Stormwater Flooding, Levee Failure, Severe Weather: Heavy Rains and Storms, Severe Weather: Wind and Tornadoes, and Subsidence

Goals Addressed: 1, 2, 3, 4, 5

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 Bulletin 192-82 standard.

Project Description: The District will bring those portions of levee along Threemile Slough and Sevenmile Slough currently below the Bulletin 192-82 Standard to six inches above the Bulletin 192-82 Standard with a District minimum crown width of 24 feet to allow for future levee raises to address climate change and sea level rise. This project will also include addressing levee crown elevations where levee embankment

settlement has occurred. This work will likely be divided into several phases or projects, depending on the funding available.

Other Alternatives: none

Existing Planning Mechanism(s) through which Action Will Be Implemented: District Five-year Plan

Responsible Office/Partners: RD 1601

Cost Estimate: $90 -100 million

Project Priority: High

Benefits (Losses Avoided): Preservation of 1601 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: Delta Levee Subventions, Delta Levee Special Projects, HMGP Grant Programs, State Funding Opportunities, seeking cost sharing partners.

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

Action 2. Rock Slope Protection Project

Hazards Addressed: Earthquake; Earthquake: Liquefaction; Flood: 100/200/500-year, Localized Stormwater Flooding, Levee Failure; Severe Weather: Heavy Rains and Storms, Wind and Tornadoes; and Subsidence

Goals Addressed: 1, 2, 3, 4, 5

Issue/Background: The goal of this Mitigation Action is to provide additional protection to the levee by installing additional riprap.

Project Description: The District plans to ensure the protection of the existing levee by adding quarry stone riprap above the existing riprap to any portions of the waterside slope of the levee requiring additional rock slope protection. This will prevent erosion and reduce future erosion repairs. Prior to submitting a project proposal, a thorough riprap inventory of the District must be completed to determine where additional riprap may be necessary and determine more definitive quantities and costs required to complete the project.

Other Alternatives: none

Existing Planning Mechanism(s) through which Action Will Be Implemented: District 5-Year Plan and Delta Levees Program

Responsible Office/Partners: RD 1601

Cost Estimate: $4 million

Project Priority: High

Benefits (Losses Avoided): Preservation of 1601 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: Delta Levee Subventions, Delta Levee Special Projects, HMGP Grant Programs, State Funding Opportunities, seeking cost sharing partners.

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

Action 3. San Joaquin River Setback Levee

Hazards Addressed: Earthquake; Earthquake: Liquefaction; Flood: 100/200/500-year, Localized Stormwater Flooding, Levee Failure; Severe Weather: Heavy Rains and Storms, Wind and Tornadoes; and Subsidence

Goals Addressed: 1, 2, 3, 4, 5

Issue/Background: The goal of this Mitigation Action is to provide "fish friendly" levees and additional flood conveyance.

Project Description: The District would like to implement the levee improvement recommendations along the San Joaquin River in accordance with the 2009 GEI geotechnical report by constructing a toe berm and setback levee. The setback levee along the San Joaquin River also includes a channel margin habitat component that will provide approximately four miles of much needed "fish friendly" levees in this part of the Delta. This work would likely be divided into several phases or projects, depending on the funding available.

Other Alternatives: none

Existing Planning Mechanism(s) through which Action Will Be Implemented: District Five-year Plan

Responsible Office/Partners: RD 1601

Cost Estimate: $153 million

Project Priority: High

Benefits (Losses Avoided): Preservation of 1601 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: HMGP Grant Programs, seeking cost sharing partners for project.

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

Action 4. Backup Power Project

Hazards Addressed: Climate Change, Earthquake; Earthquake: Liquefaction; Flood: 100/200/500-year, Localized Stormwater Flooding, Levee Failure; Severe Weather: Heavy Rains and Storms, Wind and Tornadoes; and Subsidence

Goals Addressed: 1, 2, 3, 4, 5

Issue/Background: The goal of this Mitigation Action is to provide backup power to Reclamation District 1601 facilities when power goes out.

Project Description: The District would like to ensure continued operation of District infrastructure during a Public Safety Power Shutoff through obtaining backup power generators, quick connects, and associated electrical improvements. The project would design and install main disconnect systems to allow for safe use of generators as needed during a power shutoff or power failure. The project would include one generator per district and improvements for a disconnect systems for each pump station.

Other Alternatives: none

Existing Planning Mechanism(s) through which Action Will Be Implemented: District Five-year Plan

Responsible Office/Partners: RD 1601

Project Priority: High

Cost Estimate: $200,000

Benefits (Losses Avoided): Preservation of 1601 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: State – Delta Flood Emergency Response Grant Program, HMGP Grant Programs

Timeline: 1-10 years depending on regulatory process

Action 5. Flood Safety Plan Updates, Training, and Exercises

Hazards Addressed: Flood: 100/200/500-year, Localized Stormwater Flooding, Levee Failure; Severe Weather: Heavy Rains and Storms, Wind and Tornadoes; and Subsidence

Goals Addressed: 1, 2, 3, 4, 5

Issue/Background: The goal of this Mitigation Action is update RD 1601's Flood Safety Plan, participate in training, and to exercise the flood safety plan to ensure it can successfully be implemented. This is especially important to mitigate against the effects of staff turnover.

Project Description: The District would like to ensure continued training of staff, board members, and agents with response functions with regards to flood fighting and associated activities. Updating RD 1601's Flood Safety Plan is essential to continue to protect infrastructure protected by the district's levees. The Emergency Operations Plan provides guidance on how the District will organize, coordinate with outside partners, flood fight, dewater, recover, and serves as a planning document for future flood fight operations.

Other Alternatives: none

Existing Planning Mechanism(s) through which Action Will Be Implemented: California Water Code Section 9650-51 (AB156), Central Valley Flood Protection Plan's emergency preparedness priority, the District's Five-year Plan, and Districts Flood Safety Plan

Responsible Office/Partners: RD 1601

Project Priority: High

Cost Estimate: $100,000

Benefits (Losses Avoided): Preservation of 1601 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: State – Delta Flood Emergency Response Grant Program, HMGP Grant Programs

Timeline: 1-10 years depending on regulatory process